# Physics in Canada
# La Physique au Canada

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November / novembre 1993


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# SEASON'S GREETINGS FROM

# CANADIAN UNIVERSITY PHYSICS DEPARTMENTS HEADS/CHAIRS

The Physics Department at Concordia sends its best wishes and greetings to our colleagues in other physics departments in Canada. We are busy re-activating our COOP system and working hard on putting together an applied physics programme. We hope that this will give a certain uniqueness to our department, help to increase our student numbers, and point the way to better interaction between university physics and industry.

David Cheeke

Greetings from Acadia University. Although hard times have hit the maritimes, the highest tides in the world continue to slosh back and forth in the Bay of Fundy and we have the largest number of students majoring in physics in our history. It is our hope that the new federal government will pursue policies that encourage research (fundamental and applied) and development so that our young people will have real opportunities to pursue viable careers in science and technology. Best wishes for the new year.

Cyrus MacLatchy

Best wishes to all for 1994 from the members of the Physics Department at the University of Ottawa. We join with all of you in the hope that the tight financial squeeze which most of us have felt recently will begin to ease in 1994. Let us also work together to lobby our new government for improved support of high education and for NSERC. Il y a un bout du tunnel.

Richard Hodgson

Let's be optimistic for 1994. A Canadian has just become a Nobel Laureate in Chemistry and the new Secretary of State for Science and Technology is a scientist -- for the first time! The latter is a professor in the Faculty of Medicine of our university (University of Manitoba) and has experience both as a grantee and as a member of a national grant selection committee. So there's hope. Best wishes to all our colleagues from the (geographical) centre of our country!

Robert Barber

Le département de physique de l'Université du Québec à Montréal présente ses meilleurs voeux à la communauté canadienne des physiciens et lui souhaite une année des plus fructueuses ainsi que la pleine reconnaissance de la part du public et des autorités gouvernementales du rôle fondamental qu'elle joue dans le rayonnement scientifique du Canada.

Elie Boridy

Members of the UBC Physics Department extend their greetings and best wishes to all their colleagues across the country. We look to the new Federal Government to increase the level of funding for scholarship and research in Physics, an action that will produce the qualified people, intellectual awareness and spin-off technology needed to keep Canada internationally competitive into the 21st Century.

Brian Turrell

Warm greetings from southern Canada. I extend wishes to colleagues across this land for the time to enjoy physics research, for intelligent administrators and well-funded granting agencies who can appreciate the immense significance of our work, for responsive students eager and able to discover the beauty of nature and its mathematical description, and for wise employers who recognize the tremendous value to them of graduates trained in critical analytical thinking, in creative problem solving, and in the basic workings of the physical universe.

William Baylis

Astronomy and Physics have a new look at Saint Mary's this year, with the merger of both Departments and the hiring of three new faculty. We greet the New Year with all of the enthusiasm and excitement associated with renewal and invite others in Canada, particularly the Maritimes, to share in this feeling and to interact with us in the coming years.

David Turner

Greetings from the Department of Physics and Engineering Physics at University of Saskatchewan. We have just hosted the 29th Canadian Undergraduate Physics Conference and were so impressed by the quality of the young people entering our field that all our pessimism has been wiped away. The future of Physics in Canada is in good hands.

Henry Caplan

The members of the Department of Physics and Astronomy at the University of Victoria send greetings to their colleagues across the country and join them in attempting to meet the challenge presented by reduced budgets for both the teaching and research programs. We believe that Canada's most valuable resource is the student generation which we provide with the knowledge and skills required to meet the social and economic challenges of the future. The people and Governments of Canada will provide us with the resources to fulfill this role only if we convince them of the value of our contribution.

John Dewey

Good wishes to our fellow physicists. We at McGill University are exited about our involvement in the Phenix detector at RHIC, B-factory at SLAC, search for top quark at Fermilab, physics with Zeus at Hera, the new synchrotron at Argonne, materials research, low temperature properties of heavy fermions, pattern formation and scale invariance in systems far from equilibrium, quantum devices, mesoscopic systems and complex fluids, the standard model and beyond, string theory, quantum gravity, fractals, and dileptons in RHIC.

Subal Das Gupta

The members of the Physics Department of the University of Waterloo offer their greetings and best wishes to the Physics community in Canada for the year 1994. We strongly hope that the new political leadership of Canada will understand and support the important role that science and technology play in not only the economic well-being but also the intellectual health of our society.

Jim Lepock

To readers of *Physics in Canada* at home and abroad, very best wishes for 1994 from the Department of Physics and Astronomy at York University.

Robert Prince

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

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**Page No.**



## Departments / Rubriques



## Front Cover:

"Christmas Colours" by Pauline and David Brawn of Thompson, Manitoba – featured as part of the CAP's first Art of Physics exhibition currently on display at the Ontario Science Centre in Toronto, Ontario. Full Caption on page 318.


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# *EDITORIAL* -- Funding of Basic Research

A new year, a new Federal Government, and renewed hope for the future of science and technology in Canada are suddenly upon us. Let us hope that a moderate degree of healthy optimism is now appropriate for 1994, in place of the low morale, insecurity and lack of opportunity to advance scientific knowledge that have characterised the recent past.

Clearly, future planning by Government will be steered as much by what is possible as by what is desirable. It is no longer reasonable economically to move forward on all fronts, and difficult choices will therefore have to be made. A hope fervently held by members of the community of physicists in this country is that the need for basic fundamental research will be appropriately recognized when final decisions are made.

Historically it is clear that the somewhat brief love affair between society and science in the post war years has run its course. In a now familiar financial environment of increasing stringency and diminishing resources, the need to fund basic scientific research is frequently being called into question, and doubts as to the essential value of such research to our future technology are continually being raised.

Basic research in science is not always the easiest of endeavours to defend. Pure research, although directed towards broadening in some sense the foundations of scientific knowledge cannot be justified intrinsically by any immediate arguments concerning utility. This is true whether the research be in microbiology, chemistry, or condensed matter physics.

However, this fact should not belittle its fundamental relevance. Chadwick's discovery of the neutron in 1932 was not related in any conceptual or direct way to the development of energy sources in the 1950s. Indeed, had the same funding agencies existed sixty years ago as exist today it might have been difficult, in the absence of an adequate theory for the process, to justify the financing of a 'search for neutral particles in the bombardment of Beryllium by alpha-particles'.

Such esoteric research is indeed not often directly of benefit to society at large, although it clearly contributes to the broad base of scientific knowledge, and indirectly to the development of new ideas and technologies. Indeed, it seems clear that basic science will continue to underpin all applied science and technology to the extent that without the acquisition of new knowledge, the development of future technologies may well be in jeopardy.

The most attractive, and in many ways the most useful, definition of basic science is as a consensus activity in which the participant contributes directly to the store of public knowledge. This view was first put forward by Ziman in 1968, and is worthy of further consideration at the present time. In his view, scientific knowledge is something to which any reasonable person who makes the effort at understanding can subscribe, and this definition gives science a uniqueness not found in other disciplines. According to Ziman, the rules of scientific communication and controversy are dominated by a single principle; namely, the establishment and extension of a free intellectual consensus. Therefore, while the love affair of society with science was in full bloom, the health of the scientific community over which the consensus was established was synonymous with the health of society as a whole. There existed an implicit unity of interest and responsibility between the two. Recently however, it has become increasingly apparent that this unity of purpose is no longer to be found. The scientific community is to a significant extent being rejected by a suspicious and sceptical society, which sees the scientist as the villain rather than the hero of the contemporary scene.

The pendulum of popularity has, for reasons perhaps more political than rational, swung so far that the need for scientific research is no longer apparent to the community at large, and financing of fundamental scientific investigation is regarded as an unnecessary indulgence by society. Nonetheless, experience and history suggest that a developing technology requires sound scientific principle upon which to build, and that in the absence of new discoveries and continuing detailed investigations, not only pure science, but also technology, will stagnate. So, the funding of both basic and applied science continues to be important to a technologically dependent society, and the Ziman criterion can be used to distinguish, in a sensible manner, between the two.

If we accept science as an activity directed towards public knowledge and a consensus, then the financing of pure research cannot in any way be justified by arguments about utility despite the fact that such research has often in the past provided the springboard for a new technology. Conversely, if research is intentionally directed towards usefulness, which is a prevailing trend at the present time, then it is no longer basic science, no matter how 'scientific' the work appears to be to the observer. The Ziman criterion, however, enables us to distinguish clearly between the financing of production-oriented research and development programs and the much lower level of funding for basic non-utilitarian pure research projects.

The economic benefits of particular R and D programs can of course in most cases be readily assessed. The economic benefits of basic research, on the other hand, should in a real sense be accepted as an article of faith, a situation which both governments and funding agencies instinctively dislike. There may, however, be a realistic solution to this difficulty. Weinberg, 1967, suggested that funding of basic science may best be considered as either an overhead charge on, or an investment in, applied science and, by implication, on R and D in general. This formula may be an attractive if difficult one to implement because the funding of the two is usually undertaken by different agencies using quite separate and unrelated criteria for evaluation. The splitting of the science pie into applied and pure science is not usually carried out in a transparently logical way. Pure research is largely seen as an investment in the future, a present outlay in the hope of later rewards, and accordingly difficult to evaluate in terms of current worth. A possible formula to guarantee continuing support for fundamental research might be to devote at least 20% of the total budget for Canadian Research and Development to this end.

But, while all original work is in some sense or other valuable, the cost of each separate research program must require analysis and the degree of duplication between laboratories be taken into account. 'Adequate' funding is not 'unlimited' funding. The current situation in Canada is of 'inadequate' funding.

The immediate and dominant need requiring attention from the Federal Government is for a science and technology policy and the identification of national objectives for science. The quantification of the Weinberg criterion might be a useful stepping stone toward such a policy and defining a component of funding for fundamental research. Of course it can be said that limited resources must go to those researchers whose work is most likely to succeeed, that duplication be avoided, and that entry into expensive new fields of scientific endeavour be avoided at this time. The word 'limited', however, requires to be rationalized. Pure research must be able to attract funding at a level consistent with maintaining the kind of forward-looking programs and imaginative projects that were a feature of pure science in Canada until recent years.

If it becomes possible to define and maintain a degree of stable basic research funding that is related to both R and D and to federal spending as a whole, this will ensure a continuing investment in the future of science and technology in Canada and that degree of scientific independence essential to the health, confidence, and inventiveness of the present generation of Canadian scientists.

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A. Weinberg, Reflections on Big Science, M.I.T. Press, 1967.

J.S.C. McKee
Editor

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*NOTE from Editor: A comment received from an individual who read the editorial prior to publication is included here for your interest. I invite all our readers to submit any comments they may have about this or any other articles. Ed.*

Dear Jasper:

Just a few notes on your editorial. We hear a lot about the trials and tribulations of those seeking funding in academe (and industry and government for that matter). Rather than try to divide up the pot differently, I think the crux of the matter is really the very low level of total funding for academics in Canada. If we believe that the government actually speaks for the people of Canada, then it is probably most important to understand and address their feelings about Canadian science. I believe that the feeling that Canadian science is not producing, as well as possibly a "trend of the times", can be traced to two major factors:

(1) people no longer see the payoff from science in Canada, and

(2) Canadian universities and government labs have not done a good job of weeding out low performers and hiring stars.

It is apparent that the demand for industrial and social relevance for research which is so prevalent now within the funding agencies is simply trying to address item 1. And, for whatever reason, basic research is not viewed as providing the payoff. This is an unfortunate conclusion, as you point out, but one solution is "education" of the public. Canadian scientists and NSERC have shown an abysmal record of PR and this is where "Physics in Canada" could play a big role! Logically, increased funding for basic research, if efficiently spent, should increase the payoff.

On the other hand, despite Canada's John Polanyis, maybe the overall level of quality of the people asking for funding for basic research in Canada is not at a level to warrant increased funding. I believe that (2) above is an anchor on Canadian science because without the best people the results can hardly be top notch. Two glaring problems in Canada are the "parochial" hiring practices of some universities despite the increasing number of top notch scientists displaced from places like IBM, Bell Labs, etc., and the closed shop practises of NRC which dictate that NRC employees must have first chance for any new jobs. Canadian science has been unwilling to undertake any purging and rejuvination of the ranks which is so common in industry, and the overall level of quality has suffered (in my opinion).

T. McKee, Lumonics

**IMPORTANT EDITORIAL ANNOUNCEMENTS**

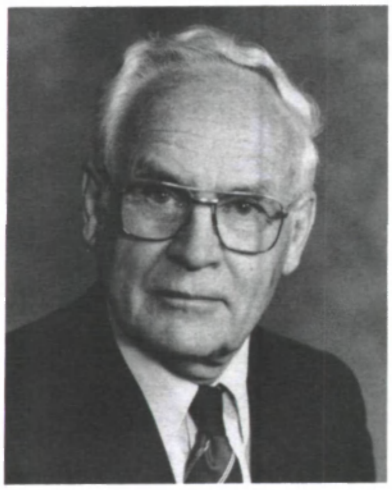
1. The first exhibition of the CAP's Art of Physics competition is on display at the Ontario Science Center. Anyone interested in securing the exhibit for any upcoming event or local science center should contact the CAP office -- times are booking up fast, so act now!!!

2. The 1994 March issue of *Physics in Canada* will be dedicated to **"Particle Physics in Canada"**, with M. Vetterli of TRIUMF as Honorary Editor for that issue. Any letters or opinions appropriate to this theme issue should be sent to the Editor by 1994 January 31. Suggestions for potential advertisers or organizations who might purchase bulk orders of the issue should be sent to the CAP office as soon as possible.

# 'IN MEMORIAM

## PROFESSOR GEORGE SINCLAIR - 1912-1993

by Keith G. Balmain, U. of Toronto



*Professor George Sinclair died on 16 Aug 1993 less than one month after the death of his wife, Helen. He leaves three daughters, Andrea, Valerie, and Lissa, all of Toronto.*

Professor Sinclair was born on 5 Nov. 1912 in Hamilton, Ontario, Canada. He moved to Alberta at an early age, and received the B.Sc. and M.Sc. Degrees from the University of Alberta in 1933 and 1935, in Electrical Engineering. He received his Ph.D. from the Ohio State University in 1946, also in Electrical Engineering.

George Sinclair first rose to prominence while still a graduate student at the Ohio State University during World War II. Professor W.L. Everitt had conceived a new scale-model measurement technique for antennas and had turned over development of the technique to Sinclair and another of his students. When Everitt left to assume a wartime job, the burden of leading the rapidly growing research group fell to Sinclair who became the first Director of the Antenna Laboratory, now known as the ElectroScience Laboratory.

His work in the Laboratory focused on the technique of scale modelling and similitude applied to both the design of communication antennas mounted on aircraft[1] and the measurement of radar cross-sections. On the theoretical side, he wrote a definitive paper[2] on the principles of scale modeling for materials of arbitrary permittivity and conductivity. His original work on generalizing the radar range equation (in which he introduced the concept of the radar scattering matrix) was classified until 1962. It is worthy of special note that his experimental and theoretical achievements were matched by his effectiveness in persuading commercial and military authorities of the significance of the work and its potential for enormous cost saving in the development of antennas and radar systems. In recognition of this work, Sinclair was awarded the U.S. Army-Navy Certificate of Appreciation in 1948.

After receiving his Ph.D. degree in 1946, Dr. Sinclair accepted a position on the faculty of the University of Toronto, in the Department of Electrical Engineering. There, he pursued a very active research career, with classic early publications on slotted cylinder antennas[3] and antennas mounted on or near elliptical cylinders[4]. In his paper on the transmission and reception of elliptically polarized waves[5], he originated the concept of complex vector effective length of an antenna. In addition, he was one of the first to recognize the potential importance of integral equation formulations for the numerical solution of problems in antennas and wave scattering[6].

Professor Sinclair's career as a teacher at the University of Toronto was equally remarkable. Those who were his undergraduate students remember well his ability to simplify and clarify even the most complicated and abstract subject matter. He was just as effective in graduate education, and he led in the establishment of the Ph.D. program in the Department of Electrical Engineering. Always ready to encourage others and to explore new areas of activity, he sparked a major research thrust in what was then the very new field of radio astronomy.

Professor Sinclair formed his own company, Sinclair Radio Laboratories Ltd. in 1951. In this venture, he was aided by many, including his early partner, Peter Yachimec, and his former student, who eventually became a Vice-President, the late Dr. William V. Tilston. The company established quickly and maintains to this day a strong international reputation for pioneering designs and high quality products, especially multicouplers and antennas. In due course the Company opened a plant in the United States, near Buffalo, and then moved its head office from Toronto northward to larger facilities in the town of Aurora, Ontario.

In recent years, Professor Sinclair's thoughts had turned to broader issues. He took every opportunity to emphasize the importance to engineers of innovation, entrepreneurial activity, and economic policies, often being very critical of economists and their theories. Most of all, he was interested in professionalism in engineering, which was for him a dominant, driving theme. He deplored the over-use of the word "technology" which he viewed as describing only a body of knowledge. He emphasized that engineering is very much a profession, in other words a human activity that requires the exercise of judgement, responsibility, and ethics, thus going far beyond the mere accumulation of knoweldge and mastery of a discipline, no matter how complex it might be.

He was very active in the International Union of Radio Science (URSI), serving on the Canadian National Committee and as the International Chairman of Commission VI. He organized and chaired the 1959 International Symposium on Electromagnetic Theory, held in Toronto. He chaired the Technical Program Committee for the 1967 URSI Spring Meeting in Ottawa and the 1969 URSI General Assembly in Ottawa. He was equally active in the Institute of Electrical and Electronics Engineers (IEEE), and its forerunner the Institute of Radio Engineers (IRE), serving as a member of the Board of Directors for eight years and on committees far too numerous to mention. He was the Chairman of the IEEE Professional Group on Antennas and Propagation in 1951-52, the period during which the first issue of its journal, the "Transactions", was published. Prof. Sinclair was a long-time supporter of the Canadian Association of Physicists, having joined in 1957.

He was not only generous with the time he devoted to professional organizations, but also generous in support of the Ohio State University and the University of Toronto. In both, he planned and funded special academic staff awards for excellence in their Departments of Electrical Engineering.

Professor Sinclair was the recipient of many honours, being a Fellow of the IRE, the American Association for the Advancement of Science, the Royal Society of Canada, and the Canadian Academy of Engineering. He received a Distinguished Alumnus Award and an Honorary Doctorate from the Ohio State University, the Canada Silver Jubilee Medal, the General A.G.L. McNaughton Gold Medal of the IEEE Canadian Region, the Polish Electrical Society Gold Medal, the Julian C. Smith Medal of the Engineering Institute of Canada, the Ernest C. Manning Award of Merit, and the University of Alberta Professional Achievement Award. Most recently, at his home and only six days before his death, he received the 1993 Distinguished Achievement Award of the Antenna Measurement Techniques Association.

At the University of Toronto, George Sinclair will be remembered as a true personification of his professional ideal, and a greatly respected colleague and friend.

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## COVER ILLUSTRATION - "Christmas Colours"
## by Pauline and David Brawn, Thompson, Manitoba

The photograph demonstrates the following: change of state of matter, lens focussing, and the additive principle of light.

Water vapour in the air is matter in the gaseous state which is transformed by the solid state (ice crystals) when it comes in contact with a relatively cool surface. This is the mechanism by which the frost and ice crystals on the window pane were produced.

The camera was focussed on the ice crystals on the window. The Christmas tree lights are at a greater distance from the lens and are therefore out of focus, so the individual bulbs appear only as enlarged globes of colour. When these globes of light overlap, additional colours are produced. The three primary colours - red, green, and blue - produce the secondary colours of yellow, cyan, and magenta. When all three primary colours (or a primary plus a secondary made from the other two primaries) combine, they add up to white light as shown by the white portion of the yellow globe near the bottom centre of the photograph.

*This photograph forms part of the CAP's first Art of Physics exhibition currently on display at the Ontario Science Centre in Toronto. Rules and entry forms for the 1994 competition are available by contacting the CAP office at 903-151 Slater Street, Ottawa, ON, K1P 5H3. Tel: (613) 237-3392.*

# HIGHLIGHTS OF THE XXI GENERAL ASSEMBLY OF IUPAP

by A.J. Alcock
IUPAP Secretariat, NRC

The 21st General Assembly of IUPAP was held in Nara, Japan during the week of September 20, 1993. The Canadian delegates were:

A.J. Alcock, NRC
W.J.L. Buyers, AECL
B.P. Stoicheff*, University of Toronto
M. Thewalt, Simon Fraser University

Following the address of Prof. Yu. A. Ossipyan, President of IUPAP, the main items of business considered at the General Assembly were: the admission of new members, reports of the IUPAP Commissions and Liaison Committees, the report of the Secretary-General, IUPAP finances and annual dues for the next three years, the election of Commission members and Executive Council members, the future role and structure of IUPAP.

A considerable amount of time was spent on the discussion of the last topic since one of IUPAP's principal objectives had been largely achieved, namely the removal by recent political changes of many of the barriers to the free movement of scientists to attend international meetings. Many delegates felt that the structure and role of IUPAP should be reviewed in order to ensure that it would involve more young physicists and continue to have a singificant international impact.

As a result of this discussion the General Assembly passed a resolution directing the Executive Council to set up a working group to examine "the further role and future structure of IUPAP along the lines discussed at the XXI General Assembly" and to make recommendations for dsicussion at the 1994 and 1995 meetings of the IUPAP Council.

Other resolutions which were passed included:

- a resolution to establish a working group t consider how to incorporate Computational Physics into IUPAP;
- a resolution aimed at ensuring that no community adhering to IUPAP would have more than one member on any IUPAP Commission;
- a resolution to establish a Task Force on Communication in Physics;
- a resolution to establish a working group to explore the field currently codified as "Mineral Physics" in relation to IUPAP current and future interests.
- a resolution that IUPAP propose to ICSU an international congress celebrating science to be held in the year 2000.

The elections for positions on the Executive Council and the Commissions of IUPAP resulted in 12 Canadians being elected to the positions indicated below:

R.C. Barber - Associate Secretary-General

B.P. Stoicheff - Vice-President

A. Astbury - member, Commission on Particles and Fields

W.J.L. Buyers - member, Commission on Magnetism

G.A. Daigle - member, Commission on Acoustics

G.W.F. Drake - chairman, Commission on Atomic and Molecular Physics (and Spectroscopy)

B.C. Gregory - member, Commission on Plasma Physics

K.S. Sharma - member, Commission on Symbols, Units, Nomenclature, Atomic Masses and Fundamental Constants (SUNAMCO)

M.L.W. Thewalt - member, Commission on Semiconductors

H.M. vanDriel - member, Commission on Quantum Electronics

E.W. Vogt - vice-chairman, Commission on Nuclear Physics

In addition to the business sessions and elections, the General Assembly included two afternoons of Academic Sessions having "Physics and Industry" as their theme. The speakers and titles of their presentations were as follows:

Yu.A. Ossipyan (Russian Academy of Sciences): *Fullerene - New Materials with New Characteristics*

P. Chaudhari (IBM, T.J. Watson Res. Centre, USA): *Physics and its role in Technology*

Y. Farge (Pechiney, France): *New Subjects in Physics are often meeting well with Industrial Needs*

A. Arima (Hosei Univ., Japan): *The Role of Universities in the Development of Basic Science*

Y. Takeda (Hitachi, Japan): *A New Paradigm of Science and Technology for the Coming Century*

B.C. Tan (Hong Leong Engineering, Malaysia): *Physics in Industrial Development in Malaysia and in the ASEAN Region*

M.H. Cohen (Exxon Research and Engineering, USA): *Physics in Industry: The Historical Context of Current Events*

* delegation leader

The General Assembly concluded with the transfer of the Presidency to Professor Y. Yamaguchi (Institute for Nuclear Study, Univeristy of Tokyo and Department of Physics, Tokai University) who is the first Japanese President of IUPAP.

Prof. Yamaguchi commented on the important role which had been played by IUPAP during the "cold war" and expressed the opinion that the time had come to re-activate IUPAP. He strongly supported the views expressed in the General Assembly and welcomed the resolution to set up a working group to consider the future of the organization.

In his concluding remarks, Prof. Yamaguchi acknowledged the very long and dedicated service of Prof. Larkin Kerwin who had served IUPAP for over three decades who had now completed his term as Past-President. He then read the citation on a commemorative certificate which would be sent to Prof. Kerwin.

A more detailed report on the General Assembly has been prepared and can be obtained on request from:

> Dr. A.J. Alcock, Secretary,
> Canadian National IUPAP Liaison Committee
> Institute for Microstructural Sciences
> National Research Council
> Montreal Road, Ottawa,
> Ontario, K1A 0R6

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## *CAP OFFICE/BUREAU DE L'ACP*

**SCIENCE POLICY COMMITTEE -- Call for Members & Issues**
P.S. Vincett, CAP Vice-President Elect

In recent meetings of the CAP Executive and Council, various ideas have been raised for an expanded CAP effort in the lobbying area. It is becoming increasingly apparent that we must make government decision-makers more aware of the concerns of physicists, and of the role that physics can play in achieving national goals: if we do not do it, no-one will do it for us. CAP has been involved for some time in the lobbying activities of the National Consortium of Scientific and Educational Societies, and on a more ad hoc basis has for many years made its own representations to government bodies as issues arose.

The ideas being floated now are in two areas. First, the CAP should play a more active role in the National Consortium, to ensure that the interests of physicists are well represented. Second, the possibility of a more long-term and pro-active lobbying and science policy effort by CAP itself has been raised, perhaps along the lines of the successful activities of the Canadian Federation of Biological Societies.

As one step in ths process, the CAP Science Policy Committee was re-established at the CAP Council meeting on October 16, 1993. An inaugural meeting of interested Councillors and Executive Committee members took place immediately afterwards, with CAP President, Ann McMillan, in the chair. If CAP is to move towards a more active role in the lobbying area, it is essential that the right issues be identified and that any solutions proposed be well researched and thought out. The Science Policy Committee should be a key player in this, in consultation with the membership generally and with the CAP Council and Executive. The present proposal is that the Committee should meet after each Council meeting.

Any CAP member who is interested in serving on the Science Policy Committee, who has an issue that the Committee should consider, or who has any other ideas in this area, is invited to contact Francine Ford at the CAP office.

**Rental Car Discount at AVIS**

AVIS Rent-a-Car has assigned a special AVIS WIZARD NUMBER to "Association Canada - Ottawa" that entitles CAP members to special benefits. When renting an AVIS car, special discounts on Daily, Weekly, and Mini-lease programs are applied at participating locations.

The Avis Worldwide Discount Number (AWD) C855901 is the key to receiving the special discounts. When you reserve, simply quote this number and present the AWD sticker at the time of rental. To request stickers, send your name, address, telephone number and the quantity of stickers required to AVIS's fax (613) 225-3725 -- please refer to AWD number C855901, "Association Canada - Ottawa", and the CAP when requesting your sticker.

**ONTARIO UNIVERSITIES TAKE NOTE --- CAP JOINS IUTS**

Ontario University departments will be pleased to note that the CAP has entered into a contract with the Inter-University Transit System operated through York University for the delivery of mail between the CAP and the Ontario Universities (and others on the system). This service has taken effect 1993 November 1. Our station number is 6B at 151 Slater St.

**1994 RENEWAL PROCESS BEGUN**

The 1994 renewal notices have now been sent to all current CAP members. In addition, the CAP Vice-President Elect has been very active in his efforts to invite non-members to join. As you can see from reading the various articles in this issue, the CAP is quite vigorously undertaking efforts to protect the practice of physicists in Canada.

I encourage you to take a moment to read the enclosed articles carefully and, once you have, I invite you - if you have not already done so - to take a moment and renew your membership with the CAP. If you cannot locate your renewal form, please feel free to use the one printed on the opposite page. We would also welcome applications from your non-member colleagues to help to strengthen the CAP's voice as a representative of Canadian physicists at home and abroad.

Thanks for your support.

**1994 FEE CARD – CARTE DE FICHES 1994**


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University ..........

Course ..........    **Expected date of graduation** ..........

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a) **Full and Affiliate Members***
(To be completed by a member of the CAP to whom the Membership Committee may refer with respect to your qualifications.)

**I hereby certify that to the best of my knowledge the above statements are correct and that the applicant is qualified for membership in the Canadian Association of Physicists.**

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**I hereby certify that the above statements are correct and enclose a cheque for $.......... in payment of my membership fee for the first year, as per the attached fee card.**

.......... Date    .......... Signature of Applicant

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* Application forms may be submitted without sponsorship.
These will be reviewed by the Membership Committee.

# A STATUS REPORT ON THE ACTION OF THE CAP AND OTHER SCIENCE SOCIETIES TO DEFEND THE NATURAL SCIENCE PROFESSIONS IN CANADA

by Peter Kirkby (Chair of the CAP's Committee on Professionalism), Ann C. McMillan (CAP President), J.C. Douglas Milton (CAP Past President), Roger A. Lessard (CAP Vice-President), and Paul S. Vincett (CAP Vice-President Elect)

**SUMMARY**

The Canadian Association of Physicists (CAP) is leading a major effort by natural scientists to stop proposed legislative revisions to engineering acts which could destroy the natural science professions in Canada as we know them. There have been some important initial successes, but much work remains.

The Canadian Council of Professional Engineers (CCPE) has developed a new definition of the practice of professional engineering which encompasses what most physicists and many other natural scientists do. Provincial engineering associations are preparing new engineering acts which would make it illegal for non-engineers to perform such tasks. When the CAP became aware of the situation, the first such act (in BC) was only weeks away from becoming law. The acts could impact virtually all physicists: unless you were a Professional Engineer, it would be illegal to perform almost any activity which involves the use of scientific principles and which impacts economic interests, property, public welfare, or other very broad areas. Directing or managing such activities would also be illegal, unless you were a Professional Engineer. This could directly affect all applied and industrial, and most government, physicists. Since the management of all such technical teams would apparently have to be done by Professional Engineers, the effect on university physics enrollments, and thus on university physics itself, could be profound.

The CAP first mobilized the efforts of the scientific community to deal with the immediate BC problem. The proposed changes there have been stopped for now and efforts are underway to get a broad independent review of the whole topic in BC. Other provinces are being monitored and have been told that the CAP will vigorously oppose the new definition. Nationally, the CAP convened a meeting between seven national scientific societies and the CCPE. The parties agreed to set up a working group, convened by the CAP and the CCPE, to discuss how the engineering definition might be amended. Even if agreement is reached, however, provincial and territorial engineering associations may change their own definition in their acts. The CAP will therefore need to remain heavily involved in this issue for many years.

**INTRODUCTION**

In Canada, there are twelve professional engineering associations; one for each province and territory. Each association has the authority to regulate the local engineering profession and control the local practice of professional engineering. The practices are exclusive, that is, no one may practise without being a member of the association. In Ontario, you could suffer a fine up to $15,000 for a first offense, such as practising professional engineering without a license, and up to $30,000 for subsequent offences.

The Canadian Council of Professional Engineers (CCPE) is the national body coordinating the interests of the professional engineering community, but having no direct regulatory authority. The members of the CCPE are the twelve professional engineering associations. In 1987, the centennial year for engineering in Canada, the CCPE set up a Task Force to look into the future of engineering in Canada. The Task Force issued a report in 1988[1] which provided recommendations on the way in which the practice of engineering should be defined throughout the country. The recommendations included the following:

(a) Encourage the provinces to amend their Professional Engineering Acts by broadening the definition of engineering work to encompass the management and application of technology;

(b) Expand the notion of public protection as a key element of decision-making in the practice of professional engineering to incorporate its social, economic, environmental, cultural, and political ramifications and consequences.

**THE DEFINITION OF PROFESSIONAL ENGINEERING**

As a result of the recommendations by the Task Force, the CCPE established a committee on professional issues to develop a national guideline on the definition of the practice of professional engineering. In 1990, the committee released the following national guideline on the practice of professional engineering[2]:

- any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising, or
- managing any of the foregoing
- that requires the application of engineering principles, and
- that concerns the safeguarding of life, health, property, economic interests, the public welfare, or the environment.

This definition was directed to the autonomous provincial and territorial engineering associations. It should be compared to the Ontario definition introduced in 1984:

- any act of designing, composing, evaluating, advising, reporting, directing or supervising
- wherein the safeguarding of life, health, property or the public welfare is concerned and
- that requires the application of engineering principles, but
- does not include practising as a natural scientist.

The 1984 Ontario definition included a fundamentally new element: the protection of the public interest. Previously it was in the body of the Ontario Act, but not in the practice. However, the definition was flawed, as originally proposed. "Engineering principles" could not be distinguished from "scientific principles". Scientific societies, with the CAP taking a lead role, objected. The CAP put forward the exclusion clause in the practice: "but does not include practising as a natural scientist". This was accepted and has been there since 1984[3-5]. As a result of the situation in Ontario, the CAP set up a Committee on Professionalism, having as one of its duties that of informing the CAP Executive of changes to practices that may infringe on the practice of physicists.

## THE BC ENGINEERING ACT

In the Spring of 1993, a revised practice of professional engineering was introduced in British Columbia based on the new national guideline. The CAP Executive was advised of this by the Chair of the Professionalism Committee in March 1993. A letter was sent promptly by the then CAP President, J.C.D. Milton, to the Minister responsible for the BC Act, expressing concern. The CAP did not know then that the Act has been approved by the BC Cabinet and was about to be put before the BC Parliament.

Other science societies were advised of the CAP's concern and the action taken by the CAP. The Canadian Society of Chemistry, the Statistical Society of Canada, and the Canadian Federation of Biological Societies wrote to the Minister expressing concern. It was not until the second science society wrote that the CAP had a reply from the Minister. The reply, dated 23 June 1993, stated that it was unlikely that the bill would be proceeding during the current Legislative Session.

There was immense pressure on the CAP to meet with the CCPE, and the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). The CAP took the position that the issue went far beyond that of physicists and engineers -- it involved the scientific community; it involved the community of technicians and technologists; and it involved the entire community of employees when "managing" was included in the exclusive practice. It had a direct bearing on the economic interests of the province.

## THE NATIONAL GUIDELINE

The CAP and the CCPE agreed to meet on Sunday, 3 October 1993, in Toronto. The CAP had approached many science societies and invited them to be present at the meeting. Representatives of the science societies met the day before to gain some background on the law covering self-regulation in Canada and address the national guideline on the practice of professional engineering. This led to scientists addressing their concerns over the national guideline and the impact it would have on their own professional identity.

The science representatives identified many problems with the proposed national guideline, and with the way in which engineering acts operate.

- Engineering principles cannot be distinguished from scientific principles, and most work impinges on "economic interests" and the "public welfare". Thus, a large proportion of work in the natural sciences would be illegal unless performed by a Professional Engineer. Even "pure" science could be drastically affected, since the reduced job opportunities could cause science enrollments to plummet.

- The introduction of the "managing" language could require that almost all technical teams be directly managed by an engineer, and that several layers of management above this level be filled with engineers.

- In addition to the obvious natural sciences affected, such as physics, chemistry, biology, etc., most work in disciplines such as statistics, mathematics, meteorology, oceanography, and computer science would be off-limits to non-engineers.

- The exclusion of non-engineers from all engineering activities is in any case not necessary to safeguard the public, and is not done in the US or the UK. Only specific areas of engineering really need to be regulated: consulting work, where there is a direct interaction with the client, and specially-designated areas, where there is a clear need for competency.

- No Professional Engineer could be competent in the totality of engineering, yet every Professional Engineer is licensed to practise in all areas covered by the definition.

- Professional Engineers are not the sole protectors of the public safety in the technical arena.

- Although the reason for providing the sole right to practise is the protection of the public interest, the public at large had no say over the new definition.

There were seven science societies represented at the meeting with the CCPE on 3 October 1993:

1) Association of Chemical Profession of Ontario (ACPO),
2) Canadian Association of Physicists (CAP),
3) Canadian Federation of Biological Societies (CFBS),
4) Canadian Mathematical Society (CMS),
5) Canadian Meteorological and Oceanographic Society (CMOS),
6) Canadian Society of Environmental Biologists (CSEB), and
7) Statistical Society of Canada (SSC).

The Canadian Society for Chemistry (CSC) and the Canadian College of Physicists in Medicine (CCPM) had been at the meeting the previous day, but were unable to be present for the meeting with the CCPE. The CAP invited representatives from the Ontario Association of Certified Engineering Technicians and Technologists. The CCPE took the position that they should not attend as there were continuing discussions with the technicians and technologists. OACETT representatives did not attend.

At the meeting with the CCPE, both groups presented an explanation of their position. The groups agreed that a working group be set up. The first meeting of that group, convened by the CAP and the CCPE, is scheduled for mid-November. Hopefully it will lead to a much more constructive relationship between the parties.

**THE PRESENT SITUATION**

In British Columbia, the first province in which a revised practice based on the national guideline made it to a Cabinet Committee, the new definition of professional engineering would have become law had the CAP not mobilized the scientific community. Pressure from the APEGBC was so great that a revised act was in fact passed, in spite of the CAP being led to believe that it would not proceed. However, a key concession was obtained: the revised definition of the practice of professional engineering was removed and the old one retained.

While this is an encouraging interim outcome in BC, it would appear logical and fundamental that an exclusive practice, addressing the public interest and involving so many groups, should be examined publicly, before it is accepted by any province or territory in Canada. The CAP has been clear throughout that the revised practice was an issue that involved many groups. A proposal to have a broad review in BC was put forward by the Head of the UBC Department of Computer Science, Maria Klawe, by letter on September 4, 1993 to the Premier of BC. The CAP continues to support a broad review, and subsequent to the meeting with the CCPE, the CAP sent a strong letter to the responsible BC minister advocating it.

**WHAT YOU CAN DO TO HELP**

This is a national issue which will be with us for many years. Any of the provinces or territories may, at any time, introduce revisions to the local practice of professional engineering. Both Alberta and Saskatchewan are known to have been considering revised legislation for some time, and Ontario and Quebec are likely to do so before long. The President of the CAP has written letters to all 12 jurisdictions expressing concern over the national guideline and requesting that the CAP be informed of any contemplated changes to their engineering acts, and all have now replied.

Even with this action, it is important to understand that there is no guarantee whatsoever that the CAP will, in fact, be informed of upcoming changes to engineering acts. As this article was being finalized, the CAP found out (via a routine enquiry) that a new Saskatchewan Act, based essentially on the national guideline, had advanced quickly and was now poised to move rapidly towards the legislative process. The CAP had to make representations in less than 24 hours to a key meeting that included cabinet ministers and civil servants. Midnight faxes, however, are not a good way to conduct this kind of businessl

- We need you to keep a close eye on what your provincial or territorial government is doing in this area, so that we have reasonable time to respond.

In addition to monitoring what your provincial or territorial government is doing, what else can you do?

- If you are a physicist at a university, show this article to your Department Head or Dean and encourage them to write to the premiers, as the Dean of Arts and Science and Department Heads in the natural sciences at Queen's University have just done.

- If you are a physicist at work in industry or with the government, ask your senior management to make their concerns known to your provincial or territorial government.

- Whenever you have the chance, show this article to a potential member of the CAP to demonstrate what the CAP is doing for the physics community. We need all the support possible in membership. It helps to have a high membership when we make a position before a legislature. It helps to have the resources, both in finances and ideas. Please do your share. If the CCPE definition of the practice becomes law throughout Canada, the effect on all scientists could be severe.

- We, therefore, suggest that you as well show this report to your fellow scientists and encourage them to join their science society.

The scientific community must assert itself, if it is to survive as a viable entity in Canada.

**REFERENCES**

1. "The Future of Engineering". A special report prepared on behalf of the Canadian Council of Professional Engineers by the Task Force on the future of engineering in association with Employment and Immigration Canada, July 1988.

2. "Professional Engineering Practice in Canada", Canadian Council of Professional Engineers Guideline.

3. "The Ontario Professional Engineers Act", *Physics in Canada*, Vol. 40 (1984), p. 50.

4. "Comments Regarding Bill 123, An act to Revise the Professional Engineers Act", *Physics in Canada*, Vol. 40 (1984), p. 50.

5. "The Professional Status of the Physicist and Other Natural Scientists in Canada", *Physics in Canada*, Vol. 40 (1984), p. 113.

## UNIVERSITY NEWS

**UNIVERSITY OF MANITOBA** Third Year Honours Physics student Melanie Schachter is one of two students chosen by the Youth Sciences Foundation to represent Canada at the most prestigious event for science students in the world. The other was Lucas Skoczkowski of Ottawa. Both are being sponsored by the Natural Sciences and Engineering Research Council of Canada. Held December 4 to 11 in Stockholm, Sweden in conjunction with Nobel Prize Ceremonies, the Stockholm International Youth Science Seminar brings 31 international students between the ages of 19 and 24 years together for eight days of lectures from the Nobel Laureates and from many of the other 300 scientists who participate in the Nobel Ceremonies. As guests of the Swedish government, they will be meeting with the Swedish royal family in private audience as well as attending all the Nobel festivities, including a private cocktail party with this year's Laureates, the Nobel Prize Ceremonies, the Nobel Banquet, and the Nobel Bell.

Melanie was chosen on the basis of her outstanding background and qualifications and on her involvement with the promotion of science to youth. A Grant Park High School graduate, Melanie is one of the founding members of the Winnipeg Chapter of the Young Scientists of Canada, a national youth group that conducts natural science and technology-related extra-curricular activities. The Winnipeg Chapter involves students 14 to 24 years old who meet approximately once a month. Programs include weekend field trips, speakers, and exchanges with other Canadian chapters.

Presently attending university on a $37,000 Women in Engineering and Science National Research Council Canada scholarship, Melanie spent the summer of 1993 doing research at the National Research Council Institute for Marine Dynamics in St. John's Newfoundland. In previous summers she did research at the Canadian Synchrotron Radiation Facility in Stoughton, Wisconsin and at Brookhaven National Laboratory in the Upton, New York. She plans on pursuing a graduate degree in Physics. **(Extracted from a Youth Sciences Bulletin dated Oct. 19, 1993)**

Dr. Bruce Clayman has been named **SIMON FRASER UNIVERSITY**'s acting vice-president, research for the next year, ending August 31, 1994. The position combines Clayman's current duties as dean of graduate studies with those of the vice-president, research. He replaces Dr. Bill Leiss, who resigned from the position. **(Extracted from SFU News dated September 20, 1993)**

Sophisticated. State-of-the-art. Well-designed. These are some of the adjectives used to describe **SIMON FRASER UNIVERSITY**'s newest science building. After five years of planning, design, and construction, the south science building was declared officially open at a ceremony on October 22. The $30.3 million building, which has been in use since March, provides SFU's faculty of science with 10,835 square meters of much-needed space, including more than 40 new labs, 54 support rooms, and 44 new offices. Construction of the building was paid for by the B.C. government. Two generous donations - from MacMillan Bloedel Limited and the estates of George and Ida Halpern - provided funds for equipment and furnishings. **(Extracted from Simon Fraser Week, vol. 57, no. 7, October 21, 1993).**

In an era of cutbacks, during a difficult economy, the significant and wide-ranging benefits of cooperative education have never been clearer or shown more promise of increasing. As a result, during National Co-op Week, (Nov. 1-6), there was cause for celebration at one of Canada's largest, longest-running, and most successful programs. Co-op education, which combines academic study with semesters of full-time paid work, arrived at **SIMON FRASER UNIVERSITY** in 1975, when 15 computing science students began work-study placements. Now offered in more than 40 areas of study, SFU's co-op program ranks as fourth largest in Canada with over 1400 student placements annually. Despite the continuing economic downturn, 1993 placements increased overall, including jumps over 10 percent in engineering science and science, and continuing growth in computing, and arts, SFU's largest faculty. **(Extracted from SFU Feature dated November 3, 1993)**

Two **YORK UNIVERSITY** students successfully defended Ph.D. theses in CRESS and were granted their degrees at the fall, 1993, convocation at York University. Congratulations to: Michael COLLINS, whose thesis was entitled "Response of an Airborne Synthetic Aperture Radar to Sea Ice in the Marginal Ice Zone", and Julian Philip LOWMAN, whose thesis was entitled "Mantle Convection Flow Reversals Due to Continental Collisions".

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## CANADIAN PHYSICISTS / PHYSICIENS CANADIENNE

**Prof. ROGER A. LESSARD**, Director for the Centre for Optics, Photonics, and Lasers (COPL) at Université Laval, as well as the 1992-93 Vice-President of CAP, has received three distinctive honours this year. In 1993 May he was made a Senior Member of the IEEE (only 8% of the over 320,000 IEEE members hold this grade); in 1993 July he was appointed a Fellow in The International Society for Optical Engineering (SPIE); and in October 1993 he was appointed a Fellow in the Optical Society of America (OSA). A dedicated educator, Prof. **Lessard** has served as an academic visitor to the Blacket Laboratory at the Imperial College of Sciences and Technology in London, and as an invited professor at the Department of Precision Instruments at Tiangin University in China. At COPL, he holds one of the most significant positions in optics and electro-optics technology in Canada. Prof. **Lessard** is also active with the Canadian Association of Physicists, the International Union of Pure and Applied Physics, and the Materials Research Society, in addition to SPIE.

Two Trent faculty will be among 18 Ontario professors to be recognized at its first annual Lieutenant Governor's Awards for Teaching Excellence. Lt-Gov. Henry Jackman will present awards to physics professor **AL SLAVIN** and Canadian Studies professor John Wadland at a ceremony

Nov. 10 in toronto. The awards honour outstanding university teachers who are 1992-93 recipients of other national and provincial teaching awards. **Prof. Slavin** was one of 10 professors selected this year as a 3M Teaching Fellow. Selected from 59 nominees from 28 Canadian universities for the prestigious national award, **Prof. Slavin** is the first ever Trent faculty to win the award since it was offered in 1986. **Prof. Slavin** has also received Trent's Symons Teaching Award (1992). In her nomination of him for the 3M fellowship, biologist Christine Maxwell gathered student and faculty testimonials to Prof. Slavin's exceptional teaching, innovative approach, accessibility to students, encouragement of women in science and promotion of science education in the broader community. (Extracted from Trent Fortnightly dated 1993 Sept. 23)

**JIM JURY** (Computer Studies/Physics) and researchers at the Saskatchewan Accelerator Laboratory and the University of Alberta have been awarded a block of accelerator time equal to 500 hours, worth approximately $1 million. (Extracted from Trent Fortnightly dated 1993 October 21)

**Prof. ERIC HESSELS** of the York Physics and Astronomy Department was awarded the John Charles Polanyi Prize for 1993. The John Charles Polanyi Prize is a Province of Ontario fund which is intended to provide 5 prizes annually to outstanding researchers in the early stages of their careers, who are continuing post-doctoral studies at an Ontario University.

Dr. **MARTIN J. ZUCKERMANN**, of the Department of Physics at McGill University was elected a Fellow of the Academy of Science's Mathematical and Physics Sciences Division. (Extracted from Profile, Vol. 3, No. 2, Spring 1993).

Dr. **G. MICHAEL BANCROFT** has been re-elected Director of the Mathematical and Physical Sciences Division of the Academy of Science for a one-year period. (Extracted from Profile, Vol. 3, No. 2, Spring 1993).

Dr. **RICHARD E. TAYLOR** was elected a Foreign Associate of the National Academy of Sciences (USA) in recognition of experiments conducted on the deep inelastic scattering of electrons on protons and neutrons which have been of essential importance in the development of the quark model in particle physics. (Extracted from Profile, Nov. 3, No. 2, Spring 1993).

Dr. **GORDON SHEPHERD** of the ISTS Solar Terrestrial Physics Laboratory (STPL) received the title "Distinguished Research Professor" from York University in ceremonies in July. "Dr. Shepherd is an eminent international scholar whose distinguished work has contributed to the development of auroral physics and studies of Earth's upper atmosphere", according to the York Gazette announcement. His numerous honours include a Killam Fellowship and election as a Fellow to both the Canadian Aeronautics and Space Institute and the Royal Society of Canada. The DRP designation is a lifetime designation, and at York, there are no more than 20 Distinguished Research Professors at any one time. (Extracted from Waves, Vol.4, No.2, July '93).

## CORPORATE MEMBER NEWS

### SPECTRA RESEARCH CORPORATION SIGNS EXCLUSIVE AGREEMENT FOR PHOTONETICS FIBRE OPTIC INSTRUMENTS AND DISTRIBUTION AGREEMENT FOR OPTICAL TABLES

(SRC Press Releases dated 1993 October 14)

**Introduces fibre optic telecommunications products for** research and testing

Spectra Research Corporation (SRC) is pleased to announce a new agreement with Photonetics, Inc., a leading manufacturer of fibre optic components and instruments for the communications industry. Under the terms of the agreement, SRC will be the exclusive Canadian representative for fibre optic telecommunication products from Photonetics.

Photonetics has a strong reputation for innovation and high quality products. With this agreement, SRC is able to expand its product offering to include photonic instruments and devices for the fibre optic telecommunications market. These products include wavelength selective fibre optic couplers and the TUNICS, a wavelength tunable infra-red laser diode. The TUNICS is designed for fibre optic system research and component testing at 1550 nanometers or 1300 nanometers.

Photonetics, Inc. is a subsidiary of Photonetics S.A., a French manufacturer of fibre optic components and instruments. The company is based in Wakefield, MA.

**Vibration isolation systems will complement SRC's** electro-optic products

Spectra Research Corporation (SRC) has recently expanded its product offerings to include optical tables and breadboards for its laser and electro-optic products. In a recent agreement with TMC (Technical Manufacturing Corporation), SRC will act as Canadian distributors for TMC's range of vibration isolation products, components and accessories.

TMC's list of products are counted among the industry's finest and most complete line of vibration isolation products. From small lab tables and table-top platforms to its series of floor and sub-floor platforms, TMC products are designed to keep vibration away from ultra-sensitive processes and experiments.

Established in 1969, TMC is a leading provider of vibration solutions for science and industry. Its exclusive line of table tops and breadboards are considered to be an industry standard around the world. Its customer base includes research facilities, semiconductor manufacturers and OEM suppliers around the world.

Spectra Research Corporation serves as exclusive Canadian distributors for a range of laser and electro-optic products. A subsidiary of Allan Crawford Associates Ltd., Spectra operates from its head office in Mississauga, Ontario. For product information, please contact: Paul Greenwood, Spectra Research Corporation, telephone: (905) 890-0555.

## *CALENDAR / CALENDRIER*

**Fourth International Conference on Improvement of Materials**, 1993 December 1-3. Euro Disney Resort, Paris, France. For further information, please contact: Institute for Industrial Technology Transfer, 94 Promenade A. Ballu, F-93460 Bournay sur Marne. Tel: 33-1-45921771; Fax: 33-1-45929215, Telex: 250303 (Att. IITT).

**2nd Workshop on Neutron Powder Diffraction**, sponsored by CINS, NSERC, and AECL Research, 1994 May 26-27. Chalk River, Ontario, Canada. The Workshop will introduce students to crystal structure refinement by the technique of neutron powder diffraction. It includes formal lectures and "hands-on" work. Fee is $100. For more information, please contact Dr. B.M. Powell, AECL Research, Chalk River Laboratories, Chalk River, Ontario, K0J 1J0. Tel: (613) 584-3311, x 3974; fax: (613) 584-4040, e-mail: BMPOWELL@NVE.CRL.AECL.CA.

**Fifth Global Warming Science and Policy International Conference and Expo (GW5), Symposium on Global Warming and Public Health and Symposium on Energy Resources and Their Impact on the Environment**, 1994 April 4-7. San Francisco, CA, USA. For further information, please contact Dr. Sinyan Shen, The Global Warming International Center, PO Box 5275, Woodridge, IL, 60517 USA. Tel: (708) 910-1551 or (419) 372-8207; Fax: (708) 910-1561.

**12th International Conference on Spectral Line Shapes**, 1994 June 13-17. Toronto, Ontario, Canada. For further information, please contact A.D. May, Physics Department, University of Toronto, Toronto, Ontario, Canada, M5S 1A7. Fax: (416) 978-5848.

**International Conference on Hypernuclear and Strange Particle Physics**, 1994 July 4-8. UBC Campus, Vancouver, B.C., Canada. For more information, please contact: HYP94, TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C., Canada, V6T 2A3. E-mail: HYP94@TRIUMF.CA (internet); ERICH::HYP94 (Hepnet)

**23rd DOE/NRC Nuclear Air Cleaning and Treatment Conference**, 1994 July 25-28. Buffalo, New York. Title, authors, and a 300-500 word abstract summarizing results obtained and significant conclusions from work performed are due by 1994 February 1. Abstracts and inquiries should be sent to the Conference Chairman: Melvin W. First, Sc.D., Harvard University Air Cleaning Lab., 665 Huntington Ave., Boston, MA 02115-9957, U.S.A. Tel: (617)432-1164; fax: (617)432-3349.

**14th International Conference on Atomic Physics**, 1994 July 31 - August 5. Boulder, Colorado. For further information please contact: ICAP-14, JILA, University of Colorado at Boulder, Campus Box 440, Boulder, Colorado, 80309-0440.

**Gordon Conference on Order/Disorder in Solids**, 1994 August 7-12. New London, New Hampshire. Topics will include $C_{60}$ and other disordered solids, including both theory and experiment. For more information, please contact Prof. Mary Anne White, Department of Chemistry, Dalhousie University, Halifax, NS, Canada, B3H 4J3, Tel: (902) 494-3894; Fax: (902) 494-1310; Bitnet: MAWHITE@AC.DAL.CA.

**22nd International Conference on the Physics of Semiconductors**, 1994 August 14-19. Vancouver, B.C., Canada (sponsored by the International Union of Pure and Applied Physics). For more information, please contact: C. Schwerdtfeger, Physics Department, University of British Columbia, Vancouver, B.C., V6T 1Z1. Tel: (604) 822-3853; Fax: (604) 822-5324.

**1994 World Congress on Medical Physics and Biomedical Engineering**, 1994 August 21-24. Rio de Janeiro, Brazil. For further information, please contact Solange Oliveira, Congress Secretariat, Rua do Ouvidor, 60/414, Rio de Janeiro, Brazil, CEP 20040.

**Joint Meeting - DAMOP (APS) / DAMP (CAP)**, 1995 May 17-19. Toronto, Ontario, Canada. For further information, please contact A.D. May, Physics Department, University of Toronto, Toronto, Ontario, Canada, M5S 1A7. Fax: (416) 978-5848.

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**MARK YOUR CALENDARS -- FUTURE CAP CONFERENCES**

**CAP 1994 Annual Congress**, 1994 June 26-29, University of Regina, Saskatchewan.

**CAP 1995 Annual Congress -- 50th Anniversary**, tentative dates, 1995 June 18-21. Université Laval, Quebec.

**CAP 1996 Annual Congress**, tentative dates, 1996 June 16-19. University of Ottawa.

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### 1994 CAP CONGRESS

Deadline for Abstracts -- 1994 March 15

see 1994 January issue of

*Physics in Canada*

for forms and congress information

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## *NEWS / NOUVELLES*

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**Networks of Centres of Excellence Program Funding Extension**
(Extracted from ISC News Release dated 1993 Sept. 7)

The Honourable Rob Nicholson, Minister for Science and Minister responsible for Small Businesses, today provided details on the budget for Phase Two of the Networks of Centres of Excellence (NCE) Program announced August 27 by Prime Minister Kim Campbell. The new four-year budget of $197 million provides for an annual budget matching that of the first phase of the program, namely $240 million over five years.

"The decision to increase the program budget responds to demands from the academic and industrial research communities for continued strong federal support of this innovative and productive program", said Mr. Nicholson. "In a time of fiscal restraint, the decision to maintain NCE funding levels illustrates the government's commitment to make the investments in research and development that will position Canada to compete successfully in the 21st century".

Phase one of the program has funded 15 networks carrying out long-term applied research and technology transfer in the natural, health, and social sciences and engineering. It is anticipated that the Phase two funding levels will allow support for some new networks. The existing networks were invited to submit proposals for renewal by October 29, 1993. In a rigorous competitive process, they will be ranked by a selection committee on the basis of their progress to date and the soundness of their strategic research and business plans. A decision on which networks are to be renewed will be made in early 1994. The recommendations of the selection committee will be made public at that time.

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**A Canada-Wide Electronic Learning Network Highlights National Science and Technology Week**
(Extracted from ISC News Release dated October 15, 1993)

Science Minister Rob Nicholson and Fisheries Minister Ross Reid launched Canada-wide activities for the fourth annual National Science and Technology Week by demonstrating *SchoolNet*, a cooperative federal-provincial-territorial initiative which will not only link 300 technology-intensive schools across Canada in its start-up phase, but also provide access to a wealth of national and international education resources.

This computer network will provide students and teachers with access to Canadian and international databases, advice from more than 350 scientists and engineers worldwide, and innovative electronically-based projects. *SchoolNet* presents a tremendous opportunity for collaboration throughout Canada, especially by students and teachers in rural and isolated locations.

*SchoolNet*'s major partners include provincial and territorial ministries of education, Canadian universities and colleges, CA*net Networking Inc., STENTOR, Sun Microsystems of Canada Ltd., Apple Canada Ltd., *The Globe and Mail*, Southam News, and CANARIE Inc. *SchoolNet* will create new market opportunities for innovative electronic products and services, especially as it eventually expands to encompass all of Canada's 16,000-plus schools.

National Science and Technology Week and *SchoolNet* are just two components of the federal government's year-round science and technology promotion efforts. Others include the Canada Scholarships Program, Science Culture Canada, Innovators in the Schools, Computers for Schools, and the Prime Minister's Awards for Teaching Excellence in Science, Technology, and Mathematics.

For further information, please contact Industry and Science Canada at (613) 995-8900, ext. 265, or by fax at (613) 952-9620.

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**CISTI Enters New Era in Electronic Document Delivery**
(Extracted from NRC News Release dated Sept. 28, 1993)

The Canada Institute for Scientific and Technical Information (CISTI) has awarded a contract to Network Support Inc. to develop an innovative system for electronic document delivery. Over the next six months, CISTI's photocopy operations will be replaced with workstations that will give clients the option of receiving documents in various ways.

Documents from CISTI's collection of scientific and technical information, one of the largest of its kind in the world, can be scanned for transmission from CISTI directly to a client. The development of this system places CISTI in the vanguard of document delivery technology. The system has certain contemporary features that will greatly enhance efficiency and productivity. For example:

- regardless of how a client wants to receive a document the system can automatically supply the document in the manner requested;

- as the document is scanned into the system, staff can view the document to ensure legibility.

There are three major software packages. The first manages the orders and their associated documents. This enables clients to receive a status report on their requests. The second program allows the scanned images to be manipulated. For example, pages can be inserted or deleted as needed. The third program manages the workflow. It will also produce statistical reports that will help CISTI monitor the efficiency of the workflow.

To support the operation of the electronic document delivery workstation, CISTI will use its existing call-numbering program that computer matches orders against the online catalogue to provide shelf locations. CISTI is also developing a client information file so orders can be matched against the client's address, billing instructions, preferred method of receiving a document, and other requirements. The system will also be able to track copyright information and related fees.

This system launches CISTI into the age of electronic document distribution and sets the stage for future developments. In time, CISTI will have a system which can receive a document order, process it, and send it without any human intervention.

For more information, please contact Clare MacKeigan, Assistant Manager, Document Delivery Service, CISTI, National Research Council Canada, Building M-55, Montreal Road, Ottawa, ON, K1A 0S2. Tel: (613) 993-7055, fax: (613) 952-8243; Internet: clare.mackeigan@nrc.ca.

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**Canada to Host 1997 International Chemistry and Physics Olympiads**

Canada's bid to host both the International Chemistry and Physics Olympiads for 1997 has been accepted, with host sites of Sudbury, Ontario and St. Jean, Quebec. These are exciting, large scale projects which will allow for a good deal of prestige and visibility for our sponsors. Students and support staff from 50 nations will be coming to Canada and it will be The Canadian Chemistry & Physics Olympaid organization's responsibility, with the participation of Laurentian University, Science North, Collège Militaire Royal, Bishop's University and local communities, to show Canada off at its best, to expose the gathering to Canadian Science and to run a fair and probing academic competition.

Inco Limited has already confirmed its role as a principal sponsor for the International Physics Olympiad to be held in Sudbury. Any other parties interested in participating/sponsoring this exciting event, or finding out more about it, should contact Dr. John Wylie, Director, Canadian Chemistry and Physics Olympiad, 306 Lawrence Avenue East, Toronto, ON, M4N 1T7, Tel: (416) 484-6533, ext. 249; fax: (416) 488-3090.

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**1993 Manning Awards Recognize Ten Canadian Innovators**
(From Manning Awards News Release dated Sept. 22)

The environment is the beneficiary of outstanding work by two Canadian innovators. Ms. Dusanka Filipovic of Toronto, Ontario received the 1993 Manning Principal Award ($100,000) and Dr. David Schindler of Edmonton, Alberta was the recipient of the 1993 Award of Distinction ($25,000). Two other Canadian innovation leaders and six outstanding young Canadian innovators also were honoured.

*Dusanka Filipovic*, an engineer, has developed and patented what has become known as the "Blue Bottle" technology, which eliminates emissions of CFCs from equipment being repaired or abandoned.

Working in a "wilderness laboratory" setting, *Dr. Schindler* and his group did definitive, large-scale "whole lake" experiments that have had enormous global significance. Dr. Schindler's work is considered to be largely responsible for the banning of phosphates in detergents. His efforts have also been influential in shaping legislation controlling sulphur dioxide emissions into the atmosphere in many countries.

Fred Dimmick of Parry Sound, Ontario and Yves Potvin of Vancouver, B.C. are 1993 recipients of the $5,000 innovation awards. *Fred Dimmick*'s patented illuminated signs are reliable, energy efficient, simple and highly effective. Combining list-emitting diodes, fibre optics and tough acrylic lenses, the signs consume little energy, have no light bulbs to burn out, and are virtually maintenance free. *Yves Potvin*, a professional chef, started his own company and is now marketing a very successful line of meatless hot dogs and burgers which contain no cholesterol, low saturated fat, and no preservatives.

The "cream of the crop" in a competition with 500,000 entrants is very special. That is certainly the case with the four winners of the $2,000 Young Canadian Innovation Awards for 1993. Chosen in conjunction with their participation in the National Science Fair program, their achievements are outstanding. Winners for 1993 were *Nathan Litke*, St. Catharines, ON (painting by computer); *Samir Gupta* and *Denis Tsui*, Montreal, QC (fibre-optic biosensor for cell monitoring); *Holly Pekau*, Calgary, AB (bioinorganic tracers); and *Francois Bouffard* and *Dany Theriault*, Levis, QC (plastic film electrostatic parabolic mirror). In acknowledging the quality of one of these projects, a university professor noted "I would accept that for a Masters Degree presentation!"

For further information contact Frank Stewart, Executive Director, The Manning Awards, (403) 266-7571.

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**NSERC Stategy Document**

NSERC is in the process of defining its strategic direction for the next five years. The CAP Office has received a copy of the statement of the direction that NSERC Council approved at its last meeting in October and intends to follow during this period. A more detailed operational plan for NSERC's activities will be prepared after the new strategy has been formally approved by NSERC Council in January. Comments on the draft statement of direction are currently being solicited from the university community (by December 10). Anyone wishing a copy of this document, in English or French, can contact the CAP Office, or NSERC's Steve Shugar (Director, Policy, Planning and Evaluation) or Catherine Wilson (Senior Planning Analyst) at (613) 995-6449.

# CANADA AT THE XXIV INTERNATIONAL PHYSICS OLYMPIAD

by J. Wylie, Canadian Chemistry & Physics Olympiad

Canada won an unprecedented three bronze medals at the XXIV International Physics Olympiad held in Williamsburg, Virginia in the United States. Robert Kry, Xiao Dong Yang, and Jurgen Hissen all won bronze medals and Paul Tupper won an honourable mention award as well. Canadian teams have never won three medals before and never have four students taken home awards. In addition, the 1993 team totalled the highest Canadian team score since starting participation in 1985.

Forty-one countries took part in the XXIV IphO which was held from July 10-18 at the College of William and Mary in Williamsburg. The American Physical Society and the American Association of Physics Teachers in cooperation with the College put on a fine show for the nearly 200 top physics students from around the world. In the end, top honours and gold medals went to two students from Germany and China. These students scored an impressive 80% on ten hours of examinations on both theoretical and laboratory problems.

The Canadian Team was composed of four students from Western Canada; Paul Tupper and Ari Benbasat of Vancouver and Jurgen Hissen from Victoria represented British Columbia and Robery Kry was from Calgary, Alberta. The fifth team member was Xiao Dong Yang from Toronto, Ontario. Xiao Dong is thrilled to see his Olympiad dream come true as he once tried for the Chinese Olympiad Team before coming to Canada.

The Canadian program starts each fall when every high school in the country is sent a poster and information. Participating students take part in one of a number of provincial programs working on problems throughout the year and many attend a Provincial Final where, in addition to talks, tours, and laboratory exercises, a National Selection Exam is written. On the basis of this Exam, written by all Olympiad hopefuls across Canada, 20 of the top students are invited to the National Olympiad Finals. Paul Tupper is the "old man" of the Canadian program having attended four B.C. Provincials, three Canadian Nationals and two International Olympiads, winning a bronze medal in the 1992 Finnish competition.

The 1993 Canadian National Olympiad Final was held during the last week in May at Memorial University of Newfoundland in St. John's, North America's oldest town. The Finals are an intensive week of advanced training in which students are examined on world class Olympiad problems, both theoretical and experimental. The five member Canadian Team is chosen at the end of this week. Just for fun, some of the students were challenged to estimate the mass of the iceberg still in the St. John's harbour. Amongst their non-academic activities were a cruise to a North Atlantic island bird sanctuary, a visit to Cape Spear (the eastern most point in North America) and a climb up Signal Hill where the first transatlantic radio signal was sent.

The International Olympiad gave the students an exciting schedule of tours and events including visits to NASA at Langley, the Continuous Electron Beam Accelerator Facility in Newport News and Busch Gardens theme park near Williamsburg. At this event, the park opened early to allow the 200 students to perform experiments while riding the three impressive roller coasters on the site. A Canadian, Ari Benbasat, distinguished himself by winning an Amusement Park Physics contest analyzing the dynamics of the Big Bad Wolf suspended coaster. Of course, visits to the site of colonial Williamsburg were a highlight of the week.

The Canadian Chemistry and Physics Olympiad organization is looking forward to 1997 when it will be hosting both the International Physics and Chemistry Olympiads. This will be the first time that both events will be held in the same country simultaneously. The 28th International Physics Olympiad will be held at Laurentian University in conjunction with Science North, both of Sudbury, Ontario. Participants from perhaps 50 nations will be treated to the beauty and geology of the Canadian Shield, and a visit to the Sudbury Neutrino Observatory 2km underground. These projects represent a significant fundraising challenge and the Canadian organization is looking for eager corporate partners willing to share in the funding and planning for 1997. Inco Limited has already committed itself to the Sudbury Olympiad with a very generous donation.

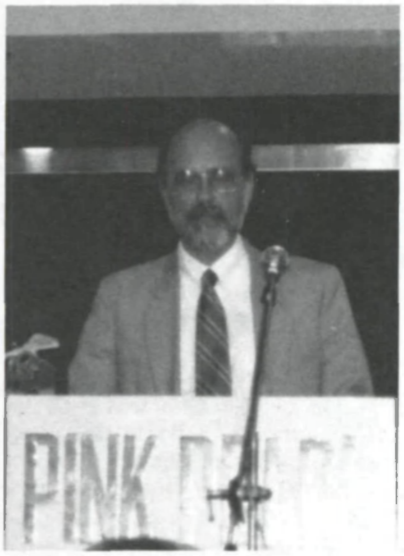
The Olympiads in Canada were founded by The Toronto French School and the principal sponsors are Inco Limited, Merck Frosst Canada, and the Natural Sciences and Engineering Research Council of Canada. The Canadian Olympiad program is supported by: The Governments of Quebec, Ontario and British Columbia, Imperial Oil, Dow Chemical, Bell Canada, Du Pont Canada, Shell Canada, Bombardier Inc., Celanese Canada, Ciba Geigy Canada, The Boland Foundation, the McLean Foundation, Investors Group, The Royal Bank of Canada, AECL Research, Canadian Society for Chemistry, and the Canadian Association of Physicists. The Olympiad also recognizes the University of British Columbia, University of Manitoba, University of Toronto, McGill University, The Royal Military College, Bishop's University, Dalhousie University, and Memorial University of Newfoundland for their work in training and selecting students for the program.

1993 Canadian Physics Olympiad Team: Ari Benbasat of St. George's School, Vancouver (teacher - Robert Bacon); Paul Tupper of Point Grey Secondary School in Vancouver (teacher - Axel Kellner); Robert Kry of Western Canada High School (teacher - B. Head); Jurgen Hissen of Stelly's Secondary School of Saanichton, B.C. (teacher - Lionel Sandner); Xiao Dong Wang of Harbord C.I. in Toronto (teacher - T. Jutcovich).

# 1993 CAP AWARDS

## 1993 CAP MEDAL OF ACHIEVEMENT TO DR. WALTER N. HARDY

by B. Turrell




The CAP Medal for Achievement in Physics for 1993 is awarded to Dr. Walter N. Hardy of the University of British Columbia.

It is a very great pleasure to make this nomination address for the CAP Medal of Achievement. The Medal is awarded on the basis of distinguished service to physics over an extended period of time and/or recent outstanding achievement.

Walter Hardy's scientific contributions satisfy both these criteria.

When I first arrived at UBC in 1964, Walter had just completed his doctoral thesis under the supervision of Myer Bloom, and he and his wife Sheila, and their two young boys, were just leaving for France where Walter was to spend two years as a Postdoctoral Fellow working with A. Abragram at Saclay. It was clear to me at that time that the people at UBC had a great respect for Walter's talents and they expected great things from him: they have not been disappointed.

He returned to North America to work with the Spectroscopy Group at the North American Rockwell Science Centre. During the next five years George Volkoff and Myer Bloom orchestrated several attempts to recruit Walter. They were eventually successful and he returned to UBC in 1971 as Associate Professor. He was promoted to Professor in 1976 and has won many prizes and Fellowships including the Herzberg Medal (1978), the Steacie Prize (1978), a Canada Council Senior Killam Fellowship (1984-86), and the B.C. Science & Engineering Gold Medal in Natural Sciences (1989). He was one of the youngest people ever elected to the Royal Society of Canada in 1980. He is an Associate Member of the Canadian Institute for Advanced Research Superconductivity Program.

The point is that Walter, like his mentor, Myer Bloom, is versatile. He is the complete scientist: innovative, talented and hard-working, who investigates important problems and is ready to meet challenging new ones. Among the areas that Walter has made very significant contributions are: NMR in hydrogen and other gases; studies of solid hydrogen, including measuring the Raman spectra of $H_2$ and $D_2$ leading to an understanding of the orientationally ordered state in these systems and, later, measuring the ortho-$H_2$ pair spectrum; the dielectric properties of organic conductors; investigations of atomic hydrogen at low temperatures; orientation of $H_2$ at low temperatures; the cold hydrogen maser which was developed into the world's most accurate clock; and high temperature superconductivity, his current subject of interest. Here his contributions have included crystal preparation, measurements of electronic properties, and muon studies. We heard during the Congress today how recent studies by his group are giving important information on the nature of the ground state in the cuprate superconductors.

He is a great teacher who leads by example. His graduate students emerge as first-class physicists, and a number of them have gone on to carry on the tradition as faculty members at other universities.

Walter's talents do not stop at science. He, like Sheila, is an accomplished pianist and appreciates music greatly; he enjoys gardening; he likes sports and, until age and injury caught up, was a good soccer player. (I speak with some authority here because in the Seventies we both played on the same team which enjoyed modest success including, on one occasion, reaching the semi-final of the Province Cup.) Actually, his graduate students are relieved that he has these other interests; otherwise they would spend seven days and nights per week in the lab rather than six.

I know that Walter's many friends in Canada and abroad, who share my great respect for him, will join me in congratulating him for winning the Medal of Achievement.

### RESPONSE BY WALTER N. HARDY

It is an honour to be awarded the CAP Medal of Achievement, and it is a particular pleasure to receive it in my home town. Both the site of the conference and the location of this banquet [Pink Pearl Restaurant in Vancouver] bring back special memories - the top of Burnaby Mountain was part of my rather extended playground as a boy, and the building where we are having this wonderful meal was an important landmark: it was the site of National Dairies, which served the best ice cream in town. I might add that my mother was born only a few blocks away from where I stand.

On an occasion like this, it is entirely appropriate to acknowledge some of the people that have helped me in my career. George Volkoff, who is present tonight, gave crucial encouragement when I was having doubts about my ability to function as a physicist. Myer Bloom, my thesis supervisor, longtime colleague, and friend, was and remains a source of inspiration through his love of physics, pubs, chinese restaurants, Paris, and life in general. I do not know the details, but it is said that George and Myer conspired to bring me back to UBC as a faculty member - and I am extremely grateful for that. Anatole Abragram, in whose group I did my post doc, was an important influence in my career, as was Maurice Pryce, who at an important time offered both moral and material support.

To the many wonderful colleagues and collaborators with whom I have worked, and especially to all of the students and post-docs who have worked in my lab, please accept my thanks for all you have contributed. You all own a piece of this award.

Most recently in High Temperature Superconductivity years, trying years I would say, there has been much collaborative work with such people as Ian Affleck, Jess Brewer, Rob Kiefl, Philip Stamp, David Williams, and others at UBC, Chuck Irwin and others at SFU, John Berlinsky, Catherine Kallin, Tom Timusk and others at McMaster, Bryan Statt at Toronto, etc.

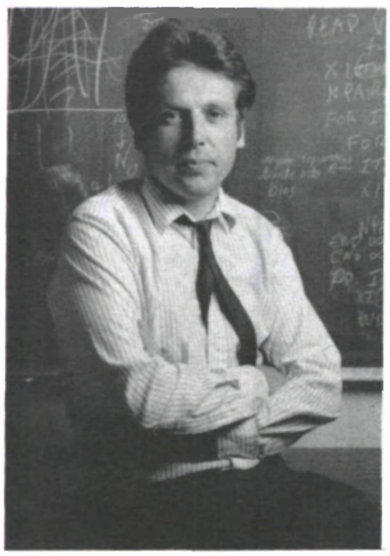
There are two people, however, who deserve special mention: Doug Bonn, who has carried the greatest load in the microwave work, and Ruixing Liang who grows the wonderful crystals we have all studied. This is also the place to acknowledge that without the support of Fraser Mustard's amazing creation - the Canadian Institute for Advanced Research - the HiTc effort at UBC would never have gotten off the ground.

Finally, I would like to thank my family and especially my wife, Sheila, for putting up with a physicist's hours and habits for so many years.

In closing, I express my thanks and sympathy to Brian Turrell and whoever else was involved in the nomination for this award, and to the CAP.

## 1992 HERZBERG MEDAL TO NICHOLAS KAISER

by S. Tremaine
(read by B. Unruh in Dr. Tremaine's absence)



Nick Kaiser was born in Britain in 1954. He received his Ph.D. from Cambridge in 1982 under the supervision of Martin Rees, then went on to postdoctoral work at Berkeley, with shorter periods at the Institute for Theoretical Physics in Santa Barbara and the University of Sussex. He returned to Cambridge, where he was awarded a prestigious SERC 5 year Advanced Fellowship, and remained there until we were able to attract him to the Canadian Institute for Theoretical Astrophysics at the University of Toronto in 1987. His career has continued to flourish since then: he was named a Fellow in the Cosmology Program of the Canadian Institute for Advanced Research in 1988; received the Warner Prize of the American Astronomical Society for significant contributions to theoretical astronomy in 1989 (the first time this has been awarded to a scientist working in Canada); and was awarded an E.W.R. Steacie Memorial Fellowship by NSERC in 1991.

Nick's research concentrates on physical cosmology and the origin of large-scale structure in the Universe. He has investigated the consequences of a variety of candidate theories for structure formation, including cosmic strings, massive neutrinos, and cold dark matter. He has stressed the importance of cold dark matter scenarios because they make a wide variety of testable predictions, and has been one of the leading participants in the program of comparing the predictions of cold dark matter model with observations.

Nick burst into prominence in cosmological research with an influential paper, written while he was still a postdoctoral fellow, which suggested that one might identify rich clusters of galaxies with high-density regions in the primordial density field. He showed that this simple and natural hypothesis predicted that clustering of the clusters would then be considerably enhanced over that of the mass field, in agreement with an otherwise puzzling observation. This bold suggestion has led to the concept of biased galaxy formation (galaxies are more likely to form in high-density regions), which is the most promising way at present to reconcile the low densities implied by dynamical measurements of clusters with the high densities predicted by inflationary models of the Universe.

Since then his interests have spanned many of the most active research areas in physical cosmology, including statistical techniques for data analysis, the theory of Gaussian random processes as models for primordial fluctuations, gravitational lenses, and the anisotropy of the microwave background. He has even taken and analyzed data, at the Canada-France-Hawaii Telescope and other instruments, to study gravitational lensing in clusters of galaxies and to map out the large-scale distribution of galaxies. Results from the latter survey, which were reported in the front page of the *New York Times*, indicate that there is too much large-scale power in the density fluctuations for standard models of structure formation to explain, and have contributed to the growing sense that radical new models may be required to explain how structure formed in the Universe.

He has taken a leading role in developing cosmology in Canada, not only by bringing in visitors and postdoctoral fellows, but also through interactions with his colleagues in the Canadian Institute for Advanced Research and at many universities. He has been an influential advocate and organizer of a coordinated Canadian campaign to survey rich clusters of galaxies, which testifies to the respect in which he is held by his observational colleagues.

Nick Kaiser is one of the most accomplished and original physicists working at the border between theory and observation in physical cosmology, and I am delighted that his contributions have been recognized by the award of the Herzberg Medal.

**RESPONSE BY NICK KAISER**

It is a great honour indeed to be awarded the Herzberg Medal. I would like to take this opportunity to express my gratitude and appreciation to some of the people who have influenced my career in astrophysics.

The earliest influence must have been my father Tom. Originally trained in chemistry, he moved, via research on radar during the war, into ionospheric physics, setting up a highly successful group at Sheffield, which is where I grew up. I remember how often, during a meal, Tom's attention would wander and he would sit there obviously pondering some deep physical problem and complete oblivious to what was going on around him. This naturally annoyed my mother Pam greatly, but we all realized that this was part of what living with a physicist entailed. I have fond memories of being taken as a lad into the physics lab at weekends and marvelling at the beautiful brass instruments in polished wood and glass cases which lined the corridors. I also remember impromptu demonstrations such as Tom holding his fingers up to the HT leads leading to some enormous vacuum tube and getting a discharge some centimetres in length - luckily the capacity of the power supply was limited!

As a teen I worked a couple of summers helping out in his lab, and was thus able to see at first hand what research was like. I particularly recall the tedium of punching cards and taking the deck across campus to the computing centre only to discover on retrieving the output several hours later that the program failed to compile or crashed because of some trivial error. Amazingly, this frustrating experience did not deter me from science. It is a tribute to the progress of computing technology that I can now experience the same frustration not once but hundreds of times in a single day!

The next vital, though somewhat accidental, influence came from David Williams, the brother of a close friend of mine. At the time I was dropping out of a course at art school (where I had rapidly discovered I had little or no artistic talent) and David was dropping out of undergraduate physics in order to pursue a career in music. He gave me some of his textbooks. Most of these were utterly boring, but one I fell in love with; it was Volume 1 of Feynman's Lectures on Physics. While much of this was beyond me, Feynman's obvious love for the subject came through clearly, and gave me an inkling of what it was that had so mesmerised my father at mealtimes. This encouraged me to go back to college, this time to take the A-level (metriculation) courses in physics and maths.

At Leeds, where I took my B.Sc., the strongest influence was my supervisor, Professor Dugdale. He was a very sympathetic person - I recall him lending me his sweater one day when I turned up for his tutorial with a stinking cold (quite remarkable considering my level of personal hygiene in those days) - and he did me a great service by lending me books such as Lanczos' monograph on the variational principle. This permitted me a glimpse of what lay beyond the rather limited perspective on theoretical physics allowed by a UK undergraduate course. He also tried to deter me from applying to take the Part III Maths Tripos at Cambridge. Unfortunately for me, he was unsuccessful, and it took me a couple of years to recover from the blow my ego suffered from doing rather poorly on this course.

My dreams of doing elementary particle physics shattered, I was luckily rescued by Martin Rees at the Institute for Astronomy who took me on as a Ph.D. student, and to whom I owe my greatest debt. While the extensive phenomenology and acronym dominated world of astronomy was almost as bewildering as the tensor index jungle of Part III, Martin judiciously selected a project for me where I could become master of a tiny piece of astrophysics and, thus encouraged, proceed to slowly explore the wider territories of the subject. His guidance also served me well in the scary first years of independence as a post-doc at Berkeley, where the euphoria of an 'original' discovery was always followed by a humbling realisation along the lines of "Ah, so *that* is what Martin was trying to explain!" Another important influence at Cambridge was Bernard Jones, whose boundless supply of enthusiasm more than once buoyed me up when I was feeling inadequate.

Finally, I would like to express my appreciation to Fraser Mustard of the Canadian Institute for Advanced Research and Bill Unruh, the director of the CIAR Cosmology Programme. Thanks to them, I joined the programme as an Associate while still a postdoc in Cambridge. This proved very helpful for collaboration with programme members and eventually led to my coming to Toronto to take up a CIAR supported position at the Canadian Institute for Theoretical Astrophysics. As well as allowing me to come to CITA, which has proved highly beneficial to my career, the support of CIAR has been invaluable in many ways, and especially in our efforts to attract exceptional people and keep them in the programme.

# 1993 CAP MEDAL FOR OUTSTANDING ACHIEVEMENT FOR INDUSTRIAL AND APPLIED PHYSICS TO JACQUES J.A. BEAULIEU

by J. Gilbert, DREV
(read by R.D. Stuart, DRES in Dr. Gilbert's absence)

The first indication that high power output and efficiency could be attained in a gas laser came with the discovery of laser action in carbon dioxide ($CO_2$) by Patel at Bells Labs (USA) in 1964. However, the power output of these conventional $CO_2$ lasers was very low compared to the power output available from solid state lasers because a gas lasing medium has a much lower concentration of active particles than a solid medium.
In the early versions, the $CO_2$ laser used a gas discharge tube of small diameter excited longitudinally and operated at pressure levels close to one hundredth of the atmospheric pressure. Therefore, the power capability of the laser was roughly proportional to its length and its operating pressure. While the laser community was highly motivated by the prospect of developing high pressure gas discharges, the technological problems seemed unsurmountable at the time and the only way to higher power was to make longer tubes.

The technique proposed by Jacques Beaulieu solved all these problems and was indeed the first to allow laser operation up to atmospheric pressure. The breakthrough was made possible by the development of a pulsed discharge scheme providing uniform excitation transverse to the laser tube axis instead of along its length, hence the name transversely excited atmospheric (TEA). The original configuration used by Dr. Beaulieu consisted in a multi-pin linear electrode array simultaneously producing a series of glow discharges transverse to the optical axis of the laser cavity. This first operating device produced short laser pulses showing an improvement in peak power of at least two orders of magnitude over existing technologies.

Dr. Beaulieu originally conceived of the $CO_2$ laser some three years before actually disclosing it in the open literature (Applied Physics Letters, June 70). The initial series of tests demonstrating the validity of the approach were carried out at the Defence Research Establishment, Valcartier (DREV) during late 1967 and early 1968, thus predating by some three years the work done in UK, US and France. Since this formed a new class of high-power lasers with major potential military applications such as for laser radars and for driving nuclear fusion reactions, the initial phase of its development was kept under security wrap and could not be declassified until 1970. Prior to the public disclosure of the invention, the DREV laser team under Dr. Beaulieu's leadership made further important progress in the physics underlying the kinetic processes and the excitation mechanisms within the laser. These efforts led to the development of the first high-repetition rate TEA laser using a high-speed rapid transverse gas flow to achieve high average power and opened up a host of new possibilities for industrial applications. The double-discharge concept or three-electrode system was similarly demonstrated for the first time. This important refinement permitted the production of uniform discharges throughout large volumes at atmospheric pressure and the realization of high-energy TEA laser output with good optical beam quality.

When it was disclosed in 1970, the great scientific and commercial value of the TEA laser concept was quickly recognized by industrial agencies. The initial DREV research program headed by Dr. Beaulieu has led to 25 inventions for which 60 patents were issued in 15 different countries. Fourteen companies applied for a licence to develop and market these inventions. In 1970, licenses were awarded to two Canadian companies, Gen-Tec Inc. and Lumonics Research Limited, for the exploitation of Dr. Beaulieu's patents.

While the TEA laser was of critical importance for the advancement of $CO_2$ laser technology, the term TEA has since become attached to several types of gas lasers. It was a forerunner of the excimer laser emitting ultraviolet light and served as an essential catalyst to Lumonics' research and development in the field. Lumonics is currently a major supplier of TEA lasers for use in materials processing and marking as well as for use in scientific and medical applications.

In summary, it is clear that Dr. Beaulieu's contribution to Canadian laser physics was historic and immense. His insightful and creative work has not only placed Canada at the forefront of the laser research field, but it has also laid the foundation for the growth of a major Canadian laser industry that has since turned out to be a multinational giant and a vital component of Canada's high technology base.

## RESPONSE BY JACQUES J.A. BEAULIEU

To go from an applied research study to the development of a successful industrial product is seldom the responsibility of a single man. For the TEA laser development, which is being recognized by this medal, I may have been the instigator of the technology and directed the first phase of the development, but the honours of a successful industrial development must be shred with others who have played essential roles in this development.

First, I would like to mention the constant support of the Defence Research Establishment, Valcartier (DREV) for this and other research activities I was able to carry out over the 35 years I have worked for Defence Research. I must also mention the dedication of many DREV scientists and technicians who have worked with me to make this development a success. The development of the TEA Laser is an excellent example of a Defence applied research program whose military benefits are surpassed by its commercial and economic fall-outs.

However, a key factor in the success of an industrial development is the industry which has to take a prototype and develop it into a finished product meeting the requirements of potential users. The role of Lumonics, a company that was created explicitly to develop the laboratory prototypes of the TEA $CO_2$ laser into commercial products, has been crucial to the industrial success of the laser technology.

This company has made all the necessary efforts to provide a high-quality product, pursue the development of the basic technology, and apply it to other types of lasers. It has also made substantial efforts in the development of scientific and commercial applications of the laser technology, to the point of becoming one of the most important laser manufacturers in the world.

I consider myself very fortunate to have been able to work in an environment so favourable to Applied Physics research and in cooperation with an industry that has made a commercial success out of some of my research products.

## 1993 LLOYD G. ELLIOTT PRIZE (University Prize Examination)

The 1993 Lloyd G. Elliott prize was awarded to N. Arbani-Hamed of the University of Toronto. His award consisted of a $600 cash prize, an all-expense trip to the 1993 Congress held at Burnaby, B.C., and a complimentary ticket to the CAP Banquet held during the Congress, where Mr. Arbani-Hamed was presented with is cheque.

## CAP AWARDS AT THE 1993 CANADA-WIDE SCIENCE FAIR - Rivière-du-Loup, Québec

The 32nd Annual Canada-Wide Science Fair, held 1993 May 16-23 in Rivière-du-Loup, Québec, was a fair with spirit. The friendly atmosphere, the beautiful scenery, the whale watching, the imaginative activities, not forgetting the scientific essence, were the ingredients that made this fair a success. A record 106 regions from across Canada were represented by 399 students, who displayed 299 projects. In addition, over 521 volunteers, including judges, officials, and science fair representatives from across Canada participated in this important national event. Over $100,000 in cash and prizes was given away to many grateful students for their outstanding science fair projects. The CAP donated three awards of $250 for projects related to physics in three categories: junior, intermediate, and senior.

*Front row, L-R: Heather Cameron, Guillaume Fauteux, Philippe Savard*
*Back row, L-R: Matthew Galloway, Neil Pengelly, and Roger A. Lessard (award presenter)*

In the junior physical sciences category, Heather Cameron of Wolfville Junior High in Wolfville, Nova Scotia received her award for a project entitled "Crypto-Light". The purposes of her project were to make an ultraviolet (UV) photometer, standardize and calibrate her photometer, look for UV in ordinary lamps and flashlights, and take readings to study UV variations in sunlight. Conclusions: Her major conclusions for February and March 1993 were: UV was highest on sunny days from 8:30 AM to 3 PM, clouds blocked 72% of UV, glass windows blocked 43% UV, and the average UV in sunlight was 6.1%. The highest UV reached 26.3% on March 20 when the highest total sunlight readings also occurred. These unusually high values may have been due to a solar flare.

Guillaume Fauteux and Philippe Savard of Outremont, Québec paired together to win the CAP's award in the intermediate category for their project entitled "Vague ... Abondage". Hypothèse: L'hiver, un panache de rivière sous glace prend beaucoup d'expansion; il ne se mélange pas autant que l'été. Comme les vagues ne circulent plus dans un estuaire d'eau gelée, nous avons pensée que celles-ci pouvaient être responsables du mélange d'un panache, ou du moins d'une partie du mélange. Conclusions: À la suite de plusieurs analyses mathématiques, nous avons pu conclure que les vagues ne jouaient qu'un rôle négligeable dans le mélange d'un panache de rivière. Cependant, d'intéressantes observations nous ont inspiré de nouvelles hypothèses.

Finally, "Fractal Geometry of Two-Dimensional Fluid Dynamics" by Neil Pengelly and Matthew Galloway of Mayfield Seconday School in Ontario won the senior category prize. The purposes of their project were to product fractal patterns called "viscous fingering" in a Hele-Shaw cell and to analyze the pattern's characteristics to find ways to predict the outcome of specific trials. After completing extensive experimentation and analysis of their trails, they reached the conclusion that the patterns they observed were indeed fractally based. They also concluded that, although these patterns are chaotic in exact shape and form, they are influenced by several different parameters that can be changed to produce a desired effect. These parameters can be placed into three categories: Velocity of injected fluid, surface tension at interface, and proportions of Hele-Shaw cell.

The winners were provided with CAP plaques as well as the cheques presented at the Fair. Dr. Roger Lessard (CAP Vice-President Elect at the time) did the honours. Many thanks to Mr. Bernard Drouin of CEGEP F.-X Garneau, Dr. René Beaulieu of CEGEP La Pocatière, and Dr. Lessard of Université Laval who graciously accepted the challenge of being judges for this year's Fair.

### *Words of appreciation from our Winners*

**Dear Ms. Brûlé,**

I would like to thank you and the Canadian Association of Physicists for generously sponsoring the CAP Special Award in the Junior Category at the 32nd Annual Canada-Wide Science Fair.

I was pleased to receive the CAP plaque and name plate as a momento of the Canada-Wide Science Fair in Rivière-du-Loup, Québec.

With the cash award, I have already started to purchase electronic parts for my next year's project on ultraviolet light and solar flares.

Thank you for inspiring me to continue my research in Physics.

Yours sincerely,
Heather Cameron

**Dear Ms. Brûlé,**

I would like to thank the Canadian Association of Physicists for their sponsorship in the Canadian National Science Fair. As the recipient of one of your special awards, I am very thankful for your support towards youth's scientific endeavours and will use the money that came with the award to further my education. Your association and the many other organizations that sponsor the Canadian Science Fair have helped me to pursue my interests in science and technology and, for this, I am extremely grateful.

This September, I will be going to the University of Waterloo to study Pure and Applied Mathematics, a field that I became interested in when I began participating in science fairs. Thank you for assisting me in furthering my education. It is good to know that organizations such as yours are so involved in today's youth.

Yours sincerely,
Neil Pengelly

**Dear Ms. Brule,**

I would like to thank you for recognizing my achievement along with my partner Neil Pengelly, at the Canada Wide Science Fair. I genuinely appreciate your sponsorship and feel honored to have received the Canadian Association of Physicists' Special Award.

I had a wonderful time at the Science Fair and the experience gave me confidence and inspiration. I will be putting your award towards fees for the Architecture program at the University of Toronto. My special interest in science, stimulated by the Science Fair, will be focussed on applied science in the architectural field.

Thank you very much for helping to make the Science Fair a rewarding as well as an exciting experience.

Sincerely,
Matthew Galloway

## ARE YOU A HIGH SCHOOL/CEGEP STUDENT INTERESTED IN PHYSICS?

Why not try out for the Canadian Chemistry and Physics Olympiads for 1993-94? These exciting programs allow students to become eligible to represent Canada in the International Chemistry and Physics Olympiad competitions next summer.

The Olympiads are the world's most prestigious events for excellent science students. Success at the Canadian or International level can open amazing academic and career doors for you.

To be elgible you must be in full time attendance at a Canadian high school or cegep, you must be a Canadian citizen, permanent resident or have studied at a Canadian School for at least two years. A Physics Team member may not exceed 20 years of age as of the June 30 prior to the International Olympiad.

The first Chemistry and Physics Olympiads were held in Eastern Europe in 1967-68 with only three participating countries. Since then the Olympiads have been held nearly every year and now there are over 40 countries that take part. Canada sent its first team to the International Physics Olympiad in 1985. Since then we have won 10 medals including a gold and nine bronze. Our gold medal came in 1991 in Cuba when Michael Montour from British Columbia came second overall in the world.

Interested? Contact your high school science teacher or the CAP Office at tel: (613) 237-3392 for the name and address of your regional Olympiad representative.

# RESEARCH GRANT ALLOCATION REPORT FOR GENERAL AND CONDENSED MATTER PHYSICS

by P.J. Schultz (Past Chair of NSERC Grant Selection Committee #28)
with the assistance of all members of GSC#28 & #29, Darren Keyes, and Phin Perquin

In 1992 the Natural Sciences and Engineering Research Council of Canada (NSERC) announced that they were going to attempt to establish a new formula for funding the base budgets of each of the 25 Grant Selection Committees (GSC's) which they serve in their Resaerch Grants program.[1] The criteria for reallocation are Quality (40%), Discipline Dynamics (25%), Highly Qualified Personnel training (20%), and Costs of Research (15%), and these factors were discussed in a memo circulated to all university physics faculty in Canada in 1993. In addition, we published a notice and request for information in Physics in Canada, Vol. 49, No. 1, Jan. 1993 (pg. 18). The mechanism NSERC is going to adopt, as far as we presently know, is to review documents submitted by each GSC with particular attention to "Quality", and to suggest changes and/or revisions to the community in early 1994. A revised document will be required by NSERC for September 1 1994 and on the basis of these submissions they will determine which adjustments (if any) they will make to the present funding mechanism. In this first iteration, it is proposed that each discipline will stand to gain or lose a maximum of 5% of their present budget. This may not seem like much, but it may well define a future course.

With the assistance of many others, I have prepared and submittted a document on behalf of the Condensed Matter Physics (GSC#28) and General Physics (GSC#29) community. There are bound to be omissions and corrections which should be addressed in the second iteration, so the document is reproduced here in order that the entire community might have a chance to contribute. Please direct any suggestions to the new chairman of GSC#28, Dr. Byron Southern (Department of Physics, University of Manitoba, Winnipeg, Manitoba, R3T 2N2; Tel: (204) 474-6179; fax: (204) 269-8489; e-mail: souther@ccu.umanitoba.ca). Every attempt will be made to represent the views and interests of the entire community, but this can only be done if the writer is armed with all of the information!

(Please note that, in the interest of space, the table of contents has not been reproduced in this article. Ed.)

## 1.0 PREAMBLE

The origins of the Research Grant Allocation Exercise lie in the NSERC's stated desire to redress errors in the present allocation formula, which is based primarily on demand (and therefore undergraduate enrollment). This conclusion was also reached by the Strategic Planning Committee for the Division of Condensed Matter Physics (CMP) of the American Physical Society (APS)[4], who concluded that there was *"a growing sense of crisis"* in the community, relating to the fact that *"neither the overall level of funding* nor the way in which available funds are distributed seem to be adequate." The mandate is to demonstrate the "health" of each discipline through the quality of science, with other factors such as discipline dynamics, training of highly qualified personnel, and the costs of research being determined primarily by NSERC.

It is our firm belief that the only credible demonstration is objective, as opposed to the subjective submissions annually provided to NSERC as "Health of the Discipline" documents. For this reason, our document is based entirely on information that is openly available, or which we have obtained through requests and questionnaires to: *(i)* all Canadian researchers who receive NSERC Grants[1], *(ii)* all Chairs or Heads of Canadian Physics (or related) departments[2], *(iii)* selected expatriates, as suggested by the individual responses to questionnaires (defined as Canadians or Canadian-trained scientists now working abroad), *(iv)* distinguished foreign peers, *(v)* telephone and facsimile surveys of Canadian industries[3]. We also include reference lists in the Appendices (section 12) relating to total science citation index publication numbers (§12.1) and the more focussed total of publications in the Physical Review journals (§12.2). The sources and individuals are all listed in sections 11 and 12.

We have attempted to include a fair representation of the opinions expressed, ascribing direct quotations where possible, and including both positive and negative comments. We are confident that Physics in Canada is strong and very much under-represented in a balanced funding scheme.

## 2.0 INTRODUCTION

### 2.1 Physics & Condensed Matter Physics

Our society today is molded in part by science and technology. As we continue through the 1990's and on into the 21st century, we will depend more on science and technology to foster economic growth than ever before. The young physicists now in universities represent the cornerstone of our scientific future, since it is from this group that we can expect many of the important scientific discoveries and the innovative leadership on which we will rely in the coming decades. It is essential that we preserve and further develop the environment in which they can flourish, and which will attract future generations into the vital and challenging pursuit of Physics and Condensed Matter Physics.

An education in Physics is one of the best ways to develop advanced problem-solving skills: *"Physics training can be a valuable background for many different careers (radiology, patent law, environmental protection, computer science,...)"* [Freeman]. This is perhaps the true equity in the discipline,

1. NSERC publication "Contact", Vol.17, No.3, Fall 1992, pg.4.

since these skills are necessary not only for technological careers, but also for the effective management of our industrial and political future. In tomorrow's world, we must look to leaders who understand the technology which is indeed part of the fabric of our society.

### 2.2 Overview of Canadian Physics

Canada has a superb international reputation for training physicists. There have been two Nobel Prizes in Physics granted to Canadians in the past 12 years, including Alberta native Richard Taylor (1990), and University of Toronto Ph.D. Arthur Schawlow (1981), not to mention cross-disciplinary Atomic & Molecular research which has led to Nobel Prizes in Chemistry to Rudolph Marcus (1992), John Polanyi (1986), Henry Taub (1983), and Gerhard Herzberg (1971). There has also been distinguished work by others which, in the eyes of many, has missed full recognition. Included in this list would be Rutherford's pivotal work on the structure of the atom while at McGill (1911), Joe Gray's work (1913) which has been credited as the *first* discovery of the Compton effect, or Bert Brockhouse, who *"should have won a Nobel prize for his contributions to thermal neutron scattering"* [Litster].

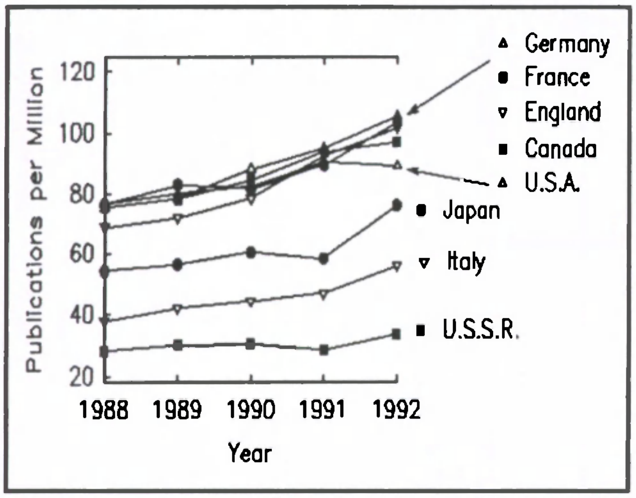



**Figure 1** *Physics publications normalized to total populations [§12.2].*

As a relatively small nation, we suffer the strain of maintaining world-class research and education against the draw of comparatively generous resources to be found south of the border: *"it is something of an embarrassment to have the MIT faculty boast that they have the best Canadian physics department in the world"* [Freeman]. Nevertheless, we have established a solid footing as a competitive nation in the world of Physics and Condensed Matter Physics. According to Dr. Hollis Wickman[6] who maintains a database of ~1500 Condensed Matter Physics reviewers for the National Science Foundation (NSF), *"Canada and France stand out particularly in terms of the per capita quality of their Condensed Matter Physics"*. A comprehensive search of Physics publications sorted according to country (Appendix 12.1) shows that Canada is, on a *per capita* basis, as strong as the best countries in the world.

This is illustrated in Fig. 1 for all Physics sub-disciplines combined. A breakdown by subdiscipline into the two most important basic research areas for combined GSC #28 & #29 is also tabulated in Appendix 12.1, and it tells the same story. The totals for condensed matter, atomic, molecular, and chemical physics show that, while Canada trails Germany by ~14% in publications per capita, it is 27% ahead of the U.S.A. and more than 100% ahead of Japan. Allowing for industrial, national and defence laboratories, it has been noted that there are likely fewer practicing physicists per capita in Canada than in Germany, the U.S.A. or Japan, which makes the data even stronger.

It may be argued that the "full" citation index scan represented in Fig. 1 and the Tables in §12.1 is too broad. However, a clear majority of practicing physicists world-wide would support the statement that the Physical Review journals published by the American Institute of Physics are a good subset, representative of a relatively uniform (high) standard of quality in the discipline. The editorial staff for Phys. Rev. have kindly prepared their own statistics for this report, some of which are contained in §12.2, and it is clear from these numbers that Canada is indeed very strong on a per capita basis.

In the sections to follow, several specific examples of the health and quality of Canadian Physics are briefly described. All of the highlighted work has received high praise from internationally renowned peers: *"The best Canadian physicists are competitive with the best from the U.S.A., Germany or Japan"* [Luryi; similar statements from Luke, Stegeman, and many others]. It is important for NSERC to recognize the need for a strategic focus of increased resources in selected areas such as Physics and Condensed Matter Physics, where strength is already evident.

In addition to very positive comments, there were many suggestions for improvements from off-shore respondents. The majority of Canadian physicists expressed their support for a broad base of research funding[1], although it has been pointed out that due to the on-going nature of funding in Canada, versus the frequent critical review in the US (which is deemed by many to be too critical), there is *"more far-out thinking in the US"* [Stegeman], or alternatively expressed, the Canadian *"system is very conservative. It does not support nor is the environment conducive to risk-taking. The excellent people should be well supported and allowed to try a few risky things"* [Dynes]. NSERC's present policy strives to achieve more critical levels of support and encourages GSC's to be more selective in their funding. This view is further reinforced by arguments which acknowledge the value of physics research in Canada, and the need to allocate more resources, with particular emphasis on *areas* of strength: *"the main problem you have is that you are subcritical, both in the number of people working in any field and in the resources devoted to research"* [Litster]. With limited resources, it has been suggested that Canadians *"give to no more than twenty universities the means to develop really competitive research programs (i.e. reward excellent programs and not only excellent people) and support only isolated excellent people in the others"* [Scoles]. This view is shared by a prominent ex-Canadian physicist, D. Allan Bromley[7], who suggests that universities in the U.S.A. should focus more on teaching, even though *"in doing so, many institutions will have to curtail some of their research activities."*

An obvious problem that was stressed was the inevitable "brain drain", which depletes Canada of many of its most talented young scientists. It relates in part to the scale of programs discussed above, and in part to the lack of flexibility intrinsic to the basic system: *"the practice followed in the U.S. of allowing universities to take overhead off of research grants is a very important difference... funds are available in the U.S. to set up laboratories for new faculty"* [MacDonald]. Fundamentally, *"the goal should be to make returning to Canada attractive to all of the young Canadian post-docs who come to the U.S.A."* [Stegeman]. While it is clearly productive to continually examine and refine the process, there is generally wide international acclaim for the Canadian system, particularly in comparison with other options: *"It actually has been easier for a young scientist... to win a prize, a Sloan Fellowship or a Presidential Young Investigator Award for example, than to obtain a regular NSF grant"*[4].

## 3.0 SELECTED HIGHLIGHTS: PAST, PRESENT, & FUTURE

Canada boasts internationally competitive research in many areas of Physics and CMP. There are of necessity "holes" in the scope of our programs due to our limited population and resources, but there are many areas in which we are distinguished. A notable example is, of course, the work of Brockhouse in neutron scattering, including the development of the triple axis spectrometer, which is still the industry-standard world-wide. For a second example, in the *"field of Positron Physics, Canada has always had a strong tradition, making a contribution comparable to that of the U.S.A."* [Hautojärvi]. This particular credit is based on more than 40 years of outstanding research, originating with two of the pioneers in the field (I.K. MacKenzie and A.T. Stewart), and it speaks well of a country whose overall research effort is more than an order of magnitude smaller than that of its southern neighbors, both in numbers and in funds. Similarly, the first developments of experimental ion-channeling techniques, now fully mature and routine in materials science and analysis, stem from the dynamic environment of Chalk River Nuclear Laboratories during the 1960's (J.A. Davies), and many of the most basic methods used in muon spin resonance originated with the work of Brewer and others at TRIUMF in Vancouver. These are, however, just isolated examples from a very long list. A few selected areas of strength are briefly described below.

### 3.1 Atomic Theory

Recent international developments have highlighted the contributions of G.W.F. Drake (Windsor), who has developed wave functions that yield energy levels in two-electron atoms to an accuracy of parts in $10^{15}$. This has allowed experimentalists such as S. Lundeen (Notre Dame) and E. Hessels (York) to probe hitherto unseen long range interactions (Casimir forces). *"There have been notable contributions from Canadian scientists. As examples, the work of Gordon Drake and collaborators on high precision calculations of energy levels in helium have been important in identifying the Casimir force and other fundamental interactions... Canadian students and postdoctoral visitors to the Harvard-Smithsonian Institute for Theoretical Atomic and Molecular Physics are as good as any and probably better than most in mathematical preparation. The senior visitors are impressive."* [Dalgarno]

### 3.2 Exotic Materials & Magnetism

For a field which has generated an estimated ~5000 publications in the last five years, high-temperature superconductivity (HTc) is surprisingly poorly understood. This is one example of a huge international effort in which the work of a few Canadians, including Berlinsky, Carbotte, Kallin and Timusk at McMaster, is clearly making a mark with the best in the world. One popular theory to describe this phenomenon involves quasiparticles with effective magnetic moments, called anyons. This has now been all but discounted by the work of the UBC $\mu$SR group (Kiefl, Brewer, and others), described by one international observer as *"the single most important experiment in HTc to date"*; this is high praise for a field which has already earned Bednorz and Müller the 1987 Nobel Prize for Physics. The theories of Affleck in this and other aspects of condensed matter have had *"a great deal of impact"*. There is, however, general agreement that so far the most significant work on HTc in Canada is that of the group led by Walter Hardy (UBC), whose approach has been to begin with the best materials, and to perform microwave experiments (with D. Bonn) described variously as *"stellar"* [Andersen], and *"the best in the world"* [Bridges]. The crystals produced in his laboratory (by R. Liang) are considered to be the best in the world. Between the groups at McMaster and UBC, this is one example of research that is funded and executed at a competitive level.

HTc superconductors belong to a larger class of materials which all involve the properties of correlated electronic or magnetic effects. Examples of these include heavy fermion systems, of which one of the pioneers is Taillefer (McGill), and phase transitions in frustrated antiferromagnets and Kagome lattices, for which Gaulin (McMaster), Mason (Toronto), and Kiefl (UBC-TRIUMF) are rapidly establishing leading reputations. The strength of Canadian research on these novel materials is an outgrowth of world class capabilities in neutron scattering developed at Chalk River Nuclear Laboratories (Brockhouse, Buyers, Collins, Egelstaff), as well as in magnetic resonance (Armstrong, Kiefte, Pintar) and $\mu$SR (Brewer) techniques. Presently this research is evolving cooperatively, utilizing all available resources both within Canada and abroad, including neutrons, X-ray synchrotron radiation, $\mu$SR, and laboratory-based techniques.

### 3.3 Atomic and Molecular Experiment

Atomic, Molecular and Optical physics is a rapidly growing field driven partly by the discovery of new phenomena involving the control and manipulation of atoms and molecules, and partly by its intimate connections with developing technologies. The Canadian effort in this field has produced high-profile contributions of vital interest to atmospheric, plasma, and astrophysics. *"The measurements of Bill McConkey on electron impact* *excitation are of considerable significance for gaseous electronics and upper atmospheric physics; the beam studies of Brian Mitchell on dissociative recombination have had major impact."* [Dalgarno] Lifetime measurements in Fe II by E. Pinnington have very nicely resolved important aspects of the solar iron abundance puzzle.

### 3.4 Nanoscience & Nanotechnology

Internationally, one of the most intensive pure and applied research areas is that related to modern semiconductor technology, and other areas of so-called nanoscience and nanotechnology. *"In the United States, it is one of the fastest-growing areas of chemistry, physics and materials science, with about $30 million a year in direct funding by government and industry. Japan recently announced it will spend $200 million over the next 10 years... in addition to $40 million already budgeted for small-scale electronic devices"*[13]. In Canada, *"the quantity of the work is not large (compared to say, Germany or USA), but the quality is high"* [Feenstra]. There are individual programs across the country that have achieved international recognition, including the pioneering photoluminescence spectroscopy of Thewalt, high-resolution optical studies by van Driel, and Young, MBE-groups at UBC (Tiedje), McMaster (Thompson), and Western (Zinke-Allmang), the ion-scattering group at Western (Mitchell), positron work on III-V's at Manitoba (Dannefaer), theoretical studies by Kreutzer and Sipe, device integration and characterization work at McMaster (Simmons) and at Montreal (Brebner, Currie, et al), and many others too numerous to mention.

This is an area which is strongly driven by strategic needs, and it can be difficult to strike a profitable balance between pure and applied interests: *"although research should not be strongly tied to product development, I think it is healthy to foster some connection between the two"* [Feenstra]. This view is also supported by Scoles, who points out that *"it is not the job of a scientist to carry out market research"*. In Canada, Centres of Excellence at both the Federal and Provincial levels contribute towards the necessary integration, as does the Institute for Microstructural Sciences (IMS) at the NRC. The IMS mandate is in the strategic area of advanced semiconductor components and works *"to ensure the base knowledge (e.g. nanoscience) generated in the universities (or internally) is transferred in usable form (e.g. nanotechnology) to Canadian industry"* [T.E. Jackman]. To do this, IMS has striven to conduct *"research and development with the necessary focus and critical mass to achieve the competitive edge from which industry can benefit"*, while at the same time *"making the sophisticated infrastructure and equipment accessible to professors and graduate students from Canadian universities"*[12]. This has been an exceptionally successful exercise, and researchers from IMS in collaboration with many university professors and industry employees are constantly making landmark discoveries in both "nanoscience" (*e.g.* discovery of quantum electron solid at zero magnetic field in very high mobility Si-MOSFETs), and "nanotechnology" (*e.g.* first electrically-pumped InGaAs/InP circular-grating surface-emitting laser at 1.3 $\mu$m wavelength, in collaboration with BNR). *"The focussing that went on at NRC has aided the semiconductor area in Canada"* [Kavanagh].

### 3.5 Lasers and Optics

The fields of electro-optics, photonics, and lasers offer large industrial payoffs in communications and computing, and at the other extreme allow fundamental studies of matter under extremely high electric fields ($10^{18}$ V/cm). *"Je peux porter un jugement dans le domaine qui est le mien, celui de l'interaction laser-matière, et il est indiscutable que les études entreprises dans le laboratoire du Prof. S.L. Chin, M. Piché, ainsi que dans le laboratoire de P. Corkum à Ottawa, ont atteint un niveau d'excellence qui fait honneur à la science canadienne."* [Mainfray] *"The status of Canadian Physics in the area of Condensed Matter Physics and in Lasers, Electro-optics, Spectroscopy and Plasma Physics is very high. Nobel laureaute G. Herzberg has attained international fame through his work on molecular spectroscopy, and I have known many many other Canadian colleagues in the field of Lasers and Optics for whom I have the greatest respect. Boris Stoicheff comes to mind as another example of the "Old Guard". There are, however, many currently active younger colleagues. Among them I may mention Professor S.L. Chin at Laval University and Dr. P.B. Corkum at the National Research Council... Among my postdocs at Harvard I have counted the following Canadians, who started their studies of Physics in Canada. Professor Eli Yablonovich (now at UCLA), Professor M. Dagenais (now at the University of Maryland, and Professor H. van Driel (now at the University of Toronto). They are all first class scientists. In my opinion it is important for Canada to retain as many as possible of such first rate scientists and to provide good research opportunities for them. The fields of Condensed Matter and General Physics are directly linked to various applications, electro-technology and alternative energy sources. In general, they do not require large central facilities. Much research can be carried out effectively at universities and provides an excellent training opportunity for future scientists and engineers, which Canada will need just as much as other countries to face the problems of the 21st century."* [Bloembergen]

### 3.6 Soft-Matter Physics

One of the most compelling and progressive areas of condensed matter these days is so-called *soft* matter, which includes structured and complex fluids such as emulsions, micelles, vesicles, gels, porous media, multi-phase fluids, liquid crystals, polymer solutions and blends, etc. The 1991 Nobel Prize in Physics was awarded to Pierre-Gilles de Gennes for his work in this area, and the field is rapidly growing throughout the world. It is one area where new physics and new technology are closely related to each other, and so the work of physicists in this area quickly finds applications in one or more of the areas of microcomposite materials, materials processing, petroleum extraction, drug delivery and bio-engineering, and many others. One example, best described as "nanotechnology" (§3.4), is the recent extraction of protein from the bacteria that turn the San Francisco Bay salt ponds red, and which may have potential as a high-density electronic storage medium[13].

Canada is not yet as active in this area as some other countries, but the work of a few researchers has elicited international recognition (Bechhoefer, Collins, Oesai, Frisken, Gaulin, Gooding, Grant, Kapral, Pink, Plischke, Singh, Sullivan, Wortis). The French are the masters, and the Americans, Japanese and Germans are learning quickly. *"One way in which NSERC could help put Canadian physics on the map would be to encourage researchers in this area."* [Cumming]. A major new Canadian Institute for Advanced Research initiative headed by Meyer Bloom is aimed precisely at this problem.

### 3.7 Plasma Physics

The work at the Varennes Tokamak (Terreault et al.) has significantly focused world attention on biased edge divertors and macroscopic plasma rotation. Kieffer et al. at INRS - Energie et Matériaux have used terawatt-picosecond laser pulses to access hot plasmas of near solid densities, achieving time-resolved plasma diagnostic spectroscopy at 2 ps temporal resolution for the first time. Chaker's INRS team has used laser-driven X-ray sources (rather than very large and expensive synchrotrons) for X-ray lithography as applied to the developing technology of Ultra Large Scale Integration; this expertise has proven to be the really useful "spin-off" from the years of experience on development of X-ray diagnostics for laser-fusion applications.

The cold plasma groups at McGill (Munz), Sherbrooke (Boulos), Université de Montreal (Moisan), and Ecole Polytechnique (Wertheimer) have made notable progress in developing low pressure and atmospheric pressure plasma sources for etching of electronic materials (semiconductors, polymers), surface modification of polymers for enhanced bondability, and deposition of thin films (electronic materials such as amorphous silicon, silicon compounds, crystalline diamond, etc.).

## 4.0 TECHNOLOGICAL INNOVATION

Recent patterns in science funding have been driven by an interest in technology transfer. This is particularly true for both Provincial and Federal "Centres of Excellence", which are largely measured by the extent to which scientific and industrial interests overlap. There is a distinct danger in this, often voiced by academics both within the country[1,2] and abroad [§11.1, 11.2], that second-rate market research will supplant high-quality science.

Canadian innovation in technology has been proportionately significant. The instrumentation used by most experimental physicists is predominantly of U.S. manufacture, but few users know that it is not American in every sense. Chalk River was not only host to the development of the Brockhouse triple-axis neutron spectrometer, but also the first fully transistorized multi-channel analyzer (MCA; Goulding), and the large germanium detectors used in many different research disciplines. Fast-slow timing systems utilized in many research areas were also developed at Chalk River (Bell and Graham), with the only major improvement being constant-fraction-discriminators developed in Alberta (Gedcke and McDonald). The entire field of "surface" and "interfacial" physics, and indeed the development of modern growth techniques which underpin today's semiconductor industry, are all areas which grew out of the development of ultra-high vacuum techniques, for which Redhead, Hobson, and Kornelsen (NRC) are credited with major contributions. Their book, *"The Physical Basis of Ultra High Vacuum"* (Chapman & Hall, London, 1968) was reprinted in 1993 as an American Vacuum Society Classic.

Technological achievement by Canadian physicists is not limited to government or university laboratories. In 1991 Canada's largest high-tech company, Northern Telecom, overtook AT&T in sales of telecommunications switching systems within the U.S., having already established leadership in most foreign markets due to pioneering developments of digital switching[9]. Currently the most promising battery technology is based on Li-intercalated cells developed at UBC (Haering). Still other developments include the avalanche photodiode (RCA, Montreal), and FTIR spectrometers for high-resolution optical research (Bomem, Quebec).

## 5.0 INTERNATIONAL PERSPECTIVE

There is considerable international support for the quality of Physics in Canada, as measured by the peer review of submissions to the Physical Review[10], or by the comments of respondents contained in the preceeding sections. However, there is concern that *"for too long Canadians have been tempted away to the U.S. by far better resources and opportunities to work at the cutting edge of science"* [Freeman]. The majority of the "ex-patriate" Canadians who responded to us indicated a strong interest in returning to Canada, but could not for a variety of reasons, including infrastructure or the non-critical group sizes. It was pointed out that the average pay is significantly less in Canada than it is in the U.S., but that is rarely a reason for not returning.

Economies are struggling in all countries of the world, and academic institutions and funding agencies are having to determine what programs can be sustained in the future of science. The NSF in the U.S.A., bowing to congressional pressures to shift funds into "strategic research", are moving a significant fraction of their total budget (~5.5%) into targeted areas which include advanced materials and processing, high-performance computing and communications, biotechnology, and manufacturing research[7]. *"Even the most prestigious university can no longer aspire to having departments in every human endeavor"* [Bromley, 7], and the cost of this directive is born largely by basic research. This is the cachet of today's scientific policy, and it is important that funding agencies (just as the NSF is attempting) stem the tide by building strength in these areas *without* irreparably crippling more fundamental science. In Canada, we have internationally acclaimed programs funded in part by the Physics and Condensed Matter Physics NSERC Committees, including semiconductor growth and characterization, superconducting device development and marketing, optoelectronics and laser interactions with matter, and the physics of soft matter. Increased support in these areas can help to refine our focus on strategic research without compromising the fabric of our system.

## 6.0 EMERGING TRENDS

New trends in Physics and Condensed Matter Physics are determined by a variety of factors, including: (i) the political pressures to increase industry-driven research (§5.0 and 8.2), (ii) the escalating costs of experimental physics (§9.0), (iii) the growing interest in cross-disciplinary problems, and, of course, (iv) existing strengths. One reason for the increasing emphasis on interdisciplinary research is that the study of complex many-bodied ordered and disordered systems, both in equilibrium and under dynamical and non-linear conditions, has led to the development of versatile theoretical, mathematical and experimental tools and techniques which are finding new applications in a variety of other areas of physical, earth and biological science.

A few examples would include overlapping programs in surface physics and chemistry, the application of non-linear mathematics to the description of artificially produced amorphous materials, and the phase behaviour of soft matter. Brute-force computer techniques, fueled by the exponential rise in computing power for decreased cost, have opened new avenues for simulating and ultimately understanding physical phenomena on a microscopic scale. As the tools of Physics are applied to an ever-expanding range of problems, the discipline boundaries are slowly fading. This is to be encouraged and continued, until these boundaries disappear.

## 7.0 DISCIPLINE DYNAMICS

Physics has been important as long as there has been a desire to understand the world in which we live, and therefore Department sizes in Canadian universities have always been adequate, remaining relatively static in recent years. This is one reason why the per capita funding in Physics and Condensed Matter Physics has been declining (inflated dollars), as pressures on NSERC from other areas have steadily increased.

Yet, the importance of physics research in areas of industrial, socio-economic, and strategic importance is growing (see §5, 6, and 8), and it is essential that Canada maintain its world-competitiveness in this research.

Departments across the country range from 2-3 to almost 60 faculty, and it has always been the practice to fund scientists on their individual merits, irrespective of department size. This is typical throughout the NSERC system, and is illustrated in Fig. 2 by the fraction of faculty receiving NSERC grants (cross-hatch level). This figure also illustrates that about half of the research-active physicists are supported by GSC's 28 & 29 (solid bar). As pressures increase for collaborative and interdisciplinary research, and as the costs of (particularly experimental) research continue to rise, it may be more difficult in the future to sustain an "even" funding base. This is a serious policy issue that should be dealt with by NSERC.

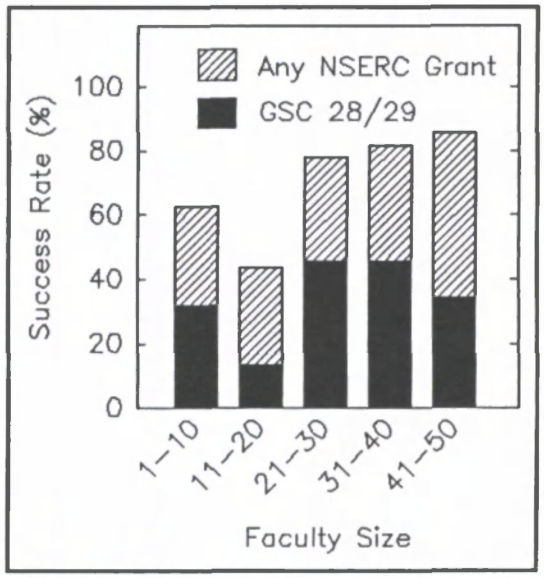



**Figure 2** *NSERC Grant success as a function of Physics Department size [3].*

## 8.0 TRAINING OF HIGHLY QUALIFIED PERSONNEL (HQP)

### 8.1 Student Patterns

Canada is renowned for the training of undergraduate and graduate students: *"...my undergraduate preparation ...was excellent, putting me far ahead of my American counterparts when I arrived at M.I.T."* [Cumming]. Similar high praise for physics education in Canada has been expressed by many familiar with other systems [Freeman, Kavanagh, Luryi, ...]. This attitude is also reflected in Fig. 3, which shows a steady increase in Physics graduates over the past 15 years[11].

Part of the credit lies in the more personal interactions possible in our smaller universities, and part lies with a fundamental awareness of the inspirational benefits of hands-on training at the earliest levels, which is an integral feature of a physics degree at many Canadian institutions:

*"There were fantastic opportunities while I was an undergraduate to pick up the real flavour of research through summer jobs... it's interesting that proportionally there were far more openings like this for undergrads in Canada than there are in the States"* [Freeman]. This will always result in top quality graduates, and with a healthy funding base there will always be those who return to Canadian faculties.

The survey of Department Heads[2] also suggests that student populations are increasing, in agreement with the data presented in Fig. 3.

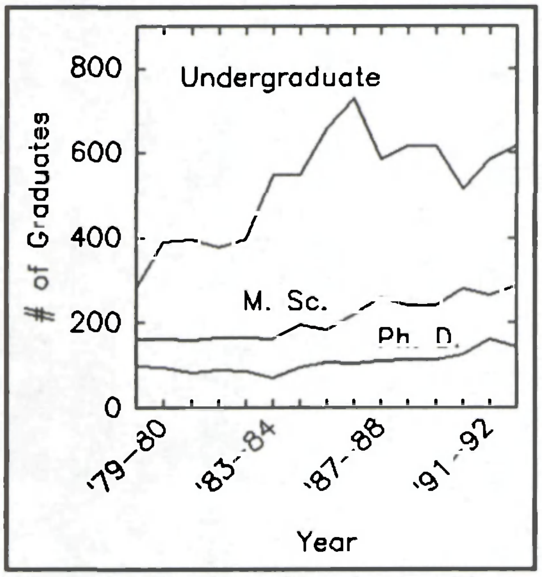



**Figure 3** *Number of graduating Physics students annually from Canadian Universities [11].*

Of those responding, 35% forecast increasing enrollments in undergraduate programs, as compared with 55% predicting status quo, and 10% declining enrollment. Further, these data[2] reflect the relatively even distribution of graduate students throughout the system, shown in Fig. 4, which follows from the even funding pattern discussed in the §7 above.

### 8.2 Industrial Demands

The invention of the transistor in the 1950's, and the subsequent development of integrated silicon technology, has changed our lives possibly more than any other technological or scientific event of the past century. At their March 1993 meeting, the APS hosted a session examining the current state of the technology[5]. According to Gordon Moore, chairman and CEO of Intel Corporation (the largest manufacturer of integrated circuits worldwide), the industry still has a long way to go: *"In the physical world, no exponential goes on forever, but we haven't yet reached the saturation point."* Moore and other experts continued to point out the essential role of basic physics: *"We can't solve problems in applied research without the science of basic research"* [Robert Galvin, former CEO, Motorola Corporation].

In Canada and the United States, new economic growth will require an expansion of our manufacturing capabilities, based on continuing research and development, innovation, bold marketing, and expanding exports. This will require a re-alignment of our priorities, away from the current North American practices of managing corporations with lawyers, accountants, and MBA's. According to Akio Morita, CEO and co-founder of Sony Corp. (and a 72-year-old physicist), *"Manufacturing and high technology corporations must be led by those who understand not just business but technology as well"*[6].

Canadian industries presently hire physicists *because* of their special training for technological applications. A total of 28 companies have responded to our request for information regarding the quality and the future need for Canadian trained physics graduates[3]. These companies range from 1 or 2 physics-trained employees to ~75, and represent all academic levels from B.Sc. through to Ph.D. Of these, 18% indicate that Canadian graduates are better trained than their counterparts from elsewhere, and 82% indicate equivalent training. On a performance basis, 5% indicate "much" better, 15% slightly better, 75% equivalent, and 5% slightly worse.

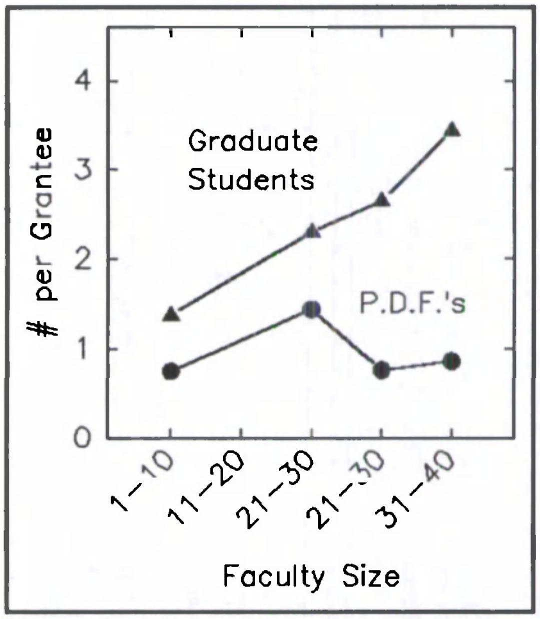



**Figure 4** *Average number of graduate students and PDF's per faculty member sorted by Department size [2].*

In addition, 27% of the companies surveyed suggested an *increased* need for physics graduates in the near future (~3 years), as compared with 58% at the same level as before and 15% requiring less. In general, most companies responding reflect a positive outlook for growth and development. Echoing the above advice of Morita, it is important that we recognize and strive for a new agenda for Canada's economic future, and look to our Physics graduates to develop and lead strong and innovative companies.

## 9.0 COST OF RESEARCH

The cost of a world-class laboratory for physics or condensed matter physics has risen steadily, which is an obvious result of the increasing need for control: ultra-high-vacuum equipment and characterization tools are essential for surface or growth studies; ultra-stable and high intensity magnets are required to push the boundaries of various spectroscopic studies; multi-photon and fast timing are driving modern laser labs into the category of "big" facilities. At the present time, the average capital investment in Physics laboratories in Canadian universities is several 100K$, and there are many above 1M$, as illustrated in Fig. 5. These data represent *all* respondents funded by either GSC #28 or #29[1], whether theorists or experimentalists.

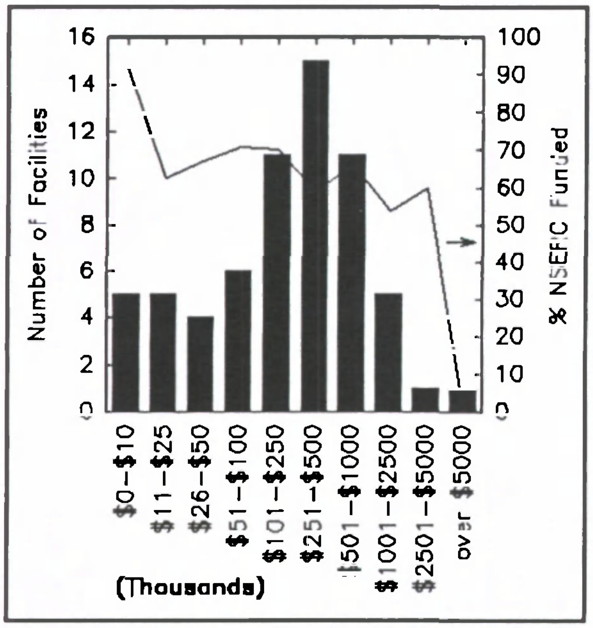



**Figure 5** *Demographic distribution of facility costs in Canadian universities [1].*

It is also interesting to note from Fig. 5 that NSERC funds ~60% of the equipment for most of these laboratories, the remainder leveraged from other sources (*e.g.* Provincial Centres of Excellence) or provided as startup by universities. One of the greatest difficulties facing researchers in Canada is the lack of infrastructure for this equipment.

The average NSERC Research grant is ~10% of the average capital investment, yet a normal working figure for facility management is ~15-20%. It is stated that NSERC research grants are only "in aid of" research, but the funding opportunities for all but a privileged few are very scarce. This is clearly demonstrated by the operating budgets of the same group of respondents who are represented in Fig. 5, which is shown in Fig. 6. Once again, the fraction of support which is contributed by NSERC decreases dramatically as the operating budget increases, which is to be expected.

It is interesting that the average number of personnel supported by these research programs, and in particular the number of graduate students, does not increase as dramatically as might be anticipated for the larger operations, as illustrated in Fig. 7.

This suggests that university supported infrastructure is still an important component, allowing many with small grants to direct meaningful programs.

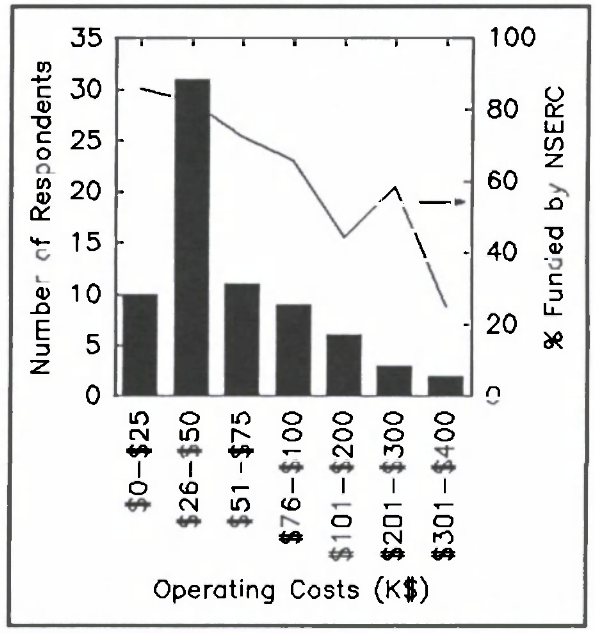



**Figure 6** *Total operating cost demographics for Physics and Condensed Matter Physics [1].*

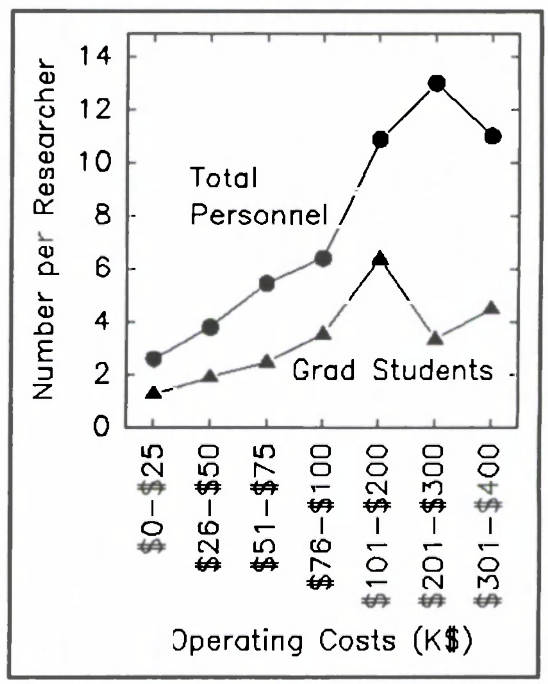



**Figure 7** *Average number of total personnel and graduate students per researcher [1].*

## 10.0 CONCLUSIONS

In this document we attempt to justify an increased funding allocation in NSERC's future by presenting a picture of the health and dynamic nature of physics research in Canada.

The evidence presented includes both objective and subjective opinions from scientists inside and outside the system, as well as statistical data solicited from grantees, department heads, Canadian industries, outside funding agencies, international journal and science citation databases. Without any attempt to hide the scars, Canada comes through very clearly as a small populace that has achieved no small degree of success in establishing a leading role in many areas of research, and an internationally *renowned* reputation for the highest quality training of young physicists.

In spite of this success, there is a critical need for a strengthened commitment to funding, especially in the strategically important areas represented by Physics and Condensed Matter Physics. There are many problems which could be addressed with an increased budget, and we suggest two urgent priorities:

*(i) There is a critically low level of infrastructure support in the physical sciences, and this would be one of the first problems addressed by GSC's 28 & 29. Particular emphasis would be given to programs where multi-investigator support can stimulate cross disciplinary physics in the areas of (e.g.) materials-physics, biophysics, geophysics, mathematical physics, non-linear systems, computational analysis, chemical-physics, astro-physics, and so on.*

*(ii) A second priority would be to ease the existing funding caps, which are not legislated but which are, in fact, practically imposed by the present demands for funding. This is an important step which, for the very best, would relieve their present inability to pursue more speculative and potentially rewarding new ventures.*

## 11.0 REFERENCES

### 11.1 Surveys and General Sources


1 Survey of all NSERC Grant recipients for GSC's 28 & 29 (1993): 81 respondents.

2 Survey of all Department Heads (1993): 22 respondents.

3 Survey of Canadian industries who hire Physics graduates (1993).

4 Report of the Strategic Planning Committee, Division of Condensed Matter Physics for the American Physical Society, June 1990.

5 Highlights from Seattle: APS News, Vol. 2, No. 6, June 1993.

6 *"Sony chief points to villain in manufacturing decline"*, by David Crane, Toronto Star, pg. H4, Jan 31 1993.

7 Science, Vol. 259, pg. 20-21, Jan. 1993.

8 Letter to P.J. Schultz from Dr. Hollis Wickman, Division of Materials Reserach, National Science Foundation, March 7 1993.

9 Business Week, July 1992.

10 Information provided by the editors of Physical Review & Letters, June 1993.

11 Rostoker reports in "Physics in Canada", March issue 1979-1993.

12 NRC Institute for Microstructural Sciences, Five Year Strategic Plan 1993-1998.

13 *"Nanotechnology: Atom-size field with a big future"*, by Glennda Chui, Toronto Star, pg. B6, Dec. 20, 1992.


### 11.2 Expatriate Canadians Responding

Andrew W. Cumming *(University of Florida, Gainesville)*, B.Sc. Toronto ('84), Ph.D. MIT ('88), AT&T ('88-'90), Florida ('90-)

R.C. Dynes *(University of California, San Diego)*, B.Sc. Western ('64), Ph.D. McMaster ('68), AT&T Bell Labs, UCSD

Randall M. Feenstra *(IBM T.J. Watson Research Center)*, B.Sc. ('78), Ph.D. Cal. Inst. Technol., IBM

Mark Freeman *(IBM T.J. Watson Research Center)*, B.Sc. Canada ('81), Ph.D. Cornell, IBM

Karen L. Kavanagh *(University of California, San Diego)*, B.Sc. Queens, 3-years with Bell Northern Research, Ph.D. Cornell, PDF IBM, UCSD

J. David Litster *(Vice President & Dean for Research, M.I.T.)*, B.Sc.

Graeme M. Luke *(Columbia University)*, B.Sc. Queens, Ph.D. UBC ('88), Columbia ('88-)

Serge Luryi *(AT&T Bell Labs)*, M.Sc. ('75), Ph.D. U.of.T. ('78), AT&T ('80-)

Allan H. MacDonald *(Indiana University)*, 13 years work (NRC) & Ph.D. in Canada, Indiana ('87-)

P.J.E. Peebles *(Princeton University)*, B.Sc. Manitoba, Ph.D. Princeton

Giacinto Scoles *(Donner Professor of Science, Princeton University)*, Prof. of Physics & Chemistry Waterloo ('71-'86), Princeton ('86-)

George Stegeman *(University of Central Florida)*, B.Sc., Ph.D., U.of T. faculty ('69-'79), Arizona ('80-90), Florida ('90-)

### 11.3 Foreign Scientists Responding

P.W. Andersen *(Joseph Henry Professor of Physics, Princeton University, and Nobel Laureate, 1977)*

David Belanger *(Professor of Physics, Univ. of California, Santa Cruz)*

N. Bloembergen *(Professor Emeritus of Physics, Harvard University, Nobel Laureate, 1981)*

Frank Bridges *(Professor of Physics, Univ. of California, Santa Cruz)*

Hidde Brongersma *(Professor of Physics)*

Alex Dalgarno *(Phillips Professor of Astronomy, Harvard University)*

Pekka Hautojärvi *(Director of Laboratory of Physics, Helsinki University of Technology)*

Gérard Mainfray *(Chevalier de l'Ordre des Palmes Académiques, Paris; Saclay, France)*

******************************************************************

## 12.0 APPENDICES

### 12.1 Total Publications in Physics

The following tables list numbers of papers published by country of origin for the lead author. Tables are organized according to descending population, the first showing all areas of Physics integrated and the next two showing break-outs for the most important areas of Physics for GSC's 28 and 29. Data were compiled by CISTI Reference services in Ottawa, based on a complete search of Science Citation Index, June 1993.

| TOTAL (All Physics) | Pop'n (Million) | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 (partial) |
|---|---|---|---|---|---|---|---|
| USSR | 278.7 | 7882 | 8418 | 8546 | 7960 | 9380 | - |
| US | 238.7 | 18364 | 19173 | 19702 | 21625 | 21330 | 9601 |
| JAPAN | 121.5 | 6601 | 6865 | 7355 | 7101 | 9275 | 3794 |
| GERMANY | 76.2 | - | - | - | - | 8045 | 3560 |
| (FRG) | 59.6 | 5132 | 5411 | 6031 | 6560 | - | - |
| (GDR) | 16.6 | 615 | 581 | 692 | 692 | - | - |
| ITALY | 57.2 | 2175 | 2414 | 2540 | 2683 | 3205 | 1519 |
| FRANCE | 55.4 | 4249 | 4603 | 4534 | 4959 | 5741 | 2612 |
| ENGLAND | 47.3 | 3263 | 3408 | 3719 | 4387 | 4806 | 1969 |
| CANADA | 25.6 | 1933 | 2003 | 2168 | 2402 | 2487 | 1190 |

| Atomic, Molec., and Chem. Phys. | Pop'n (Million) | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 (partial) |
|---|---|---|---|---|---|---|---|
| USSR | 278.7 | 206 | 198 | 457 | 687 | 575 | - |
| US | 238.7 | 2842 | 2522 | 2382 | 2620 | 2544 | 1224 |
| JAPAN | 121.5 | - | 484 | 508 | 558 | 656 | 264 |
| GERMANY | 76.2 | - | - | - | - | 1040 | 454 |
| (FRG) | 59.6 | 766 | 773 | 844 | 1012 | - | - |
| (GDR) | 16.6 | 47 | 485 | 71 | 72 | - | - |
| ITALY | 57.2 | 261 | 237 | 252 | 273 | 280 | 135 |
| FRANCE | 55.4 | 475 | 497 | 497 | 642 | 593 | 283 |
| ENGLAND | 47.3 | 522 | 530 | 663 | 699 | 687 | 317 |
| CANADA | 25.6 | 421 | 375 | 367 | 447 | 462 | 228 |

| Condensed Matter Phys. | Pop'n (Million) | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 (partial) |
|---|---|---|---|---|---|---|---|
| USSR | 278.7 | 1881 | 2080 | 2240 | 1960 | 2500 | - |
| US | 238.7 | 3130 | 3589 | 3251 | 3509 | 3862 | 1722 |
| JAPAN | 121.5 | 923 | 1217 | 1461 | 1161 | 1866 | 819 |
| GERMANY | 76.2 | - | - | - | - | 2195 | 979 |
| (FRG) | 59.6 | 1098 | 1495 | 1616 | 1592 | - | - |
| (GDR) | 16.6 | 273 | 282 | 321 | 313 | - | - |
| ITALY | 57.2 | - | 472 | 393 | 514 | 631 | - |
| FRANCE | 55.4 | 901 | 1380 | 1115 | 1323 | 1695 | 760 |
| ENGLAND | 47.3 | 562 | 937 | 828 | 928 | 1228 | 475 |
| CANADA | 25.6 | 319 | 392 | 387 | 436 | 479 | 209 |

## 12.2 Physical Review Published Manuscripts

The "Physical Review" is internationally considered as the leading journal for the publication of Physics research. PR"A" reports work primarily on Atomic and Molecular Physics, while PR"B" represents Condensed Matter Physics. Physical Review Letters is the journal of choice for most of the world for short publications of general interest to physical scientists. The statistics below were kindly provided by Cindy Rice of the Physical Review offices, and those for PRA and PRB include full articles, brief reports, rapid communications, and comments. Numbers listed for each country are publications *per* million of population.

| PRA (Published) | Pop'n (Million) | 1987 (/Mill.) | 1988 (/Mill.) | 1989 (/Mill.) | 1990 (/Mill.) | 1991 (/Mill.) | 1992 (/Mill.) |
|---|---|---|---|---|---|---|---|
| TOTAL PAPERS | - | 1493 | 2120 | 1832 | 1892 | 1938 | 2174 |
| US | 238.7 | 3.4 | 4.2 | 3.8 | 3.9 | 3.8 | 3.8 |
| JAPAN | 121.5 | 0.5 | 0.7 | 0.6 | 0.7 | 0.7 | 0.7 |
| GERMANY | 76.2 | 1.4 | 1.9 | 1.6 | 1.5 | 1.8 | 2.1 |
| U.K. | 56.6 | 0.5 | 0.8 | 0.9 | 0.8 | 0.8 | 1.5 |
| FRANCE | 55.4 | 1.2 | 1.4 | 1.2 | 1.5 | 1.5 | 1.6 |
| CANADA | 25.6 | 2.7 | 3.9 | 3.0 | 3.2 | 3.2 | 3.6 |

| PRB (Published) | Pop'n (Million) | 1987 (/Mill.) | 1988 (/Mill.) | 1989 (/Mill.) | 1990 (/Mill.) | 1991 (/Mill.) | 1992 (/Mill.) |
|---|---|---|---|---|---|---|---|
| TOTAL PAPERS | - | 3378 | 4494 | 3789 | 3426 | 3936 | 4243 |
| US | 238.7 | 7.6 | 9.5 | 8.2 | 6.9 | 7.8 | 7.7 |
| JAPAN | 121.5 | 1.4 | 2.4 | 2.1 | 2.2 | 2.0 | 2.5 |
| GERMANY | 76.2 | 3.4 | 3.8 | 3.8 | 3.7 | 4.7 | 5.2 |
| U.K. | 56.6 | 1.1 | 1.9 | 1.3 | 1.4 | 1.9 | 2.5 |
| FRANCE | 55.4 | 2.9 | 4.3 | 3.9 | 2.7 | 3.5 | 3.7 |
| CANADA | 25.6 | 5.2 | 7.1 | 5.9 | 5.0 | 7.1 | 7.0 |

| PRL (Published ) | Pop'n (Million) | 1987 (/Mil.) | 1988 (/Mil.) | 1989 (/Mil.) | 1990 (/Mil.) | 1991 (/Mil.) | 1992 (/Mil.) |
|---|---|---|---|---|---|---|---|
| TOTAL PAPERS | - | 1633 | 1641 | 1679 | 1824 | 1931 | 2098 |
| US | 238.7 | 4.4 | 4.4 | 4.4 | 4.6 | 4.9 | 5.1 |
| JAPAN | 121.5 | 0.6 | 0.5 | 0.6 | 0.7 | 0.7 | 0.9 |
| GERMANY | 76.2 | 1.7 | 1.5 | 1.8 | 2.2 | 2.2 | 2.4 |
| U.K. | 56.6 | 0.8 | 1.0 | 0.7 | 0.9 | 1.4 | 1.5 |
| FRANCE | 55.4 | 1.2 | 1.1 | 1.3 | 1.5 | 1.5 | 1.9 |
| CANADA | 25.6 | 1.6 | 1.6 | 1.8 | 2.2 | 2.2 | 2.3 |

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## Special announcement: Call for papers

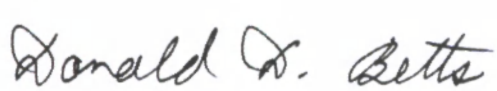
The *Canadian Journal of Physics* is pleased to announce that it will publish a special issue in December 1994 in honour of its Honorary Patron, Dr. Gerhard Herzberg, the 1971 Nobel Laureate in Chemistry, on the occasion of his 90th birthday. We intend this Herzberg Special Issue to be an exhibition of excellence in physics in Canada. Although we expect that the majority of contributions will come from Canadian institutions, the Journal will welcome papers from other countries. Contributions from Canadians working abroad and from friends and colleagues of Dr. Herzberg in other countries will be particularly welcome.

All manuscripts will be refereed in the usual way and the Editor will make the final decisions with regard to papers accepted for the Special Issue. To ensure that a manuscript can be published in the Herzberg Special Issue it should reach the Editorial Office in Halifax by March 14, 1994. It is preferred that the printed article not exceed 10 Journal pages in length.

## Communiqué spécial : Demande de communications

La *Revue canadienne de physique* est fière d'annoncer son projet de publication d'un numéro spécial de la revue, en décembre 1994, afin de souligner le 90$^{e}$ anniversaire de naissance de son patron d'honneur, Monsieur Gerhard Herzberg, le lauréat du prix Nobel de chimie de 1971. Le numéro spécial Herzberg témoignera de l'excellence de la recherche en physique au Canada. Bien que nous nous attendions à ce que la plupart des contributions proviennent d'institutions canadiennes, la revue acceptera les soumissions de l'étranger. Nous serons particulièrement heureux de recevoir des communications de Canadiens qui évoluent à l'étranger ainsi que d'amis et collègues de Monsieur G. Herzberg.

Les communications reçues seront examinées comme d'habitude et le directeur scientifique sera responsable du choix final des articles qui paraîtront dans le numéro spécial. Afin d'assurer une période de traitement suffisante pour leur insertion dans le numéro spécial, toutes les communications devront avoir été reçues par le bureau de la rédaction d'Halifax d'ici le 14 mars 1994. Nous préférons que les articles ne comptent pas plus de 10 pages, une fois publiés dans la revue.



Donald D. Betts
Editor, Canadian Journal of Physics/Le directeur scientifique, Revue canadienne de physique

# L'ACCÉLÉRATEUR DE PARTICULES HERA

par F. Corriveau
IPP/McGill University

## INTRODUCTION

Tout comme l'optique possède le microscope pour examiner les détails d'objets invisibles à l'oeil nu, la physique des particules recourt à des accélérateurs pour découvrir la structure de l'infiniment petit de la matière.

Une telle machine est entrée en action l'an dernier. Il s'agit de l'accélérateur HERA[1], situé au centre de recherches DESY[2], à Hamburg en Allemagne. HERA est de la sorte devenu le plus puissant microscope de son genre.

Le Canada a participé à la construction de ce nouvel accélérateur et poursuit son effort par une présence canadienne nombreuse au sein d'une des expériences.

## LES PARTICULES ÉLÉMENTAIRES

En 1911, l'observation par Rutherford de la diffusion de particules $\alpha$ lui permettait de conclure à un modèle selon lequel l'atome se compose d'un noyau lourd de charge positive autour duquel orbiteraient des électrons[1].

Depuis, les développements techniques continuels ont permis d'augmenter l'énergie des particules utilisées pour bombarder et donc étudier la matière. À l'égal des rayons X utilisés pour déduire la structure cristalline, les particules peuvent se voir attribuer une longueur d'onde caractéristique $\lambda$ de Broglie

$$\lambda = \frac{h}{p} \qquad (1)$$

où $h$ est la constante de Planck et $p$ est la quantité de mouvement de la particule. Ainsi, plus l'énergie ou la quantité de mouvement sont élevées et plus l'échelle de dimensions à laquelle on a accès peut être réduite.

## LE PRINCIPE DE HERA

La plupart des accélérateurs utilisent des particules semblables (p.ex. électrons-positrons au CERN, protons-anti-protons au Fermilab) et profitent des avantages que confèrent les propriétés de symmetrie lors de la construction et de la mise en marche de la machine. Avec deux faisceaux de particules se déplaçant en sens inverses, l'énergie disponible dans le centre de masse du système est aussi beaucoup plus élevée que pour des collisions sur cible fixe.

Le grand intérêt et défi de HERA est qu'on y amène des électrons de 30 GeV[3] à heurter frontalement des protons de 820 GeV, d'où 314 GeV dans le centre de masse du système. On a déjà reconnu au proton, composante principale de la matière, une structure correspondant à 3 quarks de valence *uud* retenus ensemble par la force forte représentée par l'échange de gluons. Quant à l'électron, on sait indirectement, à partir de l'observation de la diffusion Bhabha ($e^+e^-$)[2], qu'il est une particule ponctuelle de rayon inférieur à $10^{-20}$ mètres. Selon l'équation (1), l'électron devient donc la sonde qui nous permet ainsi de descendre jusqu'à $3 \times 10^{-18}$ mètres, soit 3 ordres de grandeur en deça du diamètre du proton et au moins un ordre de grandeur plus bas que ce que permettaient les expériences précédentes.

## LES ACCÉLÉRATEURS D'HIER ...

Un centre de recherche comme DESY, reconnu sur la scène internationale, s'est construit par étapes en se maintenant à la fine pointe de la technologie et de l'intérêt scientifique. Le projet HERA représente l'aboutissement de plusieurs années d'efforts, de développements et de découvertes.

Fondé en 1960, DESY voyait en 1964 son premier synchrotron accélérer des électrons au moyen d'un système de hautes fréquences. L'anneau de 317 mètres de circonférence permettait des énergies allant jusqu'à 6 GeV, que des modifications en 1968 devaient hausser à 7.5 GeV. En plus des expériences maintenant conventionnelles sur la structure du proton et du neutron (les composantes du noyau atomique), un grand nombre d'expériences ont été dérivées d'un sous-produit de la machine: le bremsstrahlung i.e. la radiation de freinage. Celle-ci est émise en grande partie lorsqu'une particule légère comme l'électron est déviée de sa trajectoire rectiligne, par exemple dans un champs magnétique pour la conserver sur une trajectoire circulaire. Le spectre très riche en rayons X et ultra-violets est alors utilisé pour des expériences en physique atomique et moléculaire, en physique de l'état solide, en biologie, etc.

Une double anneau d'accélération et de emmagazinement, appelé DORIS, devait en 1974 offrir des collisions frontales électron-positrons. La circonférence n'était que de 288 mètres et les particules n'atteignaient plus que 3.5 GeV par faisceau, mais les 7 GeV vraiment disponibles dans le centre de masse ouvraient ainsi les portes à de nouveaux domaines. Avec des transformations majeures en 1982 des lignes de faisceau et l'augmentation des énergies à 5.6 GeV, un ordre de grandeur d'amélioration en intensité était réalisé.

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1 "Hadron-Elektron Ring Anlage" (accélérateur circulaire hadron-électron)

2 "Deutsche Elektron-SYnchrotron" (synchrotron allemand d'électrons)

3 1 GeV = $10^9$ eV, 1 TeV = $10^{12}$ eV, etc..., où eV = électron-Volt

Une moisson de nouveaux résultats en découla: l'étude approfondie de particules possédant le quark charmé *c*, la mise en évidence du lepton lourd $\tau$ et par exemple la découverte du mélange d'états dans le système de la particule B.

Pendant ce temps, en 1978, l'expertise acquise à **DORIS** était étendue à **PETRA** pour couvrir le site entier de **DESY**: avec leurs 2300 mètres de circonférence, les faisceaux d'électrons et de positrons pouvaient d'abord atteindre 18.5 GeV, puis 23.5 GeV en 1984. La découverte du gluon, particule médiatrice de la force forte dans le proton, devait consacrer la nouvelle machine. Les propriétés de ces gluons et des quarks furent étudiées en détail dans le domaine d'énergie accessible. La théorie de la force électro-faible (combinant les forces électromagnétique et faible) a aussi pu être testée.

## ... DEVIENNENT LES PRÉ-ACCÉLÉRATEURS DE DEMAIN

La décision de passer avec **HERA** à un nouveau concept d'accélérateur fut prise en 1984 et signifia l'arrêt précoce de **PETRA** en 1986. Dans la nouvelle configuration, la plupart des machines déjà existantes, y compris leurs chaines d'injection, deviennent à leur tour les injecteurs de **HERA**. La figure 1 illustre l'agencement de toutes les composantes sur le site.

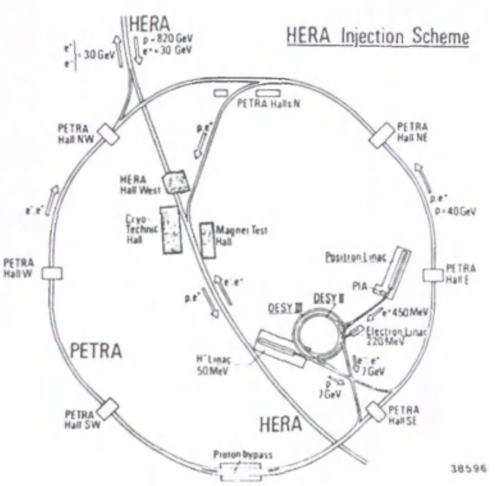


**Fig. 1 Le système d'injection de HERA.**

Le synchrotron original de **DESY** a été transformé en **DESY II**, et rendu capable d'accélérer les électrons à 9 GeV. Dans la même salle mais de rayon un peu plus grand, **DESY III** a été construit pour produire un faisceau de protons de 7.5 GeV. Le Linac III amène des ions $H^-$ à l'énergie requise avant de les faire traverser une mince feuille d'aluminium qui leur arrache les électrons et ne laissent plus que le noyau $p^+$ pour l'injection dans **DESY III**. **PETRA** sert maintenant tour-à-tour d'injecteur d'électrons et de protons pour **HERA**, amenant les particules à 14 GeV et 40 GeV respectivement.

## LES FAISCEAUX D'ÉLECTRONS ET DE PROTONS

**HERA**, avec ses 6.3 km de circonférence, dépasse les limites du site de **DESY** et est situé à 8 étages sous la terre[3]. Les protons peuvent ainsi atteindre 820 GeV, tandis que les électrons, soumis à d'importantes pertes par radiation synchrotron, sont limités à 30 GeV.

Avec les systèmes d'accélération à hautes fréquences, il n'est depuis longtemps plus possible d'utiliser des faisceaux continus de particules. Au lieu de cela, les particules sont accélérées et injectées en paquets très denses. Dans **HERA**, on aura ainsi 210 paquets pour chacun des types de particules, avec de l'ordre de $10^{11}$ protons par paquet et trois fois moins pour les électrons. À des vitesses approchant celle de la lumière, ils font environ 50,000 tours par seconde, avec une distance moyenne de 30 mètres du paquet d'un à l'autre.

La ligne de faisceau des électrons est faite de 2009 aimants conventionnels, vu que le champs nécessaire pour garder les électrons sur leur trajectoire est faible (0.165 Tesla). Les protons par contre nécessitent 4.68 Tesla et **HERA** a eu recours à la technique des matériaux supra-conducteurs, refroidis aux 4.3 degrés Kelvin et l'hélium liquide, pour atteindre ce but. Cette ligne de faisceau ne compte pas moins de 1833 aimants supra-conducteurs, d'abord les dipoles, mais aussi des quadrupoles, sextupoles et autres composantes de correction.

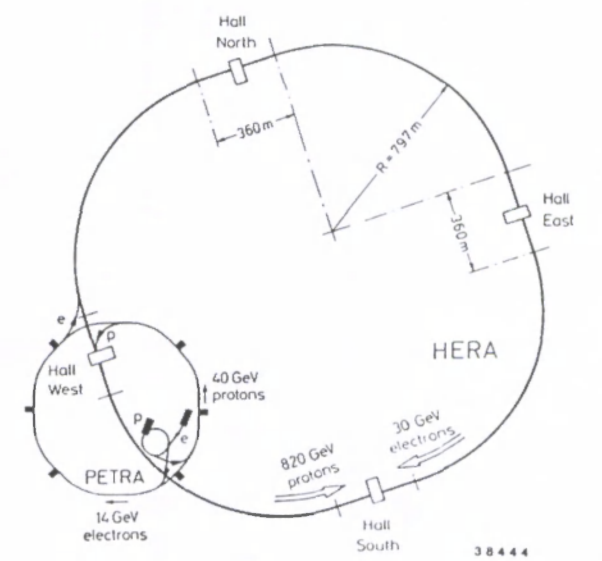


**Fig. 2 L'accélérateur HERA**

Comme on peut le voir à la figure 2, **HERA** n'est pas tout-à-fait un cercle mais possède 4 sections droites au milieu desquelles on retrouve les 4 points d'intersection des lignes de faisceau. Les longues sections droites permettent une importante réduction de la radiation de freinage des électrons aux endroits où les détecteurs sont installés. De plus, l'assymétrie des énergies (30 GeV et 820 GeV) et donc de l'effet des aimants sur les électrons ou protons rend possibles les collisions exactement frontales.

Il faut environ 20 minutes à la chaîne d'injection pour faire le remplissage de protons et à peine moins pour celui des électrons. La stabilité du faisceau de protons couvre facilement une dizaine d'heures, alors qu'à toutes les quelques heures il devient nécessaire de renouveler les électrons pour compenser leurs pertes plus importantes.

## LES COLLISIONS ÉLECTRONS-PROTONS

Lorsque les paquets de particules se rencontrent aux points d'intersection, il est essentiel d'obtenir le plus de collisions possibles. Malgré le grand nombre de particules impliquées dans chaque paquet et leur densité, il faut encore garantir l'ajustement spatial (à mieux que 300 et 70 micromètres horizontalement et verticalement) et en temps (à une fraction de nanoseconde). On s'attend alors à un taux de collisions de l'ordre de $10^5$ par seconde, qu'on exprime en générale en terme de luminosité, une forme qui relie alors simplement le nombre d'événements attendus à la section efficace (ou probabilité de réaction) du processus physique considéré.

L'optimisation du système est l'oeuvre d'une collaboration entre HERA et les expériences physiques. Chacune d'elle en effet fournit un détecteur de luminosité à très petit angle qui mesure la réaction

$$ep \rightarrow ep\gamma \qquad (2)$$

L'observation simultanée de l'électron secondaire avec le photon, les deux se partageant l'énergie de l'électron initial, identifie donc la réaction et la distingue par exemple de collisions fortuites de l'électron avec un atome du gaz résiduel de la ligne de faisceau. De plus, connaissant déjà avec precision la section efficace de ce processus, on pourra s'en servir pour obtenir les sections efficaces absolues de toutes les autres réactions observables. La luminosité prévue est de $1.5 \times 10^{31}$ $cm^{-2}s^{-1}$.

## LES DÉTECTEURS À HERA

Ce sont aux points d'interaction que des détecteurs trè complexes ont été installés pour observer les produits de réactions. Les deux premiers, officiellement proposés en 1986, sont H1[4] et ZEUS[5], situés aux zones nord et sud respectivement. Leurs défis sont nombreux.

Tous deux sont des détecteurs "universels" qui tentent d'être sensibles au plus grand nombre possible de processus physiques. Pour ce faire, ils doivent:

- couvrir complètement l'angle solide autour de l'endroit des collisions, à l'exception de la ligne de faisceau elle-même.

- posséder des détecteurs de traces pour les particules chargées en vue de reconstituer le ou les vertex ce chaque événements.

- mesurer l'énergie de toutes les particules émises au moyen de calorimètres tout en gardant la meilleure information possible sur leurs positions.

- ajouter un spectromètre à muons pour déterminer avec précision la quantité de mouvement de ces particules très pénétrantes.

- pouvoir compléter l'image de l'événement malgré l'information non-disponible. Par exemple, l'énergie transversale manquante pourra être l'énergie d'un neutrino, etc.

Tout comme les faisceaux qui sont différents en type de particule ou en énergie, les détecteurs sont également asymmétriques et requièrent davantage de composantes dans la direction de vol des protons que dans celle des électrons.

Le temps entre les collisions de paquets d'électrons et de protons est de 96 nanosecondes, soit beaucoup moins de temps qu'il n'en faut aux composantes des détecteurs pour lire l'information, voire l'interpréter suffisamment pour permettre au déclencheur de décider d'enregistrer l'événement ou non. Cela implique donc:

- un système de déclenchement à 3 ou 4 niveaux pour filtrer les événements d'intérêt,

- un grand nombre de pipe-lines électroniques pour emmagaziner l'information de façon continue et ne la récupérer que lorsque l'événement est accepté.

## LA DUALITÉ H1 ET ZEUS

Le principe des deux détecteurs H1 et ZEUS et le même, quoique l'approche expérimentale varie selon les techniques utilisées et permet une meilleure complémentarité. Des coupes des deux montages son présentées aux figures 3 et 4 respectivement. Seules les différences le plus frappantes parmi une foule de détails seront mentionnées.

La bobine solénoidale de H1 a un diamètre de 5.6 mètres qui permet d'y insérer les calorimètres à l'intérieur et de minimiser les pertes d'énergie entre le point d'interaction et les calorimètres. Le champs magnétique généré pour les détecteurs de traces peut atteindre 1.2 Tesla.

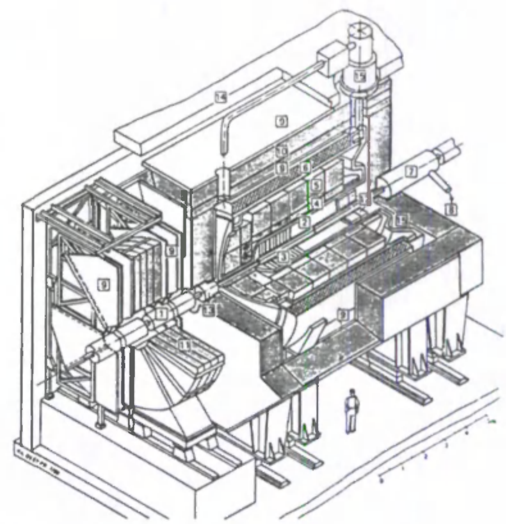

**Fig. 3 L'expérience H1**

Le calorimètre lui-même est à argon liquide, avec des plaques de plomb pour la section électromagnétique et d'acier pour la section hadronique. La segmentation en 3 dimensions est très fine et la résolution en énergie pour les signaux électromagnétiques est excellente.

Le solénoide de ZEUS, de diamètre inférieur (1.72 mètres), peut générer jusqu'à 1.8 Tesla. Situé entre les détecteurs de traces et les calorimètres, il a été spécialement conçu pour ne présenter qu'une seule longueur de radiation aux particules devant le traverser. Les calorimètres de ZEUS sont des assemblages en alternance de plaques de scintillateurs plastiques et d'uranium. Le scintillateur plastique fournit des signaux extrêmement rapides dont le système de déclenchement a besoin. L'uranium, par son faible taux de désintégrations $\beta$, garantit un signal minime mais continu qui sert à maintenir automatiquement la calibration constante à mieux que 2%. De plus, sa densité et ses propriétés nucléaires permettent aux calorimètres de donner des signaux pratiquement identiques pour différents types de particules de même énergie. La proportionnalité en énergie est alors directe, la résolution hadronique est grandement améliorée et aucun traitement additionnel des données n'est requis.

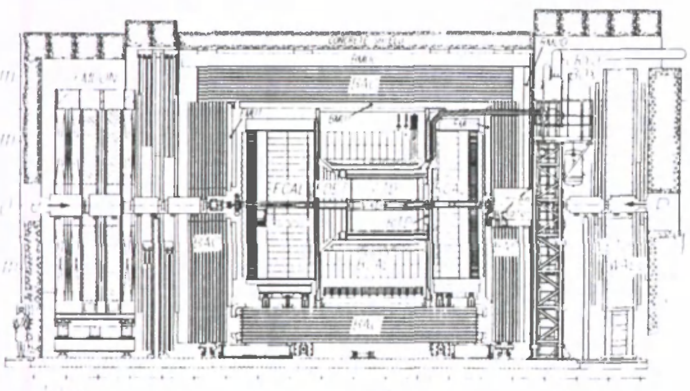

**Fig. 4 L'expérience ZEUS**

## LES CONTRIBUTIONS ET RESPONSABILITÉS CANADIENNES

Le projet HERA est le fruit d'une collaboration internationale, tant au point de vue de l'accélérateur que des expériences.

Avec l'expansion du laboratoire original de DESY au complexe qu'est devenu HERA, l'Allemagne subvient à 85% du coût et de la main-d'oeuvre, desquels 72% sont défrayés par le gouvernement fédéral et 13% par la ville de Hamburg elle-même. Aux 15% restants ont participé plusieurs pays: le Canada, la Chine, la France, Israel, l'Italie, les Pays-Bas, la Pologne, la Suisse, le Royaume-Uni et les États-Unis. L'initiative canadienne a été lancée par l'IPP[4].

[4] Institut de la Physique des Particules du Canada

Sous son organisation, le Canada a fourni en particulier le système à 52 MHz des cavités accélératrices de la ligne de protons pour PETRA et HERA (provenant de l'EACL[5]), de même que la ligne de transfert de faisceau entre le Linac III et DESY III (de TRIUMF[6]).

Le Canada est fortement représenté dans l'expérience ZEUS avec, au dernier recensement, 33 des 432 physiciens et une fraction de 9% comme contribution à la construction et à l'utilisation du détecteur. Parmi les 46 instituts des 12 pays participants, on retrouve les groupes canadiens des universités du Manitoba, McGill, Toronto et York. L'apport le plus important a été la construction et l'assemblage au Canada d'une très grande partie des modules de calorimètres de ZEUS. Le troisième niveau de déclenchement, en réalité une "ferme" de processeurs très puissants qui analysent les événements au fur et à mesure de leur acquisition pour prendre la décision finale de les garder ou non, est également la responsibilité exclusive du groupe canadien.

## LES RÉSULTATS PHYSIQUES: UN BON DÉPART

Les premières collisions électrons-protons ont eu lieu en automne 1991. En mai 1992, avec les détecteurs en place, les premiers tests ont été executés avec un paquet de particules dans chacune des lignes de faisceau et à $10^{-4}$ de la luminosité nominale. Deux mois plus tard, il s'agissait de 10 paquets de protons ou d'électrons, d'une intensité améliorée et d'une première série de prise de données. Et encore deux mois plus tard, un autre ordre de grandeur était obtenu dans la quantité et la qualité des données amassées par les expériences. Plusieurs résultats ont déjà été obtenus à partir de ces premiers échantillons[6].

Des événements de diffusion inélastique profonde ont été observés[7]. La plupart correspondent au diagramme de la figure 5, où l'on voit que l'électron incident interagit avec un des quarks du protons par échange d'un photon.

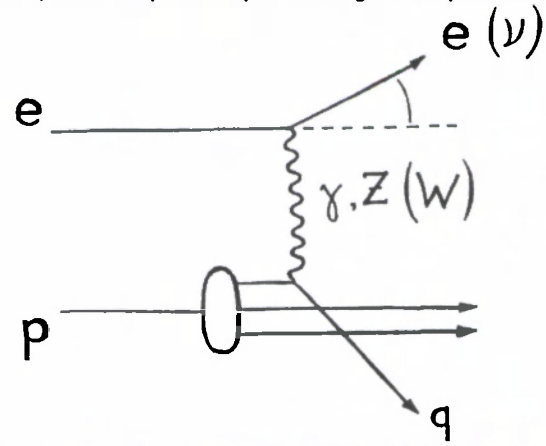


**Fig. 5 Diagramme de diffusion inélastique profonde avec courant neutre (ou chargé).**

[5] Énergie Atomique du Canada Limitée, Chalk River
[6] Tri-University Meson Facility, Vancouver

L'électron est alors diffusé, tandis que le quark s'hadronise et devient un "jet" et que les fragments du protons font de même, mais dans la direction originale du proton. Un tel événement est qualifié de courant neutre, parce que le photon intermédiaire (qui pourrait aussi être une particule $Z^0$) n'est pas chargé. Un événement de courant chargé verrait la particule intermédiaire être un $W^{\pm}$. Ainsi, l'étude de la diffusion inélastique profonde à HERA couvre tous les bosons intermédiaires de la théorie électro-faible. Les premières indications des expériences confirment les prévisions de la théorie.

Si l'on appelle $\sqrt{s}$ l'énergie disponible dans le centre de masse, $x$ la fraction de la quantité de mouvement du proton que possède le quark frappé, et $Q^2$ le carré de la quantité de mouvement échangée par le photon virtuel, la cinématique de la réaction peut être définie. En sondant l'intérieur du proton, sa structure est révélée en termes de la densité de partons (i.e. de quarks et de gluons) en fonction des variables cinématiques. Avec HERA, deux nouveaux ordres de grandeur en $x$ et en $Q^2$ sont maintenant accessibles, grâce auxquels les fonctions de structure deviendront beaucoup mieux connues. Toute déviation par rapport au modèle standard impliquera des corrections à la théorie de la chromo-dynamique quantique ("QCD" qui décrit l'interaction forte), ou l'existence d'autres particules intermédiaires, etc.

À de très petites valeurs de $Q^2$, soit lorsque le photon d'échange est quasi-réel, on peut démontrer que la section efficace électron-proton est proportionnelle à la section efficace photon-proton pour laquelle des modèles théoriques existent. Les valeurs préliminaires obtenus par H1 et ZEUS l'ont été à des énergies beaucoup plus grandes que jamais auparavant. Elles ont déjà permit d'éliminer plusieurs modèles théoriques et de préciser le domaine des fonctions de structure hadronique du photon lui-même[8]. Des processus de diffusion dure ont été observés[9].

Une autre des interactions les plus fréquentes est la création de paires quark-antiquark lourds à partir du photon d'échange de l'électron et d'un gluon provenant du proton, comme illustré à la figure 6. De tels événements ont été observés. Ils conduiront aux fonctions de structures des gluons et à l'étude de la physique des quarks lourds *c* et *b*.

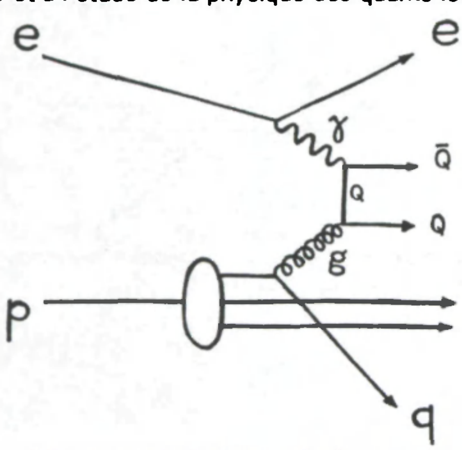


**Fig. 6 Diagramme de fusion quark-gluon avec production de quarks lourds.**

Il existe aussi des théories supposant l'existence d'états couplés entre l'électron et un quark du proton: les lepto-quarks. La signature de tels états serait un pic aigu dans la distribution en $x$. Sa non-observation dans les premières données a aussitôt permis de fixer une limite minimum pour la masse d'une telle particule: de l'ordre de 170 GeV[10].

## AU PROGRAMME CETTE ANNÉE

Après ces premiers résultats très encourageants, HERA s'est déjà préparé pour sa seconde année. Des tests ont démontré le fonctionnement de l'accélérateur avec plus de 100 paquets de particules au lieu de 10 et la luminosité pourra en conséquence augmenter d'au moins un autre ordre de grandeur.

Les détails des fonctions de structure mentionnées ci-haut devraient apparaître. En étudiant les comportements dans les nouveaux domaines des variables cinématiques, on sera à même de confirmer ou d'exclure l'existence de certains types de particules ou d'évolutions.

La quête à peine amorcée de particules dites exotiques (lepto-quarks, $e^*$, super-symmetriques,...) se continuera. Et comme dans toute expérience, un oeil critique doit être gardé ouvert pour toute indication de phénomène physique nouveau.

Avec l'augmentation de la statistique, les expériences seront en mesure de passer du stage préliminaire de la vérification ou la réfutation de modèles théoriques à celui de la déduction de nouvelles quantités physiques. Nombre de sections efficaces, en particulier dans les régions cinématiques maintenant ouvertes, pourront être déterminées.

La physique aux basses valeurs de $x$ offre aussi un façon très attrayante de comprendre la composition en quarks et gluons du proton. On s'attend à un accroissement de la densité des gluons et des quarks de la mer pour des valeurs de plus en plus petites de $x$, donnant lieu éventuellement à des effets de saturation ou encore de "points chauds" où se concentreraient les partons.

## À LONGUE ÉCHÉANCE

HERA est en mesure non seulement d'accélérer des électrons ou des positrons, mais aussi de les polariser longitudinalement en utilisant la polarisation transversale générée par bremsstrahlung. Cette avenue prometteuse constituera un test très strict de la théorie électro-faible en cherchant par exemple des événements de courant de droite, alors qu'on pense qu'il ne devrait pas y en avoir.

Une troisième expérience, HERMES, plus petite que H1 ou ZEUS, vient d'être approuvée et sera installée à la zone est de HERA. Elle utilisera aussi les faisceaux d'électrons polarisés sur des cibles fixes également polarisées pour déterminer la structure en spin du proton. De récents tests ont démontré qu'une polarisation d'au moins 56% était possible[11]. Le Canada est solidement représenté dans HERMES avec la participation des groupes de l'Alberta, Simon Fraser, et TRIUMF.

# REPORT ON ACTIVITIES
# COMPTE-RENDU

## 1992-93

## CANADIAN ASSOCIATION OF PHYSICISTS
## ASSOCIATION CANADIENNE DES PHYSICIENS

JUNE/JUIN 1993

**CANADIAN ASSOCIATION OF PHYSICISTS**

**ASSOCIATION CANADIENNE DES PHYSICIENS**

151 SLATER, SUITE 903, OTTAWA, ONTARIO K1P 5H3 TELEPHONE: (613) 237-3392 FAX: (613) 238-1677

## PRESIDENT'S REPORT

Clearly the challenging years are not yet over, in fact may only be beginning for Canada, for physicists, and for the CAP. Many challenges were met in the past year, and most were overcome. Once again, balancing the budget was difficult, but by the exercise of great diligence, a modest surplus was produced enabling us to begin building up our sadly depleted reserve fund with a transfer of $25,000. Most of the credit for this achievement must go to our Honourary Secretary-Treasurer, John Alcock, who this year retires after 4 years of outstanding service, and to Francine Brûlé, who not only survived her first full year in the office despite the serious illness and eventual resignation of Judy McCool, but even managed to institute many improvements: the renewal form was redesigned and was at least partly responsible for the increase in early renewals and the spectacular decrease in incorrectly completed forms; the accounting and database systems have been vastly improved, thanks in part to a new computer; and problems over GST were greatly diminished.

The year began with a rent crisis for our office at 151 Slater caused by the demise of the Canadian Student Pugwash (CSP) society. This could have been disastrous for us if a satisfactory agreement had not been reached with the landlord, Metcalfe Realty. The negotiations were long and arduous, but eventually a reasonable solution was found, a solution that gives even easier access to old records at a lower storage cost.

Although the Executive was disappointed at the rejection by the members of the proposal to create a category of Fellow, they were heartened by a number of other achievements: Physics in Canada has greatly improved in content, appearance and in finances; we took part in a successful lobby on Parliament Hill in November; the American Physical Society and the Sociedad Mexicana de Fisica have agreed to help us celebrate our 50th Anniversary at Laval in 1995; we are one of three sponsoring groups for CAM 94, the Canada-America-Mexico International Conference to be held in Cancun at the end of September 1994; and by the time you read this it seems likely that we will have entered into a joint agreement with the American Physical Society. The Executive expects that this will lead to a similar agreement with the Sociedad Mexicana de Fisica. A step in this direction has already been taken by our enthusiastically accepted offer to register their members free of charge at this year's Congress at Simon Fraser.

Many of you have commented favourably on the newsletter that I have been sending to all Physics Department Chairs, Councillors, Division Chairs and as many Physics Clubs as can be accessed, although the addresses of the latter have a very short lifetime. I know that some Department Chairs have been circulating these newsletters to all staff members. It is hoped that in this way all physicists in Canada will be more aware of the activities of the CAP and its relevance to them. Clearly there is at the moment a notable gap: industrial physicists are totally overlooked.

In conclusion, I thank all my colleagues on the Executive, on the Council, the Division Chairs and the CAP office for their diligence and help; and welcome our new Honourary Secretary-Treasurer, Gary Enright.

J.C.D. Milton
President

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## 2. SUBJECT DIVISIONS

The activities of the Subject Divisions are an important part of the affairs of the Association. The reports from our thirteen Divisions are summarized below. The officers of the Divisions are listed in Section 1.2. The membership figures are given in the Annual Report p.2.

### 2.1 Division of Aeronomy and Space Physics

The traditional DASP Winter Workshop was held in Saskatoon contiguous with CANOPUS and CNSR meetings during the week of February 21, 1993. (The latter two acronyms are explained below.) A total of 52 papers from the Canadian community were presented, including 6 invited. All told, there were 76 registered space scientists at the meeting, and the banquet attendance was 86. At the banquet, Dr. Alister Vallance Jones was honoured for his great contributions to Canadian space science over the past 40 years. He presented a lively review of his productive career, and showed a series of slides documenting that career. This tribute by the DASP community to an eminent member who has reached retirement was a first. The talk by Dr. Jones added so much colour to the banquet that the practice of periodically honouring a scientist will likely be continued.

At the workshop, more papers would have been presented had sufficient time been available. There was for the first time a special industrial session in which papers were presented by members of six industries involved in the business of Canadian space science. A DASP business meeting was also held. The invitation of Dr. Gordon Shepherd to host the 1994 Winter Workshop at York University was accepted.

The quality and quantity of papers at the workshop reflects the vigorous state in which the DASP community currently finds itself. Several sources have contributed to the creation of this state. The Canadian Space Agency (CSA) and its predecessors have provided our community in recent years with a number of satellite and ground-based instruments. Data from these have been the source of many significant contributions to solar-terrestrial physics. These instruments include the Suprathermal Mass Spectrometer (SMS) on the Japanese Akebono satellite, UV Imager Systems on the Swedish Viking and Freja satellites and the Cold Plasma Analyser (CPA) on Freja. The CANOPUS ground array of remote sensing instruments, which has satellite instrument status in the international solar-terrestrial physics program (ISTP), is also supported by the CSA. (ISTP is a multi-national, multi-satellite mission to study the flow of electromagnetic and particle energy from the sun, its interaction with the earth's magnetosphere and the storage, transformation and dissipation of energy within the magnetosphere).

In addition, Canadian scientists have been invited and will, with CSA support, contribute a UV Imager System to one of the Russian Interball satellites and a Thermal Plasma Analyser (TPA) to a Japanese satellite mission to Mars. These and earlier invitations reflect the high regard for the Canadian instrument science teams held by foreign satellite mission scientists.

Another very significant contributor to the current state of the DASP community is the federal government through its funding of the Canadian Network for Space Research (CNSR) as part of its Networks of Centres of Excellence program. CNSR activities have led to a dynamic enhancement in the quality and volume of Canadian research on the middle atmosphere, on the auroral and polar ionosphere and above, and in the number of participants in that research. CNSR is also involved in spacecraft instrumentation, an activity which is of benefit to Canadian industry and of assistance to the CSA in carrying out its mandate.

This healthy state of the DASP community saw it well placed two years ago for a group of its members to apply for an NSERC collaborative special project and program grant for "The Canadian Component of SUPERDARN" (The Super Dual Auroral Radar Network). SUPERDARN is an international collaboration which consists of pairs of overlapping doppler HF radars which can provide a complete convection map of ionospheric plasma flows in the f-region, from which a electric field map can be derived covering the auroral zone and part of the polar cap. The Canadian-funded radar at Saskatoon is the Western partner for the Kapuskasing radar built by Johns Hopkins University Applied Physics Laboratories. Funding for nine radars is now in place, including six in the northern hemisphere and three in the southern hemisphere; of the nine, three are in Canada. Funding will be sought for another three or four. This Superdarn program is also part of ISTP which makes this Canadian effort coherent with that described above.

All of this support has led to a significant increase in the numbers of graduate students and research associate scientists. The DASP community has never been in a better position to make contributions of international stature and is doing so. The existing state of the community could, however, relax to a less dynamic level if financial support were to significantly decline or if, as Prof. Rostoker keeps reminding us, there is no improvement in permanent employment prospects for our younger colleagues.

## 2.2 Division of Atomic and Molecular Physics

One of the major events of the Division in the year 1992-93 was the CAP Annual Congress held at the University of Windsor. DAMP organized a symposium on "Advances in Atomic Physics" with the following invited speakers: John C. Nickel (California, Riverside, co-author: Sander Trajmar, CALTEC, Pasedena), Walter E. Kauppila (Wayne State), Gordon W.F. Drake (Windsor), and S. Pedro Goldman (Western Ontario). Another symposium was jointly organized by DAMP and the Division of Optical Physics (DOP) at this Congress and the invited speakers were George C. Tabisz (Manitoba), William A. Van Wijngaarden (York), S.L. Chin (Laval; co-authors: J.E. Decker, F. Ilkov, Y. Liang and G. Xu), and Karl H. Welge (Biclefeld, Germany). In addition, 12 contributed oral papers and 20 poster papers dealing with various topics in Atomic and Molecular Physics were also presented.

The second major event was a DAMP/DOP joint meeting held on October 29-31, 1992 at the Université Laval. About 100 attendees including Nobel Laureate Gerhard Herzberg attended the meeting. The invited talks plus the contributed oral presentations totalled 28 papers and there were 50 poster papers. All in all it was a very successful joint meeting between DAMP and DOP, representing an excellent cooperation between these two Divisions. The Local Committee with Emile Knystautus (from DAMP) and Roger Lessard (from DOP) as co-chairs made excellent arrangements for the meeting and the banquet.

Members of DAMP are aware of the three year cycle of the Division Meetings introduced recently. According to this cycle the traditional Autumn/Fall Meeting is held in one year; the Joint Meeting of DAMP and the Division of Atomic, Molecular and Optical Physics (DAMOP) of the American Physical Society is held in the second year; the Divisional Meeting takes place at the CAP Annual Congress in the third year.

The third important event is a Joint Meeting of DAMP with DAMOP, being held in Reno, Nevada on May 16-19, 1993. The host institution is the Physics Department, University of Nevada, Reno. Scientific sessions and accommodation are located at the Negget Hotel in Reno. Eleven invited symposia, ten sessions of contributed papers, and three sessions of poster papers are included in the program. Gordon Drake (Windsor) has been acting as DAMP representative to the Program Committee. The next DAMP/DAMOP Joint Meeting will be held at the University of Toronto from May 18-20, 1995. The local committee consists of A. David May (Toronto), Chair, Eric Hessels (York), and William Van Wijngaarden (York).

The Newport Awards to students working in the area of optical sciences, initiated under criteria set by DAMP, DOP and DIAP, were considered again this year. By the principle of rotation, S.P. Reddy (DAMP) chaired the committee and the other members were H.M. van Driel (DOP) and A.E. Dixon (DIAP). The two winners of $1500 scholarships will be announced at the CAP Congress at Simon Fraser University.

## 2.3 Canadian Geophysical Union

The Canadian Geophysical Union is a national geophysical organization active in bringing together and promoting all of the geophysical sciences. The Union provides a focus for geophysicists in Canadian universities, government agencies and industry who study the composition and processes of the whole earth including space studies and geodesy. The membership of the Union is slowly increasing and is approaching the 450 level.

One of the most important activities that contributes to the good health of the Union is the success of our annual scientific meeting, this year held jointly with the American Geophysical Union, May 12-16, 1992 in Montreal. With approximately 2700 scientific papers and about 25 of the scientific sessions led by Canadian geoscientists, this meeting was one of our most successful to date. For the 1993 meeting (May 9-11), the CGU will return to Banff and will continue to hold the annual gathering at that location for a number of years. In this way, the Union can focus its energies on the program, rather than on logistics, and thereby promote scientific participation.

At the joint Montreal meeting, the J. Tuzo Wilson Medal for 1992 was awarded to R.D. (Don) Russell for his many outstanding contributions to the world of geophysics, especially isotope studies. The Wilson Medal is the CGU's premier award honouring Canadian geophysicists. The program of the best student paper awards has continued to be a very useful means of stimulating participation in CGU activities by our graduate students. Although no competition was scheduled for the Montreal meeting, the CGU sponsored the best student paper award at a specialized international meeting, the 5th International Workshop on Seismic Anistropy held in BANFF, Alberta. The prize was awarded to Heiner Igel from the Institut de Physique du Globe, Paris.

The Distinguished Lecturers program for 1992/93 sponsored an extensive tour by Ron Hyndman from Victoria B.C. to St. John's, Newfoundland. He will provide additional lectures to Central Canada during the fall of 1993. He is offering three lectures, entitled "The Structure and Cenozoic Plate Tectonics of the Continental Margin of Western Canada", "Thermal and Deformational Constraints on the Locked Zone of the Northern Cascadia Subduction Thrust", and "Geophysical Studies of the Lower Continental Crust - are there fluids present?".

Given the increasing appreciation of the wide range of geophysical sciences that must be brought together in the context of the international research effort on global change, the CGU is working vigorously to develop its scope in the broadest possible way. Although the Union must continue to serve as the focus for organized national activity on the physics of the solid earth, there is much to be gained by seeking increased membership from researchers in related fields, and to seek to develop a formal alliance with geophysicists working in the areas of oceanography and atmospheric science, to name but two. At the 1993 Banff meeting, members of the hydrological sciences community will hold a special scientific symposium by way of announcing their commitment to a partnership in the expanding CGU. The growth of the CGU was expressed in a symbolic form by the adoption of a new logo in which each of the geophysical sciences is given equal prominence. In the four quadrants of the circle are contained symbols representative of the solid earth, the oceans, the atmosphere and space.

The legal work required to incorporate the Union is nearly in place and this should prove extremely useful in helping the CGU to attract financial contributions to the various programs, including awards and the distinguished lecturer series. The CGU has also begun to play a more visible role internationally, not only in the context of interactions with the AGU and the European Geophysical Society, but also in the role of host for major international conferences such as the International Studies of the Earth's Deep Interior meeting that will be held in August, 1994 at Whistler, B.C.

## 2.4 Division of Condensed Matter Physics

The Division of Condensed Matter Physics continued its traditional high level of involvement in the CAP Annual Congress, accounting for approximately one-half of the contributed papers at the 1992 Annual Congress in Windsor. Invited sessions were held on the following subjects:

1. Semiconductors (Roorda, Schultz) plus 11 contributed oral papers
2. Synchrotron Physics (Bancroft, Crozier, Sutton, Gaulin)
3. Condensed Matter Theory, joint session with the Division of Theoretical Physics (Desai, Côté, Joós, Grindlay)

There was also a contributed oral paper session on phase transitions, with 11 presentations, and over 40 posters in the area of condensed matter physics.

The Windsor Congress saw the introduction of the idea of having the Annual Symposium of the Division in conjunction with the Annual Congress of the CAP. In Windsor, a highly successful Symposium on superconductivity was organized for the Sunday preceding the Congress by Allan Griffin, Jules Carbotte and Catherine Kallin. The executive of the Division are indebted to these volunteers for their efforts in producing a well attended and very informative session. In addition to 10 contributed oral papers there were 6 invited presentations (Statt, Bonn, Marsiglio, Scalapino, Kiefl, Taillefer).

At the Windsor Congress Prof. Michael Thewalt of Simon Fraser University was elected Chairman of the Division for 1992-93 and Dr. Eric Svensson of AECL was elected Vice-Chairman. Prof. Robert Cochrane of the Université de Montréal assumed the office of Past-Chairman, and Prof. Bela Joós of the University of Ottawa was elected Secretary-Treasurer, taking over from Prof. Anthony Simpson, Dalhousie University, to whom thanks are due for his years of service.

Continuing a long standing tradition, a committee was again formed to determine the best condensed matter physics paper published in the Canadian Journal of Physics during the current year, July 1991 to June 1992. The committee, consisting of Eric Svensson and Sjoerd Roorda, selected as this year's winner the paper by K.B. Strawbridge and F.R. Hallett entitled "Polydisperse Mie Theory Applied to Hollow Latex Spheres: An Integrated Light-Scattering Study", Canad. J. Phys. 70, 401 (1992). Prof. Hallett will present an invited talk on this work at the beginning of the Wednesday afternoon DCMP session at the SFU Congress.

Two divisional newsletters were distributed to the members during the year. The Fall newsletter contained the minutes of the annual business meeting held in Windsor and a call for suggestions for invited speakers and topics for the Sunday DCMP Symposium at the upcoming Annual Congress of the CAP to be held at SFU. A Spring newsletter was later circulated to publicize the Sunday DCMP Symposium which is to be on the topic of "Condensed Matter Physics and Materials Science Requiring Large Facilities". The symposium is aimed at a general condensed matter physics audience who would be interested in learning about new developments in physics and techniques involving neutron scattering, synchrotron radiation studies and $\mu$SR. There will be an emphasis on outlining what is happening in Canada in these fields, and what the future possibilities and proposals are. This is an opportune time for the wider community to become involved in and informed about these issues, as very important recommendations and funding decisions directly influencing all of these fields will have to be made in the near future.

## 2.5 Division of Medical and Biological Physics

No report was available at the time of publication.

## 2.6 Division of Nuclear Physics

During the past year, the division organized two invited sessions and one contributed session at the Annual CAP Congress and also made a presentation to the Nuclear and Particle Physics Advisory Panel at the town meeting held on the Sunday before the Congress. Two Regional Meetings were organized. The Western Meeting was held February 19-21 at Lake Louise followed by the Lake Louise Winter Institute. The Eastern Regional Meeting was hosted by Chalk River Laboratories March 5-7 at CRL/Pembroke. This year it was decided to award prizes for the best graduate student talks. The winners were Greg Hackman, McMaster University and James Powell, University of Toronto. This new initiative was very successful. The number of contributions increased over previous years and all of the talks were well presented. A divisional e-mail newsletter was also initiated this year with the first issue in February 1993.

At the Eastern Regional Meeting, informal discussions were held concerning the formation of a broadly-based Nuclear Physics Institute to promote the interests of all nuclear physicists. With one exception, attendees who spoke at the meeting were in favour of the proposal and many expressed a willingness to devote some effort towards forming an institute. Representative members of the Canadian nuclear physics community will meet in May to work on the formation of the institute.

## 2.7 Division of Optical Physics

During the past year DOP has been under the leadership of Henry van Driel (University of Toronto) as Chair and Truong Vo-Van (Université de Moncton) as Vice-Chair. The 1992 CAP Congress in Windsor featured several excellent symposia arranged by DOP, some in collaboration with DPP, DIAP and DAMP. The sessions and invited speakers were:

Diverse Applications of Lasers: Polanyi, McCarthy, Patterson and Measures
Imaging and Optical Spectroscopy Applications: Hockley, Reid, Fenster, Patterson and McGeorge
Joint Symposium on Optical, Atomic and Molecular Physics: Tabisz, Van Wijngaarden, Chin and Welge
Graduate student winners of the Newport awards in electro-optics were S. Mailhot (Université Laval) and M. Stoer (University of Victoria).

From October 29-31, 1992 a very successful joint DAMP/DOP meeting was held at Université Laval. More than 85 registrants participated in the mini-conference which featured several contributed and invited talks with G. Herzberg as the distinguished invited speaker. Dr. Herzberg discussed his work over the last several decades on the ionization potentials of $H_2$ and $D_2$. A superb banquet was arranged at the Musée du Quebec in Quebec City. Special thanks go to E. Knystautas, R. Lessard and the rest of the local committee for organizing the event and the Université Laval for making their facilities available. These meetings clearly illustrate how the optics/spectroscopy community is strengthened by the overlapping interests of the two divisions and by their cooperation in arranging these meetings.

The 1993 CAP Congress in Burnaby, B.C., features several sessions with invited speakers. These are:

Symposium on Optical Waveguides: Ouellette and Lacroix
Session on Lasers: May
Session on Optical Imaging: Rioux
Joint Symposium on Optical Atomic and Molecular Spectroscopy (with DAMP): Tetu, Madej, Haugen and Shelton

During the past year members of DOP have been active in bringing international conferences to Canada and helping to organize them. In particular the SPIE (International Society for Optical Engineering) will hold a 1993 International Symposium on Holography, Microstructures and Laser Technologies in Quebec City, August 15-21. R.A. Lessard (Université Laval) is the Symposium Chair. The CAP is one of four Canadian organizations sponsoring the event. From October 3-8 the Optical Society of America will hold its Annual Meeting in Toronto. The meeting is held in cooperation with the CAP and A.J. Alcock (NRC) is the Program Chair.

## 2.8 Division of Particle Physics

The Division continued with its traditional activities of organising the particle talks at the annual CAP Congress. The Division sponsored the "Beyond the Standard Model III" Conference which was held at Carleton University June 22-24, 1992. The Conference was attended by 120 physicists from North America, Europe and Japan. Divisional funds were used to subsidize the participation of Canadian graduate students, of which 40 attended. The proceedings are being published by World Scientific.

Members of the Division continue to be involved in the organization of a number of conferences, institutes and symposia:

This year's TRIUMF summer institute is being held July 19-July 30 and is being organized by Mike Vetterli and Byron Jennings. Further information can be obtained by contacting VETM@ERICH.TRIUMF.CA.

The topic for next year's Lake Louise Institute is Particle and Nuclear Astrophysics and Cosmology to be held Feb 20-26, 1994. It is being held in conjunction with the Seattle Theoretical Nuclear Physics Institute. Further information can be obtained from LLWI@UALBERTA.CA

The International Symposium on Heavyflavour Physics is being held at McGill University July 6-10, 1993. It is being chaired by David MacFarlane. Further information can be obtained from HFLAVOUR@PHYSICS.MCGILL.CA

Plans are being implemented to create an e-mail distribution list of the divisional members. This will be used to distribute information to the membership, to poll them on issues that may come up, and to report on the Council meetings.

### 2.9 Division of Physics Education

The Division sponsored an all day session (coordinated and chaired by Nigel Hedgecock) at the 47th Annual Congress in Windsor which featured a wide variety of presentations. Dr. Ian Crawford of the faculty of Education at Windsor discussed several topics in science teaching and teacher training while some aspects of computer based courses in Physics were discussed by Dr. W. Baylis (Windsor) and Drs. R.B. Hicks and H. Laue (Calgary).

The 1993 Lecture Tour was again coordinated on a regional basis, as initiated by Nigel Hedgecock in 1992. Under this format there were four regional coordinators in 1993 (G. Mason - West, R. Barber - Prairies, P. Sinervo - Ontario and Quebec, D. Dahn - Maritimes) who arranged for the speakers at the universities and colleges within their region. Coordinating the tour in this manner has enabled us to gain better control over the costs involved and in addition to be more responsive to the wishes of the individual institutions. The four coordinators listed above devoted considerable time to the 1993 tour and merit a large vote of thanks from all members of the association. See Section 5.2 for tour details.

On the administrative side, Chuck Irwin (SFU) became Chair of the Division for 1992/93, Bev Robertson (Regina) assumed the duties of Vice-Chair and Georgina Lees (UNB) remained Secretary-Treasurer for a second year.

We believe that we have managed to compile a very interesting DPE session for the 1993 Congress at SFU which will feature a plenary lecture by Prof. L. McDermott (University of Washington). It is hoped that the DPE membership will constitute a strong presence at the session and at the Congress. For 1993 we have been allowed to offer high school and college teachers a special registration rate ($25/day) and hopefully this will enable many B.C. teachers to attend, participate and benefit from the DPE sessions. In summary we are anticipating a lively and interesting session.

### 2.10 Division of Plasma Physics

The meeting and presentations for the Division of Plasma Physics, held in conjunction with the Annual Congress at the University of Windsor, were quite successful. After several years of concentrating on poster sessions, the division held a morning session of oral presentations and and an afternoon session of invited speakers. The attendance was quite good and those present felt that the format was worthwhile. Two students, Xavier Bonnin (INRS-Energie) and Bruno La Fontaine (NRC), were awarded travel support to the annual meeting, a program made possible by a donation from Fusion Canada.

This year, the Division is organizing a one-day workshop on the interaction of ultra short laser pulses with materials and the related studies of dense plasmas. This new and exciting field has already attracted many researchers from across Canada and the workshop will give us an opportunity to discuss and formulate scientific objectives for the study of ultra short laser pulse interaction physics and strengthen collaborations between researchers in Canada and abroad. If successful, this one-day symposium could become a permanent feature of DPP activities during the CAP Congress.

### 2.11 Division of Theoretical Physics

No report was available at the time of publication.

## 2.12 Division of Industrial and Applied Physics

DIAP Honours and Awards Committee: Nine candidates were nominated for the 1993 CAP Medal for Outstanding Achievement in Industrial and Applied Physics. I (A.E. Dixon) was particularly impressed with the quality of the candidates. The medal was awarded to Dr. J.J.A. Beaulieu of the Defence Research Establishment at Valcartier, for his pioneering work in lasers. His work with TEA lasers led directly to the formation of Lumonics, and thus resulted in many benefits for Candaa. This committee was chaired by Paul Vincett, and it is mainly due to his efforts and direction that it has worked so well.

Newport Awards: Seven candidates were nominated for two awards. The committee was chaired by Professor S.P. Reddy, Chair of the Division of Atomic and Molecular Physics.

DIAP Speakers at CAP Congress: The Plenary Speaker on Tuesday morning was Dr. James Wyant, president of Wyko Corp. and a professor at the Optical Sciences Centre of the University of Arizona. He is editor of "Applied Optics", and a past president of SPIE. An academic who founded a company based on Physics from his own laboratory, he has kept his university and research connections while building his company. Carla Miner, of BNR, and Savvas Chamberlain, of the University of Waterloo, were invited speakers heading up the DIAP sessions Industrial Physics I and II.

## 2.13 Division of Surface Science

The division's "Surface Canada" conferences are held every two years, and 1992 was not a conference year. Nonetheless, we organised (as usual) symposia at the Annual Conferences of the CIC and CAP. At the 75th Canadian Chemical Conference in Edmonton, Prof. Dan Thomas (University of Guelph) organised a symposium on "Reactivity at Surfaces" which included two international invited speakers (K.E. Johnson, IBM Almaden and S.M. George, U. of Colorado). We also sponsored, jointly with the Inorganic and Physical/Theoretical divisions a symposium organised by Prof. Ron Cavell, (U. of Alberta) on "Chemical Applications of Synchrotron Radiation (II)". At the CAP Annual Congress in Windsor, Prof. Tong Leung (U. of Waterloo) organised symposium on "New Imaging Techniques" and "Beams Applications for Interface Studies" with two international invited speakers (J. Barton, IBM Yorktown Heights and J.W. Rabelais, U. of Houston) and four Canadian invited speakers.

Additionally the division sponsored the "39th Field Emission Symposium", August 1992, organised by Prof. J. Kreuzer (Dalhousie University). This division is now typically sponsoring one or two meetings per year in fields of interest to surface scientists.

### Publications

As in previous years, the division produced two newsletters, an annual buyer's guide listing companies dealing in surface science products, and an updated list of members. The newsletters typically contain a letter from the Chair, upcoming conference information, reports on conferences past, new product information, sketches of programs being carried out in surface science, particularly of starting researchers, and details of openings for postdoctoral and graduate students. Newsletter circulation is now over 400.

We hope to increase the number of surface science articles in *Physics in Canada*. To achieve this, we are experimenting with making a requirement for sponsorship of meetings that the organiser agrees to provide an article on an interesting aspect of the meeting for submission to *Physics in Canada* and/or *Canadian Chemical News*. The first such meeting is the "Atomic Collisions in Solids" meeting in 1993 (see below).

### Membership

In the area of membership, we sent out membership forms with the April issue of the newsletter, to try to join up those who attend our meetings but are not CAP members. We are now also sending welcoming letters to new members who join the division. We will also be encouraging participants of next year's Surface Canada meeting to join if they are not already members.

### Activities Planned for 1993

The Surface Canada '93 Conference (14th Canadian Seminar on Surfaces) will be held in Winnipeg, May 26-28, 1993, and will be the Division's main activity in 1993. The Plenary Lecture will be given by Prof. C.F. Quate, Stanford University, on scanning probe microscopy. There will be sessions on electrochemical interfaces, soft surfaces, surface modification of material by plasmas and particle beams, oxidation and corrosion, semiconductor interfaces/surfaces, and surface aspects of mass spectroscopy. An STM/AFM workshop will be held following the meeting on May 29, and will include an invited lecture by R. Colton (Naval Research Lab.).

The division is participating in two symposia at the 76th Canadian Chemical Conference in Sherbrooke. Paul Rowntree (U. de Sherbrooke) and Michel Poirier (CANMET, Varennes) are organizing a symposium (joint with the Catalysis Division) on "Correlations Between Surface Structure, Reactivity and Catalysis", and Peter McBreen (U. Laval) and Dennis Salahub (U. de Montreal) are organizing a symposium on "Clusters". At the 1993 CAP Annual Congress, June 13-16, 1993, Simon Fraser University, Bret Heinrich will be organizing two half-day symposia, one on "Interfaces in Nanostructures", and one in recognition of Roy Morrison.

The division will be sponsoring the "15th International Conference on Atomic Collisions in Solids" at the University of Western Ontario, July 26-30, 1993, organized by Prof. Willy Lennard.

Now that the division has the Hobson Award (Best Student Presentation at the Surface Canada meeting) on a sound financial footing, we plan to investigate the possibility of a major award in the field of surface science.

## 3. MEMBERSHIP

### 3.1 Categories of Membership

There are three categories of membership in the CAP. Full membership is open to anyone who holds a Bachelor's degree in physics or a related subject; thus, graduate students belong as full members. Full members are entitled to all the rights and privileges of the Association. The category of affiliate membership is intended for those whose primary professional interest is in a field other than physics. Student membership is available only to undergraduate students in physics. Full members in good standing may, before the age of 30 and upon reaching retirement, take advantage of reduced fees, as can graduate, undergraduate members. The CAP also offers joint memberships with the Chemical Institute of Canada (CIC) and the Canadian Organization of Medical Physicists (COMP).

### 3.2 Rapport du comité de recrutement des membres/Report of the Membership Committee (R.A. Lessard)

Cette année, la campagne de recrutement a été axée surtout sur la sensibilisation des membres à maintenir une association forte pour la défense des droits et intérêts des physiciens. Jusqu'à maintenant, nous avons à peu près maintenu le nombre de nos adhérents. Les derniers avis de renouvellement ont été envoyés beaucoup plus tôt cette année car nous espérons que nos membres predront l'habitude de renouveler leur Adhésion dès la fin de l'année ou du moins dès le tout début de la nouvelle année.

Je voudrais, à titre de président de la campagne, souligner l'excellent travail qui s'es fait au Congrès des prégradués. En effet, le congrès des prégradués tenus à Ottawa a fait passer le nombre d'adhésion des étudiant(e)s en physique de 30 à 73. Nous espérons que cet enthousiasme chez nos jeunes pourra se maintenir car ils représentent notre futur force.

De plus, cette année, nous avons tenté de convaincre le plus grand nombre possible de directeurs de département de physique qu'il leur était bénéfique de se joindre à l'ACP comme membre institutionnel. Comme vous le savez, au Québec, une part importante des cours de physique se donne dans les CÉGEPS. J'ai donc invité les départements de physique de ces institutions d'enseignement supérieur à adhérer à l'ACP comme membre institutionnel. Quelques uns ont déjà répondu à l'appel. Peut-être existe-t-il d'autres institutions d'enseignement de la physique qui pourrait être contactées?

This year's recruitment campaign was primarily geared to sensitizing members to the importance of keeping the association strong so that it can protect the rights and interests of physicists. Up to now we have been able to just about maintain a constant number of members. The final membership renewal notice was sent out earlier this year because we hope that our members will get into the habit of renewing their memberships at the end of each year, or at least, early in the new year.

As recruitment campaign chairman, I would like to stress the excellent work that was done at the Canadian Undergraduate Physics Conference (CUPC). Indeed, the CUPC held in Ottawa was instrumental in increasing the number of physics student members from 30 to 73. We hope that the enthusiasm of our youth continues as they are our future strength.

In addition, this year we tried to convince as many physics department heads as possible that it would be to their benefit to join the Canadian Association of Physicists as institutional members. As you know, in Québec, a large proportion of physics courses are offered at CEGEPs. I have therefore invited physics departments in these institutions of secondary education to join the Association as institutional members. Several have already responded favourably. Are there perhaps other institutions where physics is taught that could be contacted?

Enfin, je crois que nous n'utilisons pas suffisamment les conférenciers de l'ACP comme propagandiste de notre association. Il serait préférable que ces conférenciers soient des gens convaincus de l'importance d'adhérer à l'ACP et qui seraient prêts à faire passer ce message dans une conférence. Plusieurs associations américaines et européennes demandent aux membres de leur exécutif d'agir à ce titre. Il serait bon pour notre association de faire de même et d'augmenter ainsi notre visibilité.

Enfin, its serait peut-être temps de donner plus d'importance à nos divisions qui elles pourraient revaloriser auprès de ces membres le rôle et le travail de l'Association canadienne des physiciens.

Furthermore, I believe we do not make sufficient use of CAP Lecturers as spokespersons for our Association. These lecturers should preferably be individuals who are convinced of the importance of belonging to the CAP and who are ready to get that message across during a lecture. Several American and European Associations ask that their executive members take on this task. In my opinion, our Association should do likewise, thereby increasing our visibility.

Finally, the time has perhaps come to increase the profile of our Divisions, so that they can in turn highlight the role and the work of the Canadian Association of Physicists among their members.

3.3 **Details of the paid up membership for 1993 with comparative figures for 1992 are given in the Annual Report.**

3.4 **Report of the Director, Affiliate Members** (H. Okada)

In the past year, the Director of Affiliate Members attended all Executive Council meetings and actively participated in a number of CAP sponsored events. Activities included attendance at the 1992 Annual Congress in Windsor, the organization of a University of Toronto graduate display booth at the Canadian Undergraduate Physics Conference in Ottawa, and promotion of the CAP Lecture Tour and University Prize Examinations.

The Association of Professional Engineers of Ontario and the Ontario Association of Physics Teachers were notified of the upcoming Annual CAP Congress and asked to advertise the event in their publications. Letters were sent to all CAP affiliate members encouraging input and feedback through their director.

If you have any questions regarding this or any other CAP matter please contact me.

| | |
|---|---|
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4. **CORPORATE MEMBERS** (P.S. Vincett)

The category of Corporate Members is established for those institutions with a responsibility or desire to promote and support the science of physics and its technical applications in Canada through the activities of the Association. Corporate Membership is particularly sought among those industrial organizations and government laboratories which employ substantial numbers of physicists. The corporate membership of public-spirited organizations which do not employ physicists is also much appreciated. Corporate membership fees are deposited in the tax-exempt Educational Trust Fund.

4.1 **Corporate Members Report for 1992-93**

The CAP Corporate Membership was roughly stable in 1992, in the midst of a severe recession in which some Corporate Members either disappeared or radically re-structured. Fortunately, there were enough new members to offset the losses. With the very positive recent trends in individual CAP memberships, we hope to see a comparable upswing in Corporate Memberships in the coming year. The health of the Canadian scientific enterprise and the industries which rely on it can only be improved if governments and the public come to a much better understanding of its importance and what needs to be done to foster it. A strong Corporate presence in the CAP is essential if many of the efforts which the CAP undertakes in promoting and defending the interests of the physics and technical community are to address the right questions and propose realistic answers in the applied area.

After last year's successful experiment, the 1993 Corporate Members' Conference is again being held in the form of two special sessions at the CAP Annual Congress in B.C. These were arranged by Philip Gardner of the TRIUMF Ventures Office, who is the incoming Director of Corporate Members. The sessions are a mixture of practical advice for the budding or existing entrepreneur, together with a number of high-tech success stories (with a particular emphasis on some of the excellent things which are happening in B.C.). Again, the session will be open to all Congress registrants, in the interests of enhancing the contact between the Corporate and academic communities; one of the talks (by Denzil Doyle) has in fact been designated a Plenary Session.

Many other CAP efforts which provide significant value to the Corporate Members have continued this year: such activities include government lobbying, organizing educational activities like the Lecture Tour, and recognizing excellence through the Medal for Industrial and Applied Physics. In addition, most of the Corporate Members' innovations mentioned in last years' report have now been implemented. Perhaps the most visible of these are the Corporate Members section in *Physics in Canada*, which are aimed at improving the visibility of the Corporate Members in the general physics community: once per year, a section of *Physics in Canada* is devoted to short articles by the Corporate Members describing who they are and some of the things they do, and giving news of the previous year, while a regular *"News from Corporate Members"* section carries less formal news and announcements. In addition, in an effort to improve direct University/Corporate links, Corporate Members have been invited to many CAP Lectures and physics department seminars at local universities; there have been some glitches in getting this program underway, but these should be ironed out in the coming year. As always, the Director of Corporate Members would be delighted to receive suggestions for further innovations.

### 4.2 Current Corporate Membership

Accurex Technology Incorporated
Alcan International Ltd.
Allan Crawford Associates Limited
Aptec Engineering Limited
Atlantic Nuclear Services Ltd.
Atlantis Flight Research Inc.
Atmospheric Environment Service
Atomic Energy of Canada Limited
Bell-Northern Research Ltd.
CTF Systems Inc.
Ealing Scientific Limited
Edwards High Vacuum
EG&G Canada Ltd. - Optoelectronics Division
Faircopy Services Inc.
Fisons V.G. Instruments
Gennum Corporation
Hydro-Québec
LeCroy Canada Inc.
Linear Technology Inc.
Lumonics Inc.
MPB Technologies Inc.
National Optics Institute
Newport Instruments Canada Corp.
Ontario Hydro
Optech Incorporated
Rayonics Scientific Inc.
TRIUMF
Xerox Research Centre of Canada

## 5. EDUCATIONAL ACTIVITIES

Educational activities of the CAP are defined as the activities which contribute to the education in physics of the general public and of students up to graduation at the B.Sc level. Activities which are of direct benefit to our full members, including graduate students, are by contrast called professional activities. Educational activities include the CAP secondary school examinations, the CAP university prize examination, CAP Lecture Tours, participation in the Canada-Wide Science Fair and publications on educational subjects.

### 5.1 Educational Trust Fund

The Educational Trust Fund (ETF) is a tax exempt fund in which donations from Corporate Members and individual members are accumulated to support the educational activities of the CAP. The fund is administered by a board of three trustees appointed by the CAP Executive.

### 5.2 The CAP Lecture Tours

The 1993 CAP Lecture Tour was organized on a regional basis again this year. Fourteen speakers visited 31 institutions. Special thanks are sent to all speakers for making this year's tour a success, as well as to the Regional Coordinators (G. Mason, R. Barber, P. Sinervo and D. Dahn) who undertook the next to impossible task of working with both the universities and the speakers to arrange cost effective tours.

# ANNUAL REPORT
# RAPPORT ANNUEL

## 1992-93

## CANADIAN ASSOCIATION OF PHYSICISTS
## ASSOCIATION CANADIENNE DES PHYSICIENS

JUNE/JUIN 1993

Membership Report for 1992
as of December 31, 1992

A total of 97 new members joined or were reinstated in the Association. There were 23 resignations and 163 suspensions.

Members in arrears are kept on CAP records but no longer receive CAP publications or other mailings; they are suspended when they are more than one year in arrears. The details of membership are given in the table below.

| | 1991 Members 31/12/91 | Renewals | New Members | Resigned/ Deceased | Paid up 31/12/91 |
|---|---|---|---|---|---|
| Full Members | 1012 | 918 | 53 | 15 | 971 |
| Graduate Students | 124 | 80 | 30 | 1 | 110 |
| Affiliate Members | 37 | 24 | | 1 | 24 |
| Joint Members | 107 | 108 | | 1 | 108 |
| Retired Members | 87 | 89 | | 5 | 89 |
| Without Fees | 22 | 21 | | | 21 |
| Subtotal | 1389 | 1240 | 83 | 23 | 1323 |
| Student Members | 23 | 13 | 14 | | 27 |
| Total | 1412 | 1253 | 97 | 23 | 1350 |

Membership Report for 1993
as of May 21, 1993

| | 1992 Members 31/12/92 | Renewals | New Members | Resigned/ Deceased | Paid up 21/05/93 |
|---|---|---|---|---|---|
| Full Members | 971 | 894 | 25 | 9 | 919 |
| Graduate Students | 110 | 89 | 10 | 4 | 99 |
| Affiliate Members | 24 | 24 | | 1 | 24 |
| Joint Members | 108 | 102 | | 1 | 102 |
| Retired Members | 89 | 102 | | 1 | 102 |
| Without Fees | 21 | 10 | | | 10 |
| Subtotal | 1323 | 1221 | 35 | 16 | 1256 |
| Student Members | 27 | 12 | 62 | | 74 |
| Total | 1350 | 1233 | 97 | 16 | 1330 |

Membership in Divisions

| | | As of 31/12/91 | As of 31/12/92 |
|---|---|---|---|
| Aeronomy and Space Physics | DASP | 62 | 66 |
| Atomic and Molecular Physics | DAMP | 123 | 108 |
| Canadian Geophysical Union | CGU | 35 | 31 |
| Condensed Matter Physics | DCMP | 192 | 188 |
| Medical & Biological Physics | DMBP | 39 | 37 |
| Nuclear Physics | DNP | 134 | 133 |
| Optical Physics | DOP | 101 | 94 |
| Particle Physics | PPD | 137 | 120 |
| Physics Education | DPE | 68 | 73 |
| Plasma Physics | DPP | 66 | 57 |
| Theoretical Physics | DTP | 128 | 123 |
| Industrial & Applied Physics | DIAP | 106 | 88 |
| Surface Science | DSS | 49 | 46 |
| Total | | 1240 | 1164 |

Journal Subscriptions

| | As of 31/12/91 | As of 31/12/92 |
|---|---|---|
| Canadian Journal of Physics | 50 | 43 |
| Canadian Journal of Earth Sciences | 6 | 1 |
| Contemporary Physics | 4 | 2 |
| Physics in Medicine & Biology | 4 | 4 |
| The Physics Teacher | 8 | 7 |
| Québec Science | 32 | 25 |
| Physics Today | 114 | 93 |
| Physical Review Letters | 5 | 4 |
| Medical Physics | 3 | 2 |
| Physics Education | 19 | 15 |
| Physics World | 13 | 10 |
| Total | 258 | 206 |

Report of the Honorary Secretary-Treasurer

At the end of 1992 the General Fund has a surplus of $15,168 which represents a significant increase over the surplus of $9,604 reported at the end of 1991. This brings the accumulated surplus to $49,229 and, at the meeting of Council on April 3, 1993, a motion was passed to transfer $25,000 to the Reserve Fund. As a result, the Reserve Fund now stands at $30,525 while the accumulated surplus has been reduced to $24,229. The Educational Trust Fund has a surplus of $40,211 which is slightly higher than the $39,281 reported last year. The auditied financial statements and balance sheets for the twelve month period, January 1992 to December 31, 1992 with comparative figures for 1991 follow.

ERNST & YOUNG

# AUDITORS' REPORT

To the Members of
**The Canadian Association of Physicists**

We have audited the General Fund and Educational Trust Fund balance sheets of **The Canadian Association of Physicists** as at December 31, 1992 and the statements of revenue and expense and surplus for the year then ended. These financial statements are the responsibility of the Association's management. Our responsibility is to express an opinion on these financial statements based on our audit.

Except as explained in the following paragraph, we conducted our audit in accordance with generally accepted auditing standards. Those standards require that we plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In common with many non-profit organizations, the Association derives revenue from meetings and donations, the completeness of which is not susceptible of satisfactory audit verification. Accordingly, our verification of these revenues was limited to the amounts recorded in the records of the Association and we were unable to determine whether any adjustments for unrecorded revenues might be necessary to meeting revenue, donation revenue, excess of revenue over expense (expense over revenue) for the year and surplus.

In our opinion, except for the effect of adjustments, if any, which might have been required had we been able to satisfy ourselves about the completeness of the revenues referred to in the preceding paragraph, these financial statements present fairly, in all material respects, the financial position of the Association as at December 31, 1992 and the results of its operations and the changes in its financial position for the year then ended in accordance with generally accepted accounting principles.

Ernst & Young
Chartered Accountants

Ottawa, Canada,
March 30, 1993.

Ernst & Young

# RAPPORT DES VÉRIFICATEURS

Aux membres de
l'**Association canadienne des physiciens**

Nous avons vérifié les bilans du fonds général et du fonds de fiducie d'éducation de l'**Association canadienne des physiciens** au 31 décembre 1992 ainsi que l'état des revenus et dépenses et de l'excédent de l'exercice terminé à cette date. La responsabilité de ces états financiers incombe à la direction de l'Association. Notre responsabilité consiste à exprimer une opinion sur ces états financiers en nous fondant sur notre vérification.

À l'exception de ce qui est mentionné dans le paragraphe ci-dessous, notre vérification a été effectuée conformément aux normes de vérification généralement reconnues. Ces normes exigent que la vérification soit planifiée et exécutée de manière à fournir un degré raisonnable de certitude quant à l'absence d'inexactitudes importantes dans les états financiers. La vérification comprend le contrôle par sondages des informations probantes à l'appui des montants et des autres éléments d'information fournis dans les états financiers. Elle comprend également l'évaluation des principes comptables suivis et des estimations importantes faites par la direction, ainsi qu'une appréciation de la présentation d'ensemble des états financiers.

Comme beaucoup d'organisations à but non lucratif, l'Association tire des revenus de réunions et de dons pour lesquels il n'est pas possible de vérifier de façon satisfaisante s'ils ont tous été comptabilisés. Par conséquent, notre vérification de ces revenus s'est limitée aux montants comptabilisés dans les livres de l'Association et nous n'avons pas pu déterminer si certains redressements auraient dû être apportés aux montants des revenus provenant des réunions, des revenus de dons, de l'excédent des revenus sur les dépenses (dépenses sur les revenus) pour l'exercice et de l'excédent.

À notre avis, à l'exception de l'effet des éventuels redressements que nous aurions pu juger nécessaires si nous avions été en mesure de vérifier si les revenus mentionnés au paragraphe précédent ont tous été comptabilisés, ces états financiers présentent fidèlement, à tous égards importants, la situation financière de l'Association au 31 décembre 1992, les résultats de son exploitation et l'évolution de sa situation financière pour l'exercice terminé à cette date selon les principes comptables généralement reconnus.

Ernst & Young
Comptables agréés

Ottawa, Canada,
le 30 mars 1993.

**The Canadian Association of Physicists/**
**Association canadienne des physiciens**
**GENERAL FUND**

# BALANCE SHEET

As at December 31

| | 1992 $ | 1991 $ |
|---|---|---|
| **ASSETS** | | |
| **Current** | | |
| Cash | 94,354 | 66,041 |
| Term deposits (at cost which approximates market) | 75,000 | 74,418 |
| Advertising revenue receivable | 4,950 | 8,447 |
| Other receivables | 15,597 | 20,520 |
| Prepaid expenses | 11,337 | 1,396 |
| Due from Educational Trust Fund | 6,382 | 65 |
| | 207,620 | 170,887 |
| **LIABILITIES AND MEMBERS' EQUITY** | | |
| **Current** | | |
| Accounts payable and accrued charges | 17,093 | 13,999 |
| Deferred revenue | 93,186 | 73,191 |
| Due to Divisions | 31,467 | 32,841 |
| **Total current liabilities** | 141,746 | 120,031 |
| **Members' equity** | | |
| Science Policy Fund *[note 7]* | 11,120 | 11,270 |
| Reserve *[note 3]* | 5,525 | 5,525 |
| Surplus | 49,229 | 34,061 |
| **Total members' equity** | 65,874 | 50,856 |
| | 207,620 | 170,887 |

*See accompanying notes*

On behalf of the Council:

Officer Officer

**The Canadian Association of Physicists/**
**Association canadienne des physiciens**
**EDUCATIONAL TRUST FUND**

# BALANCE SHEET

As at December 31

| | 1992 $ | 1991 $ |
|---|---|---|
| **ASSETS** | | |
| **Current** | | |
| Cash | 13,342 | 3,726 |
| Term deposits and accrued interest | 40,247 | 40,794 |
| | 53,589 | 44,520 |
| **LIABILITIES AND SURPLUS** | | |
| Deferred donation revenue | 6,996 | 5,174 |
| Due to General Fund | 6,382 | 65 |
| **Total liabilities** | 13,378 | 5,239 |
| **Surplus** | 40,211 | 39,281 |
| | 53,589 | 44,520 |

*See accompanying notes*

On behalf of the Council:

Officer

Officer

**The Canadian Association of Physicists/**
**Association canadienne des physiciens**
**GENERAL FUND**

# STATEMENT OF REVENUE AND EXPENSE AND SURPLUS

Year ended December 31

| | 1992<br>$ | 1991<br>$ |
|---|---|---|
| **REVENUE** | | |
| Membership fees | 132,293 | 130,024 |
| Physics in Canada | | |
| - Advertising | 25,858 | 21,284 |
| - Subscriptions | 2,536 | 3,882 |
| Annual meeting (net) | 36,454 | 45,552 |
| Journal subscriptions | 11,595 | 13,899 |
| Investment income | 3,992 | 7,680 |
| Miscellaneous | 2,655 | 1,264 |
| Careers in Physics (net) | 547 | 159 |
| Directory of Physicists | 130 | 35 |
| | 216,060 | 223,779 |
| **EXPENSE** | | |
| Salaries | 75,269 | 93,742 |
| Physics in Canada | 40,155 | 33,425 |
| Data processing | 5,697 | 1,104 |
| Printing and postage | 10,566 | 6,681 |
| Journals | 12,550 | 13,158 |
| Rent | 19,481 | 19,918 |
| Employee benefits | 12,174 | 12,353 |
| Maintenance and other | 14,903 | 19,379 |
| Travel | 1,052 | 3,944 |
| Legal, audit and accounting | 4,557 | 6,519 |
| Telephone | 3,773 | 2,575 |
| Medals | 715 | 1,377 |
| | 200,892 | 214,175 |
| **Excess of revenue over expense for the year** | 15,168 | 9,604 |
| Surplus, beginning of year | 34,061 | 24,457 |
| **Surplus, end of year** | 49,229 | 34,061 |

*See accompanying notes*

**The Canadian Association of Physicists/**
**Association canadienne des physiciens**
**EDUCATIONAL TRUST FUND**

# STATEMENT OF REVENUE AND EXPENSE AND SURPLUS

Year ended December 31

| | 1992<br>$ | 1991<br>$ |
|---|---|---|
| **REVENUE** | | |
| Donations | | |
| - Members | 9,042 | 5,232 |
| - Corporations | 8,000 | 8,100 |
| - Universities and schools | 2,280 | 1,180 |
| Interest and miscellaneous | 4,940 | 5,251 |
| | 24,262 | 19,763 |
| **EXPENSE** | | |
| Prizes | 10,111 | 9,870 |
| Lecture tours | 8,878 | 7,144 |
| Administration and other | 2,343 | 2,419 |
| Undergraduate physics conference | 2,000 | 2,000 |
| | 23,332 | 21,433 |
| Excess of revenue over expense (expense over revenue) for the year | 930 | (1,670) |
| Surplus, beginning of year | 39,281 | 40,951 |
| Surplus, end of year | 40,211 | 39,281 |

*See accompanying notes*

**The Canadian Association of Physicists/**
**Association canadienne des physiciens**

# NOTES TO FINANCIAL STATEMENTS

December 31, 1992

## 1. ACCOUNTING POLICIES

The financial statements of the Association have been prepared by management in accordance with generally accepted accounting principles. Revenue and expense of the Divisions and the Science Policy Fund are not reflected in the Statement of Revenue and Expense and Surplus of the Association. The more significant accounting policies are summarized below:

### Fees and donations

Annual membership fees and donations are recorded as revenue in the year to which they pertain. Revenue received pertaining to future years is recorded as deferred revenue. Membership includes a free subscription to Physics in Canada. Subscription fees for Physics in Canada purchased by non-members are included in subscription revenue.

### Brochures

Substantially all of the brochures, pamphlets and other publications purchased are intended to be distributed free of charge as part of membership and other programs; accordingly, the cost of brochures is charged to expense when they are purchased.

### Fixed assets

The cost of fixed assets is charged to expense when incurred. During 1992 fixed asset additions amount to $4,535 (1991 - $Nil).

## 2. TAX STATUS

The Association is a non-profit organization as defined in Section 149(1)(1) of the Income Tax Act and, as such, is exempt from income taxes.

## 3. RESERVE

The reserve is not to be encroached upon without approval of the Council. Transfers to and from the reserve are made when approved by Council.

**The Canadian Association of Physicists/**
**Association canadienne des physiciens**

# NOTES TO FINANCIAL STATEMENTS

December 31, 1992

## 4. EDUCATIONAL TRUST FUND

The Educational Trust Fund is a tax exempt fund under the Income Tax Act to support the educational activities of the Association. The fund is administered by a board of three trustees appointed by the Association executive.

## 5. COMMITMENTS

The Association has leased office space up to 1996 for a basic annual rental of $19,000 and office equipment up to 1996 and 1997 for approximately $8,000 and $900 per year respectively, part of which cost is to be recovered from other associations.

## 6. STATEMENT OF CHANGES IN FINANCIAL POSITION

A statement of changes in financial position is not presented since it would not provide any additional useful information.

## 7. SCIENCE POLICY FUND

The following is a summary of results of the Science Policy Fund which includes contributions made over several years to accumulate funds for special science policy - related activities:

| | 1992<br>$ | 1991<br>$ |
|---|---|---|
| **Balance, beginning of year** | **11,270** | 11,520 |
| Expenses | **(150)** | (250) |
| **Balance, end of year** | **11,120** | 11,270 |

| Speaker | Visits |
|---|---|
| Melanie Campbell | Acadia, Dalhousie, Mount Allison, St. FX |
| Francois Corriveau, McGill | U. de Montréal, U. du Québec à Trois-Rivières |
| Barbara Frisken, SFU | Alberta, Brandon, Lethbridge, Manitoba, Winnipeg |
| Stephen Godfrey, Carleton | Dalhousie, St. FX, Trent, UNB |
| Hong Guo, McGill | Carleton, McMaster |
| Judith Irwin, Queen's | Guelph |
| Werner Israel, Alberta | Toronto, York |
| Paul Johns, Carleton | Laurentian, Queen's, RMC |
| Catherine Kallin, McMaster | U. Western Ontario |
| Randy Kobes, Winnipeg | Calgary, Lethbridge, Regina, Saskatchewan |
| Ivan L'Heureux, Ottawa | Laval |
| Gordon Rostoker, Alberta | Simon Fraser, UBC, Victoria |
| Dominic Ryan | U. of Ottawa |
| Robert Sica, UWO | Brock |

### 5.3 CAP University Prize Examination

The CAP University Prize Examination is a nation-wide competition among senior undergraduates studying physics. The Educational Trust Fund provides a first prize, The Lloyd G. Elliot Prize, of $600.00; a second prize of $300.00, and a third prize of $175.00. In addition, the winner of the first prize receives an expense-paid trip to the Annual Congress to receive the prize at the banquet. This year, a tie for third resulted in two prizes of $125 each.

This year's examination was prepared and marked by a group from the University of Waterloo. The examination was written by 119 students from 27 different post-secondary institutions.

The three prize winners are:

| | |
|---|---|
| First Prize: | N. Arbani-Hamed, University of Toronto |
| Second Prize: | Michael Graesser, University of Toronto |
| Third Prize: | Carl Adams, Dalhousie University |
| | Ingrid Stairs, McGill University |

The next 6 candidates, in alphabetical order, are:

Peter Giles, Simon Fraser University
Bradley Heinrichs, University of British Columbia
Ian Hill, Queen's University
Brian May, Queen's University
Michael Montour, University of British Columbia
David Unrau, Queen's University

### 5.4 The Undergraduate Physics Conference

The 28th Canadian Undergraduate Physics Conference (CUPC) was held in November, 1992 in Ottawa, Ontario. It was organized by Pierre Laporte, together with a group of students from the University of Ottawa. Keynote speakers included Dr. Leon Lederman, Nobel Prize Winner in 1988, Dr. Gerhard Herzberg, Nobel Prize winner in 1971, Dr. Art McDonald, SNO Director, and Dr. D.B. Plewes, University of Toronto. Over 50 attendees were awarded CAP memberships.

The purpose of the CUPC is to provide undergraduate physics students with an opportunity to (1) present a scientific paper on work they have been doing at their university or work term in industry; (2) hear world renowned physicists talk of their experiences and current research; and (3) exchange information and share ideas with other physics students across Canada.

The 29th Conference will be organized by Karl Fast and held at the University of Saskatchewan from November 4-6, 1993. Accommodations have ben arranged at the Bessborough Hotel. Arrangements are presently being made for guest lectures, tours, promotions, and sponsors. Due to the hard work of the University of Ottawa organizing team in raising funds for the 1992 CUPC, the CAP's contribution towards student travel was not required and is, therefore, being transferred to the University of Saskatchewan for student travel for the 1993 CUPC.

### 5.5 Youth Science Foundation and the Canada-Wide Science Fair

The Youth Science Foundation continues to provide excellent support in various areas to promote science among youth in Canada. The major emphasis continues to be Science Fairs, with the 32nd Annual Canada-Wide Science Fair being held in Rivière-du-Loup during May of this year. The CAP once again sponsored a prize in each of the junior, intermediate, and senior physics categories. The names and photographs of the winners will be published in the 1993 September or November issue of *Physics in Canada*.

The YSF still relies heavily on its volunteer network, and continues to encourage teachers and scientists to become more involved in helping young people to channel their activities.

### 5.6 CAP Secondary School Physics Prize Competitions

The secondary school examinations continue to be administered efficiently in the Provinces across Canada. Certificates of Merit are now awarded as a means of encouraging those students who did well but not well enough to receive a prize, and have been awarded again this year. The CAP owes a vote of thanks to those who conduct the examinations. It involves a great deal of time and the financial generosity of the organizers' Physics Departments.

In each province a total of $770 was offered by the CAP, to be divided among the winners, at the discretion of the provincial examiner. The name of each principal examiner is given below in parentheses, along with the names of the winners. Additional prizes were offered in some provinces by the University Physics Departments, which are gratefully acknowledged.

### 5.7 Tables

CAP SECONDARY SCHOOL PHYSICS PRIZE COMPETITIONS - 1993

NEWFOUNDLAND (M. Clouter, Memorial University of Newfoundland)

| | | | |
|---|---|---|---|
| 1. | Anthony Lau | Brother Rice | $370.00 |
| 2. | Michael Rosales | H.H. of Mary | 250.00 |
| 3. | Paul Seaborn | Herdman Collegiate | 150.00 |
| 4. | Dave Porter | Menihek | 50.00 |
| 5. | Reza Shahidi | Bishops | 50.00 |
| 6. | Christopher Whitt | Eugene Waters | 50.00 |
| 7. | Dean Hutchings | Herdman Collegiate | 50.00 |
| 8. | Shannon Hunt | P.W.C. | 50.00 |
| 9. | Mark Stonehouse | Herdman Collegiate | 50.00 |
| 10. | Walter Parsons | Ascention Collegiate | 50.00 |

NOVA SCOTIA AND PRINCE EDWARD ISLAND (D. Dahn, University of PEI)

| | | | |
|---|---|---|---|
| 1. | Gillian Walter | Halifax West High | $400.00 |
| 2. | Mark J. Lewis | Halifax West High | 200.00 |
| 3. | Stephen V. Baird | Cobequid Educational Centre | 140.00 |
| 4. | Scott Allen | Halifax West High | 130.00 |
| 5. | Dana Lacoste | Middleton Regional High | 100.00 |
| 6. | David McClelland | Annapolis West Educational Centre | 90.00 |
| 7. | Douglas Sheppard | Glace Bay High | 80.00 |
| | Jason Doucette | Yarmouth Consolidated Memorial High | 80.00 |
| 9. | Luong Tran | Halifax West High | 70.00 |
| 10. | Todd MacAdam | Pictou Academy | 60.00 |
| | Sheila Paterson | Queen Elizabeth High | 60.00 |
| | Matthew J. Doucette | Yarmouth Consolidated Memorial High | 60.00 |
| | Meghan Gray | Halifax West High | 60.00 |
| 14. | Kevin Gatehalian | Riverview Rural High | 50.00 |
| 15. | Michael Harvey | Cobequid Educational Centre | 40.00 |
| | Christopher Gray | Montague Regional High | 40.00 |
| | Duane Currie | Digby Regional High | 40.00 |

| | | | |
|---|---|---|---|
| | Anthony Yuen | Dartmouth High | 40.00 |
| | Edward James | Digby High | 40.00 |
| 20. | Peter Wyman | Yarmouth Consolidated Memorial High | 20.00 |
| 21. | Joern Grensemann | Montague Regional High | 20.00 |
| | Tom Chalmers | Cobequid Educational Centre | 20.00 |
| | Duncan Retson | Cobequid Educational Centre | 20.00 |
| | Julien Muise | Yarmouth Consolidated Memorial High | 20.00 |
| 25. | Robbie Campbell | Montague Regional High | 20.00 |
| | Christopher Jones | Dr. John Hugh Gillis High | 20.00 |

NEW BRUNSWICK (G. Bosi, University of Moncton)

| | | | |
|---|---|---|---|
| 1. | Bernard Hachey | Nepisiguit | $300.00 |
| 2. | Tony Teakles | Mgr-Marcel-Francois-Richard | 200.00 |
| 3. | Mylène Clavette | Cité des Jeunes A-M-Sormany | 150.00 |
| 4. | André-Marc Cormier | Aux-Quatre-Vents | 70.00 |
| 5. | Gabriel Cormier | Clément-Cormier | 50.00 |

QUÉBEC (J.R. Derome, Université de Montréal)

| | | | |
|---|---|---|---|
| 1. | Rajesh J. Pereira | Marianopolis College | $1000.00 |
| 2. | Marc-André Lewis | Collège Bois-de-Boulogne | 400.00 |
| 3. | Alexandre Nadeau | Collège Mérici | 110.00 |
| | Oliver Pitts | Dawson College | 110.00 |
| 5. | Francois Bernier | Collège de Lévis-Lauzon | 90.00 |
| | Gordon Craig | Champlain Regional College | 90.00 |
| | Nicolas Gagnon | Collège de Chicoutimi | 90.00 |
| 8. | Andras Pattantyus-Abraham | John Abbott College | 60.00 |
| 9. | Pascal Gallant | Collège de Lévis-Lauzon | 45.00 |
| | Patrick Lamontagne | Collège Jean-de-Brébeuf | 45.00 |

ONTARIO (C. Benson, University of Ottawa)

| | | | |
|---|---|---|---|
| 1. | Dion Lew | Woburn Collegiate Institute | $300.00 |
| 2. | John Patrick Enright | Woburn Collegiate Institute | 200.00 |
| 3. | Clement Yip | Port Credit Secondary Schoo | 90.00 |
| | Ramsundar Myilvagansundar | Stephen Leacock Collegiate Institute | 90.00 |
| | John Paul Vrolyk | Lambton Central Collegiate | 90.00 |

MANITOBA (R. Kobes, University of Winnipeg)

| | | | |
|---|---|---|---|
| 1. | Wendy Kraayeveld | Kildonan East Collegiate | $250.00 |
| 2. | Ramon Lawrence | St. John's Ravenscourt School | 250.00 |
| 3. | Ka Ping Yee | St. John's Ravenscourt School | 250.00 |

SASKATCHEWAN (H. Caplan, University of Saskatchewan)

| | | | |
|---|---|---|---|
| 1. | Chris Lan | Aden Bowman Collegiate Institute | $450.00 |
| 2. | Kevin Kostvik | Estevan Comprehensive School | 220.00 |
| 3. | Dwight Newman | Campbell Collegiate | 100.00 |

ALBERTA (H.R. Krouse, University of Calgary)

| | | | |
|---|---|---|---|
| 1. | Robert Kry | Western Canada High | $200.00 |
| 2. | Alistair Savage | Western Canada High | 150.00 |
| 3. | Eric Pederson | Western Canada High | 75.00 |
| 4. | Rae Yip | Sir Winston Churchill High | 25.00 |
| 5. | Irene Ngar-Tun | Sir Winston Churchill High | 25.00 |
| | Jonathan Doody | St. Joseph School | 25.00 |
| 7. | Howard Cheng | Strathcona High | 25.00 |

| | | | |
|---|---|---|---|
| 8. | Calvin Cheng | Sir Winston Churchill High | 25.00 |
| 9. | Ben Thomas | Archbishop MacDonald High | 25.00 |
| | Bryant Swanson | Western Canada High | 25.00 |

Special prizes: Best Students Enrolled in Physics 20

| | | | |
|---|---|---|---|
| 1. | Jennifer Peterson | Chamberlain School | 75.00 |
| 2. | Kristine Turner | Calmar School | 50.00 |
| 3. | Chantal Johnson | Georges P. Vanier | 50.00 |

BRITISH COLUMBIA (G. Beer, University of Victoria)

Physics XII Category

| | | | |
|---|---|---|---|
| 1. | Paul Tupper | Point Grey Secondary School | $400.00 |
| 2. | Peter Dukes | Mount Douglas Senior Secondary | 250.00 |

Physics XI Category

| | | | |
|---|---|---|---|
| 1. | Roger Donaldson | Lord Byng Secondary | $120.00 |

| PROVINCE | EXAMINER | # OF SCHOOLS | # OF STUDENTS |
|---|---|---|---|
| Newfoundland | M. Clouter | 53 | 356 |
| Nova Scotia and Prince Edward Island | D. Dahn | 35 | 432 |
| New Brunswick | G. Bosi | 29 | 225 |
| Québec | J.-R. Derome | 33 | 140 |
| Ontario | C. Benson | 103 | 750 |
| Manitoba | R. Kobes | 37 | 246 |
| Saskatchewan | H. Caplan | 44 | 146 |
| Alberta | H.R. Krouse | 48 | 255 |
| British Columbia | G. Beer | 91 | 266 |

## 6. MEETINGS AND SUMMER SCHOOLS

CAP has been holding an Annual Congress ever since the Association was founded. The first CAP Summer School, in theoretical physics, was held in Edmonton in 1957. Scientific meetings and summer schools are the most important of CAP activities. Details of some of these meetings are given in the reports of the Divisions.

### 6.1 Annual Congress

The Annual Congress is the most important event of the year for the Canadian Physics Community. Here each year the vast majority of Canada's leading physicists meet to communicate the results of their research, learn of the research of their colleagues, discuss science policy, promote physics education and conduct the affairs of the Association. The success of the planning process for the Congress depends heavily on the energy and committment of the Division Chairs. This years' group deserve a round of applause from all of us for putting together a fine program. While the idea of having a high profile, general interest speaker on the Sunday night before the Congress is very appealing, this has proven a difficult slot to fill for the Vancouver meeting. It is suggested that starting the search a full year in advance is not too soon to get a committment from someone of this calibre.

The Congress has traditionally been a general meeting attracting specialists in a variety of areas, and as such, is suffering from an abundance of speciality conferences and the shortage of travel funds. We need to attract a wider audience if the Congress is to stay in its current format. Our next Congress is in Regina. It is not too early to start forwarding your suggestions for a Sunday speaker or other events at Congress to Roger Lessard at Laval, who will be Conference Chairman, or to Francine Brûlé at the CAP Office in Ottawa.

Some statistics on recent congresses are given in the following table.

| Congress Location | Year | Number of Contributed Papers | Number of Invited Papers | Total Number of Papers | Number of Congress Registrants |
|---|---|---|---|---|---|
| Vancouver | 1979 | 222 | 66 | 288 | 443 |
| Hamilton | 1980 | 206 | 76 | 281 | 511 |
| Halifax | 1981 | 190 | 78 | 268 | 402 |
| Kingston | 1982 | 216 | 74 | 290 | 494 |
| Victoria | 1983 | 258 | 67 | 325 | 545 |
| Sherbrooke | 1984 | 270 | 69 | 339 | 552 |
| Fredericton | 1985 | 170 | 58 | 228 | 349 |
| Edmonton | 1986 | 174 | 71 | 245 | 350 |
| Toronto | 1987 | 312 | 82 | 394 | 656 |
| Montreal | 1988 | 320 | 97 | 417 | 620 |
| Guelph | 1989 | 234 | 65 | 299 | 473 |
| St. John's | 1990 | 130 | 70 | 200 | 287 |
| Winnipeg | 1991 | 135 | 84 | 219 | 332 |
| Windsor | 1992 | 220 | 91 | 311 | 401 |
| Burnaby | 1993 | 164 | 86 | 240 | |

Future Congresses have been scheduled as follows: -- MARK YOUR CALENDARS NOW!!

1994 - University of Regina, June 26-29

1995 - Université Laval, June 18-21 (tentative)

1996 - University of Ottawa, June 16-19 (tentative)

## 7.0 PUBLICATIONS

### 7.1 Canadian Journal of Physics, Report of the Editor (D.D. Betts)

The Canadian Journal of Physics/Revue canadienne de physique is our national physics journal. It is a periodical of which we should all have reason to be proud. As the Editor I am firmly dedicated to strengthening the Journal's reputation. I hope that this report will provide convincing evidence of progress in enhancing the reputation of Can. J. Phys.

The Journal can only be strong with the active support of the Editor-in-Chief, the Associate Editors and other members of the Editorial Advisory Board, the authors, the referees, the Assistant Editor, the Editorial Coordinator and the publisher. I would like to express my gratitude to all these people for helping Can. J. Phys. maintain high scientific and technical standards over the past year. In particular I would like to thank for their valued service Professors John Grindlay and Béla Joós, who have recently retired from their positions as Associate Editors. During my eleven week sabbatical leave visit to Australia earlier this year, Professor David Kiang did yeoman service as Acting Editor, for which I am very grateful.

I would very much like to see more papers submitted to Can. J. Phys. by Canadians, whether working in Canada or abroad, and by citizens of other countries currently living in Canada. I am not suggesting that Canadian physicists ought to publish all of their research results in Can. J. Phys., but publishing in our Journal is an excellent way to make your Canadian colleagues aware of your work. We promise to deal with your manuscripts with both care and speed.

Statistics

For the first three quarters of the report year, excluding the large Special Issue on Semiconductor Technology, 76 manuscripts were accepted for publication, 79 were rejected and 4 were withdrawn, yielding an acceptance rate of 48%. For accepted papers the average period of time from receipt to acceptance was 5 months and, more to the point, the median time was 3 months. Similarly for rejected papers the average time period from receipt to rejection was 6 months and the more significant median period from receipt to rejection was 4 months.

Including the Special Issue on Semiconductor Technology, editorial decisions were made on 240 papers during the 9 month period under consideration. Half of these papers were from Canadian addresses, one quarter were from India, the USA and Egypt, and the remaining quarter came from 27 other countries.

Publication Policy

The Research Journals Office of the National Research Council, publisher of the Canadian Journal of Physics and 12 other Canadian science and engineering journals, issued in February a Research Journals Publication Policy, which is to be followed by all the NRC journals. This document details the responsibilities of authors, editors, referees and the publisher. Because of a number of recent examples of unethical behaviour in scholarly publishing, the necessity for strictly ethical behaviour in the publication process is stressed. The Canadian Journal of Physics reaffirms its dedication to the highest of ethical standards.

Ethics

Ethical misconduct on the part of authors is at its worst in rare cases of blatant plagiarism. It was brought to our attention last spring that in 1990 the Canadian Journal of Physics published an article by someone who had presented it to CJP as his own work although it was almost completely identical to an original article by other authors published in 1988 in another journal. In an editorial in the May 1992 issue of CJP the Editor retracted this article.

Another highly unethical practice occurs when authors publish essentially the same article in two different journals without in either article referring to the other. Such an incident of self-plagiarism occurred in 1991 when an author published a paper in the Canadian Journal of Physics and the same research in almost identical form in another journal. As the paper was first submitted to CJP, the Editors of the other journal succeeded in persuading the author to publish in their journal in January this year an erratum in which he retracted the article published therein.

Referees who spot unethical conduct on the part of authors are responsible for bringing them to the attention of the journal. It is the responsibility of editors to deal promptly and publicly with serious cases of unethical conduct.

Special Issues

The Canadian Journal of Physics continues the practice of publishing special issues. These may be in honour of a distinguished colleague, the proceedings of a conference or workshop, or centred on a theme determined by one of the CAP Subject Divisions. During the report year the CJP published two special issues - in July the Proceedings of the International Association of Geomagnetism and Aeronomy symposium on Response on the Ionosphere and Thermosphere to Major Magnetic Storms, with Guest Editors Drs. D.J. McEwan and D. Rees, and in November the Proceedings of the Sixth Canadian Semiconductor Technology Conference, with Guest Editor Dr. J.M. Baribeau. The Journal currently has five Special Issues in various stages of preparation as summarized below.

| Subject/Theme | Guest Editors | Journal Issue |
|---|---|---|
| Optics: Photoptics | Prof. John Lit, Physics & Computing, Wilfred Laurier U. & Prof. M. Piché, Physique, Univ. Laval. | January/February 1993 |
| Perturbative Methods in Hot Gauge Theories | Profs. R. Kobes & G. Kunstatter, Univ. of Winnipeg | May/June 1993 |
| High Pressure Science and Technology | Prof. A. Ng, Physics, UBC | Late 1993 |
| In honour of Professor R.T. Sharp on his 70th Birthday | Profs. J. Patera & P. Winternitz, Centre de Recherches Mathématiques, Univ. de Montréal | Late 1993 |
| In honour of Dr. G. Herzberg on his 90th Birthday | Prof. D.D. Betts, Physics, Dalhousie Univ. | December 1994 |

The Two Referee System

Effective April 1, 1992 the Canadian Journal of Physics adopted a two referee system in which manuscripts submitted for publication are sent to two referees (except in cases where the paper is obviously unsuitable for publication in CJP). A major advantage of the new system is that each referee tends to notice different ways in which the original manuscript can be improved. While fewer papers are accepted without revision, accepted papers are usually considerably better than they would have been had only the advice of one referee been available. Various forms of unethical behaviour on the part of authors are more likely to be detected by one or the other of the two referees. The main disadvantage of the two referee system is that a paper spends a longer period in the editorial process. The new system also requires more effort on the part of the Associate Editors and the Editorial Office.

Other Reforms in the Editorial Process

The most significant reform during the report year is the introduction in January of a new system of soliciting the advice of referees. Upon receipt of a manuscript, the Associate Editor or Editor sends by fax to two potential referees a copy of the title page and abstract. They are requested to inform the editor within 48 hours whether they are able to review the paper within the next three weeks. Once a referee has agreed to review the manuscript, it is sent to him or her immediately. Potential referees who must decline are asked to suggest the name of a suitable alternate referee. Once the manuscript has been sent, referees who are slow to report receive a first reminder by letter and subsequent reminders by fax or telephone.

Over the five months the system has been in operation it has proved to be very effective in a number of ways: (1) the editorial staff obtains a prompt answer from the potential referees, (2) the referees are more likely to report promptly because they have agreed in advance to do so, and (3) those who are not able to act as referees are likely to provide the names of others who can so serve.

New Instructions to Authors and Advice to Referees

New Instructions to Authors appeared in the January 1993 issue of the Journal. Though this may seem like a mundane matter, clear advice to authors can increase the efficiency and effectiveness of the entire publication process. As well, a paragraph on ethics has been added, authors are now invited to suggest the names of potential referees, the Journal's eccentric equation numbering system has been standardized and various other minor reforms have been introduced in the Instructions. Our Advice to Referees form has also been updated and improved to reflect our new refereeing policy and practices.

Publication Schedule

Over recent years the CJP has gradually fallen behind schedule in that the month printed on the cover of each issue is now some months earlier than the calendar month in which the issue appears in print. The publisher and I have agreed that the Journal must be put back on schedule as quickly as possible and then kept on schedule. To achieve this, the first four issues of 1993 will be labelled January/February, March/April, May/June and July/August. In this way we expect that the September 1993 issue will actually appear in September.

7.2 **Physics in Canada**

Year 1992/93 followed the tradition started in January of 1992 with the introduction of a list of featured articles appearing on the front of each issue of *Physics in Canada* as well as the inclusion of a section on "Physics and Education" in each issue.

Due to the success of the first theme issue, *Physics in Canada* will be featuring its second theme issue in 1993 September. The Guest Editor, Dr. W. Peltier, will be working with the Editor and Managing Editor to produce what promises to be a very interesting a topical issue on "Physics and the Environment". In addition, the Editorial Board has accepted the offer of M. Vetterli of TRIUMF to coordinate the third theme issue on "Particle Physics" which will be published in March of 1994. Suggestions for other theme issues are always welcome and should be submitted to either J.S.C. McKee at the University of Manitoba or F.M. Brûlé at the CAP Office.

The Editorial Board are always looking for new and innovative ideas to make *Physics in Canada* a magazine that the membership and subscribers look forward to receiving. Among other things, short articles on the history of the Canadian Physics Departments were solicited from CAP's members. Interestingly, the first of what is hoped to be a number of histories does not come from the universities but rather is a History of the Theoretical Physics Department at Chalk River Laboratories. It will be published in the 1993 July issue of *Physics in Canada*.

### 7.3 Journal Subscriptions

As one of its services to members, CAP acts as a "Subscription Agent" for technical publications of other organizations. The year twelve (12) publications were available to members at reduced subscription rates. Statistics are given in the Annual Report.

## 8.0 OTHER ACTIVITIES

### 8.1 Science Policy Committee

The CAP Executive has been quite active in 1992 in this area. A summary of the various activities was published in the 1993 January issue of *Physics in Canada*.

The issue of science policy is becoming of greater concern with the slowly diminishing funds available for research and, as a result, has been discussed quite thoroughly by Council over the last year. It is recognized that the CAP must become much more visible in the political arena by becoming involved in various lobbying activities and submitting position papers to various organizations whenever possible and appropriate. In this regard, Council directed that the Science Policy Committee be rejuvenated and a report be submitted on its activities at each Council meeting.

### 8.2 Physics and Society

As this committee was inactive during the past year, no report is required.

### 8.3 Honourary Advisory Council of Past Presidents

The Honourary Advisory Council of Past Presidents, constituted of all the former presidents of the CAP was officially established at the Annual General Meeting in June 1970. It has held a meeting at each subsequent Congress and will be holding one again this year at Simon Fraser University in Burnaby, B.C..

### 8.4 Employment Opportunities Committee

The Employment Contact Service whereby those seeking jobs and those with positions available could register their respective information has been suspended indefinitely at the CAP office. Consideration is being given to introducing an anonymous "position wanted" or "resumés on file" section in *Physics in Canada*, whereby interested employers will be invited to contact the CAP office for copies of any resumés of interest to them.

The annual survey of graduate students in Canadian Universities was carried out and the results published in the March 1993 issue of *Physics in Canada*. Income surveys were processed and published for 1991 and 1992 in the 1993 January and March issues of *Physics in Canada* respectively. These cover consulting income, pensions and scholarships as well as salaries to provide a comprehensive view of the income of physicists.

### 8.5 Committee of University Physics Department Heads and Chairs

The Canadian Universities Department heads met in Windsor during the 1992 CAP Congress for their annual super-meeting. A number of issues were discussed in an informal fashion. The one subject that seemed to be of significance was the now rather common practice by a number of universities to offer signing bonuses and supplements to NSERC scholars, sometimes as high as $5,000 on entrance and $4,000 per year in subsequent years. A resolution was passed by a majority vote that the Chair write a letter to Dr. Peter Morand, President of NSERC requesting that such practices be stopped by limiting the support by additional scholarships to no more than $1,000 for NSERC scholars.

### 8.6 The Directory of Canadian Physicists

The first edition of the Directory was published in January 1986. CAP members have received a copy of the Directory. The volume contains, in alphabetical order, biographical sketches of 1500 Canadian physicists, and the classification of individuals by their main area of interest. A questionnaire is available for CAP members and others who did not make it into the Directory but wish to be included in future editions.

## 8.7 Committee on Professionalism

In 1992, the Committee on Professionalism ran a questionnaire on professionalism. The results were published in *Physics in Canada* (Vol. 49, No.2, pp 97-103, March 1993). These showed that a majority of those replying supported action in the professional area. The CAP Council subsequently approved motions supporting the establishment of a stronger professional position for physicists in Canada. Individual members are invited to show their support by completing the support form on page 103 of the above issue of *Physics in Canada*.

In 1993, the Committee learnt that major revisions to the practice of professional engineering were before the British Columbia cabinet. The Committee provided advice to the CAP Executive on protecting the interests of physicists and other natural scientists in the BC act.

The Chair of the Committee has delivered talks to the Chemical Society of Canada and the Association of the Chemical Profession of Ontario, promoting the position of professionalism in the scientific community. An article, summarizing one of the talks, was published in Canadian Chemical News (vol. 45, No. 1, pp. 19-21, January 1993).

Membership in the committee covers Newfoundland (1), Nova Scotia (1), Ontario (4), Saskatchewan (1) and Alberta (2). You are invited to be on the Committee. Offers are particularly invited to those in provinces not covered.

## 8.8 Committee to Encourage Women in Physics

The CAP Committee to Encourage Women in Physics actively promotes physics as an interesting and rewarding career for women. The committee meets approximately four times a year (once in Ottawa, once at the Congress and additional meetings as required at the location of the Chair). Each of the committee members brings a unique "agenda" and the committee bases its activities largely on these. The committee maintains a list of "corresponding members" who now represent Canada from coast to coast. Although these members cannot often attend the meetings, they receive minutes and associated articles and information on the subject of women in physics. Often they are involved in local activities related to this issue.

Progress in 1992-93

No report was available at the time of publication.

## 8.9 Committee on Undergraduate Student Affairs

No report was available at the time of publication.

# 9.0 AWARDS

The Awards Committee, chaired by E.W. Vogt, has recommended that:

The 1993 Medal for Achievement in Physics be awarded to Dr. Walter N. Hardy, University of British Columbia.

The 1993 Herzberg Medal be awarded to Dr. Nicholas Kaiser, CITA, University of Toronto

The DIAP Awards Committee, chaired by P.S. Vincett, has recommended that the 1993 Medal for Outstanding Achievement in Industrial and Applied Physics be awarded to Dr. Jacques J.A. Beaulieu, formerly of DREV.

Each of the award winners will be giving a talk at the 1993 CAP Congress in Burnaby, B.C. and will receive their medals during the Tuesday evening banquet.

# 10.0 REPORTS FROM REPRESENTATIVES TO OTHER ORGANIZATIONS

## 10.1 Canadian National Committee for the International Union of Crystallography

There is currently no CAP representative on this committee.

10.2 **Technical Advisory Committee to AECL on the Canadian Nuclear Fuel Waste Management Program**

TAC has been swamped by having to read, at very short notice, drafts of the documents which AECL proposes to use when the question of what AECL proposes to dispose of used nuclear fuel comes to public hearings. Reports on the meetings, conferences, and site visits conducted by TAC are contained in TAC's annual report to AECL, copies of which are provided to the CAP Executive.

Once the question of waste disposal is brought to public hearings, it is likely that a session of the annual CAP congress will be devoted to the subject of the disposal of nuclear waste (perhaps 1995).

10.3 **Canadian Commission for UNESCO**

The 35th Annual General Meeting of the Canadian Commission for UNESCO will be held in Ottawa from 1993 June 2-4. A report from the CAP's representative will be prepared and included in the Annual Report published with the 1993 September or November issue of *Physics in Canada*.

10.4 **Canadian Liaison Committee for IUPAP**

A significant development which took place during the past year was the transfer of responsibility for the Canadian National IUPAP Liaison Committee (CNILC) from the NRC International Affairs Office to the NRC Institute of Microstructural Sciences. The conditions for the transfer, and the proposed mode of operation and terms of reference for the Committee, were approved by the CAP Council at the October 24, 1992 meeting. It was agreed that the appointed CNILC members would constitute an ad-hoc CAP Committee on International Affairs. The transition became effective on April 1, 1993 and, at that time, the President of the CAP was asked to initiate a process for the nomination of five Committee members with terms commencing on January 1, 1994.

The new arrangements governing the future operation of the Committee were published in the 1993 May issue of *Physics in Canada* together with a call for nominations. This item will also be included on the agenda of the 1993 Annual General Meeting at Simon Fraser University.

10.5 **International Council on Quantum Electronics**

The principal activity of this advisory body is to promote international co-operation among the various scientific and technical organizations holding conferences in the field of quantum electronics and laser science and to select the site and dates for the International Quantum Electronics Conferences. The conferences occur on even years and cycle between North America, Europe and Asia. H.M. Van Driel (University of Toronto) is the CAP representative on this council. At the last meeting on June 17, 1992 in Vienna, Austria, three bids from Asian locations were considered for the 1996 conference. The winning bid came from Australia which will host the meeting from July 14-19 in Sydney.

10.6 **Canadian Chemistry and Physics Olympiad**

The 1992 International Physics Olympiad

The 1992 International Physics Olympiad was held in Helsinki, Finland, from July 4th to 13th. Canada sent a team of five top high school-level students, selected from 1000 or so who were registered in September 1991 and who prepared for the one-week National Finals, held at UBC in late May. Canada's team of five was comprised of:

Adrian Dunn (North Hatley, PQ)
Mark Hamilton (Port Coquitlam, BC)
Patrick Prémont (Valleyfield, PQ)
Paul Tupper (Vancouver, BC)
Wei Yu (Ottawa, ON)

Thirty-seven countries took part, making up a student delegation of 177, the largest contingent ever to compete for this prestigious international meet. Patrick Prémont and Paul Tupper won a bronze medal; Adrian Dunn received a certificate of honourable mention. A more thorough account of the 1992 I Ph O can be found in the September 1992 issue of Physics in Canada.

The Prime Minister's office was informed of the Canadian Team's Good performance and he wrote a letter of congratulations to the five participants. The team was accompanied by Drs. C. Waltham (UBC), R. Harris (McGill) and N. Gauthier (RMC).

The 1993 National Finals

Every year, in late May, the top 20 physics students and 20 chemistry students from all over Canada take part in the National Olympiad Finals. These finals are an intensive one-week session of courses, laboratories and examinations aimed at determining who has the calibre to represent Canada at the International Physics and the International Chemistry Olympiads, which are two separate events at that level.

This year, the National Finals will take place at Memorial University, from May 23rd to 30th. Professor Paris Georghiou (Chemistry) is the coordinator at Memorial.

The CCPO Board of Directors

The Board of Directors of the CCPO is composed of the following individuals:

David MacNaughton, Chairman
(Toronto French School)

Harry Giles, Vice-President
(Toronto French School)

John Wylie, Secretary-Treasurer
(Toronto French School)

Cecil Pickett, Member for Industry
(Vice-President, Merck-Frosst Laboratories)

George Brown, Member for the Canadian Institute of Chemistry
(International Business Machines)

Napoleon Gauthier, Member for the Canadian Association of Physicists
(Royal Military College of Canada)

The CCPO Board normally meets twice a year in Toronto and is responsible for co-ordinating the efforts of the Provincial Chapters of the CCPO. The Board is also responsible for collecting the required funding for operating the Olympiad. These costs are in excess of $100,000 annually.

The CCPO Board has recently undertaken to sponsor the International Physics Olympiad and the International Chemistry Olympiad (2 separate events) in Canada. These proposals were submitted to the respective Boards of both international committees a year ago and they have been approved for 1997 in both cases. Funding in excess of $750,000 to $1,000,000 will be required for the occasion. CCPO Chairman, D. MacNaughton, has made collecting these monies a priority in his schedule of activities.

Concluding Remarks

The Canadian Chemistry and Physics Olympiad provides the Canadian Association of Physicists with a very special opportunity to reach bright young students in their schools at a critical point in their choice of a career. I hope it remains a concern of the CAP and the CCPO Board gratefully acknowledges CAP's $500 financial contribution towards these goals.

## 11.0 GROUP LIFE INSURANCE

Discussions are currently underway regarding improvements to the CAP Group Life Insurance Plan. Details will be published in ***Physics in Canada*** as they become available.

## 12. NEW EXECUTIVE AND COUNCIL: 1993-94

Suggestions were solicited for nominations by the Nominating Committee from members of the Executive and Council. The members of the nominating committee for 1993 were R.M. Lees (Chair), R.A. Lessard, J.C.D. Milton, and L. Robertson. Consultations were carried out by telephone and a list of nominees prepared by the required deadline. Additional nominations were solicited from the membership at large. The list of nominations for the various offices, for which no additional nominations were received, follows.

1993-94 COUNCIL

| | | |
|---|---|---|
| *PRESIDENT | A.C. McMillan | *AES* |
| *PAST PRESIDENT | J.C.D. Milton | *AECL* |
| *VICE-PRESIDENT | R.A. Lessard | *Université Laval* |
| *VICE-PRESIDENT ELECT | P.S. Vincett | *FairCopy Services* |
| *HONORARY SECRETARY-TREASURER | G. Enright | *National Research Council* |
| DIRECTOR - Full Members | R.C. Barber | *University of Manitoba* |
| DIRECTOR - Affiliate Members | H. Okada | *University of Toronto* |
| DIRECTOR - Student Members | K. Fast | *Univ. of Saskatchewan* |
| DIRECTOR - Corporate Members | P. Gardner | *TRIUMF* |

DIVISION CHAIRMEN

Aeronomy & Space Physics, D. McDiarmid, *National Research Council*
Atomic & Molecular Physics, J.B.A. Mitchell, *University of Western Ontario*
Canadian Geophysical Union, G.K.C. Clarke, *University of British Columbia*
Condensed Matter Physics, E. Svensson, *AECL*
Nuclear Physics, J. Barrette, *McGill University*
Optical Physics, T. Vo-Van, *Université de Moncton*
Particle Physics, M. Vetterli, *TRIUMF*
Physics Education, B. Robertson, *University of Regina*
Plasma Physics, J.-C. Kieffer, *INRS-Energie*
Theoretical Physics, B. Tupper, *University of New Brunswick*
Industrial & Applied Physics, R. Pawluczyk, *National Optics Institute*
Surface Science, J. Jackman, *CANMET*

COUNCILLORS/CONSEILLERS

| | | |
|---|---|---|
| British Columbia | (1) G.R. Mason | University of Victoria |
| | (2) D. Boal | Simon Fraser University |
| Alberta | (1) H.R. Krouse | University of Calgary |
| | (2) J.L. Pinfold | University of Alberta |
| Saskatchewan & Manitoba | (1) R. Kobes | University of Manitoba |
| | (2) E.J. Llewellyn | University of Saskatchewan |
| Ontario - Southwest | (1) J. Dutcher | University of Guelph |
| | (2) M. Singh | University of Western Ontario |
| Ontario - Central & North | (1) P.K. Sinervo | University of Toronto |
| | (2) R. Gauthier | Lakehead University |
| Ontario - East | (1) S. Godfrey | Carleton University |
| | (2) B.C. Robertson | Queen's University |
| Québec - Nord et Ouest | (1) M.J. Zuckermann | McGill University |
| | (2) Y. Lépine | Université de Montreal |
| Québec - Sud et Est | (1) S. Jandl | Université de Sherbrooke |
| | (2) S.L. Chin | Université Laval |
| New Brunswick & Newfoundland | (1) S. Ross | University of New Brunswick |
| | (2) J. Lagowski | Memorial University |
| Nova Scotia & Prince Edward Island | (1) D. Dahn | University of PEI |
| | (2) B.L. Blackford | Dalhousie University |
| At Large | (1) P. Kirkby | Ontario Hydro |
| | (1) S. Morsink | University of Alberta |

EDITOR - Canadian Journal of Physics, D. Betts, Dalhousie University
EDITOR - Physics in Canada/La Physique au Canada, J.S.C. McKee, University of Manitoba
EXECUTIVE SECRETARY/SECRÉTAIRE EXÉCUTIF: F.M. Brûlé

* Members of Executive Committee
** Vice-Chairs are elected by their respective Divisions during the Congress
(1) Term ends June 1994 (2) Term ends June 1995

# CAP Council and Division Executives 1993-94

***President,** A.C. McMillan, *Atmospheric Environment Service*
***Past President,** J.C.D. Milton, *AECL Research, Chalk River*
***Vice-President,** R.A. Lessard, *Université Laval*
***Vice-President Elect,** P.S. Vincett, *FairCopy Services Inc.*
***Honorary Secretary-Treasurer,** G. Enright, *National Research Council*
**Director-Full Members,** R.C. Barber, *University of Manitoba*
**Director-Affiliate Members,** H. Okada, *University of Toronto*
**Director-Student Members,** K. Fast, *University of Saskatchewan*
**Director-Corporate Members,** P. Gardner, *TRIUMF*

## Division Chairmen

**Aeronomy and Space Physics,** D. McDiarmid, *National Research Council*
**Atomic and Molecular Physics,** J.B.A. Mitchell, *Univ. of Western Ontario*
**Canadian Geophysical Union,** G.K.C. Clarke, *Univ. of British Columbia*
**Condensed Matter Physics,** E. Svensson, *AECL Research, Chalk River*
**Industrial & Applied Physics,** R. Pawluczyk, *National Optics Institute*
**Nuclear Physics,** J. Barrette, *McGill University*
**Optical Physics,** T. Vo-Van, *Université de Moncton*
**Particle Physics,** M. Vetterli, *TRIUMF*
**Physics Education,** B. Robertson, *University of Regina*
**Plasma Physics,** J.C. Keiffer, *INRS-Énergie et Matériaux*
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Parmi les nombreuses autres possibilités de HERA, on peut compter dans le secteur électro-faible la mesure des sections efficaces avec grande précision pour l'ensemble du domaine cinématique, les mesures d'asymmétries, etc. La majorité des analyses physiques nécessitent la quantité de données que l'on accumulera à HERA. La question d'une structure commune aux leptons et aux quarks sera également abordée.

La qualité des aimants de la ligne de protons laisse aussi espérer que des énergies surpassant le TeV seront également accessibles.

**CONCLUSIONS**

L'accélérateur HERA est innovateur en ce qu'il combine deux genres de faisceaux très différents, les électrons et les protons. Dans leur première année d'activité, HERA et les expériences H1 et ZEUS ont déjà produit de nombreux résultats physiques. Comme un microscope de type nouveau dont la mise au point vient de commencer, HERA promet de devenir un outil inégalé dans la pénétration et la compréhension de la matière.

**REMERCIEMENTS**

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# ADDENDUM TO "A BRIEF HISTORY OF HEAVY WATER"

by Chris Waltham
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My recent article on the history of heavy water[1] has provoked a small flurry of correspondence which has turned up some interesting pieces of information and a few errors in my original text. I will deal with these points in the order in which they appear in the article.

On p.81 I quote that in the electrolysis of water, D/H isotopic separation factors of six can be obtained. In fact, factors of 10 are routinely obtained at Chalk River[2], and the maximum ever achieved (by Jomar Brun and his coworkers in Norway) was 13.2[3,p.742].

The French fission group of Joliot, Halban and Kowarski did not have adequate theoretical support[4]. However, in November 1939, Halban and Kowarski did some simple modelling of neutron moderation themselves and this was enough to suggest $D_2O$ as the best candidate[5 p.133]. Halban himself, with Frisch and Koch in Copenhagen in 1937, had measured the absorption cross section of neutrons in $D_2O$ and found it to be very low. The putative moderating qualities of deuterium were then widely appreciated; as early as the beginning of February 1939 Oppenheimer had a crude drawing on his blackboard of an atomic bomb made of uranium deuteride[6 p 274].

I imply that the French group observed increased fission activity in a uranium/$H_2O$ system in April 1939. The paper I refer to here is in fact a measurement of the number of neutrons per fission[4]. The increased fission activity wasn't observed until August[5 p.116].

In the first paragraph of the second column on p.82 a sentence was missing, which changed the sense of the text. The start of the paragraph should have read:

> "In the summer of 1940, as France faced defeat, Dautry, the French Armaments Minister, ordered Joliot to ensure that his cans of heavy water did not fall into enemy hands. Hans von Halban, his colleague, first took the cargo to Mont-Dore, the spa in central France. He put his wife and one-year-old daughter in the front of the car, one gram of Marie Curie's radium in the back, and, to minimize any possible danger from radiation, the cans of heavy water in between."

Sidney van den Bergh[7], whose niece was von Halban's wife, has given me a different account of the escape story in which the $D_2O$ was placed - for extra security - in wine bottles, not cans.

The Collège de France cyclotron was not the only cyclotron in Europe in 1940 as I incorrectly stated[4]. It was, however, the only one in German-occupied Europe *available* to the German scientists. The cyclotron in occupied Copenhagen was not used[8, p 439], largely because of Bohr's immense stature.

On p.83, I imply that the detailed design of a uranium/$D_2O$ reactor was started soon after the Montreal laboratory was founded in early 1943. In fact this had to wait until the rift with the Americans had been mended; work started after a series of visits to Chicago by Volkoff and Placzek in January 1944. By then detailed design of a heavy water reactor had already been initiated in the United States[4].

I wrote that in 1941 the Canadian National Defence Research Committee offered Cominco $10/lb for $D_2O$. This offer came from the U.S. National Defense Research Committee[9]; the Canadian government only learned of the project in August 1942[2][10,p 49].

The Trail heavy water production operation closed early in 1956[11], not 1955 as I stated[2]. Cominco's contract with the USAEC was concluded in late 1955.

I state that the Trail electrolytic cells shown in fig. 1 were the primary hydrogen production cells used for both the pre-existing ammonia plant, and to supply feed to the $D_2O$ exchange towers. In fact they were purpose-built secondary cells[2] used to increase the deuterium concentration in the water from the exchange process from 2.3% to 99.8%[12,p 318].

I quoted reference [11] which states that Hugh Taylor, the Princeton professor who helped initiate the Trail operation, selected nickel as the best catalyst for the exchange process. Benedict[3] says that Taylor developed a nickel-chromia catalyst for the fourth stage tower[2].

The chief engineer at Cominco who supervised the construction of the Trail heavy water plant was one Henry F. Tiedje, grandfather of my UBC departmental colleague, Tom Tiedje. Henry Tiedje received a certificate of thanks for his efforts from Vannevar Bush, director of the U.S. Office of Scientific Research and Development[13].

The first self-sustaining chain reaction outside the United States was in the $D_2O$ reactor ZEEP at Chalk River in 1945. On p.84 I credited Lew Kowarski with initiating ZEEP. Donald Hurst wrote to me to say he was interviewed by Kowarski at Chalk River about 1945[14] (at which Kowarski remarked that he knew how to mix uranium and heavy water but was looking for someone who knew how to mix concrete and ordinary water).

Hurst doubted whether Kowarski proposed the building of ZEEP and suggested this idea came from John Cockroft in July 1944 (confirmed by references [5, p.206] and [10, p.163]).

I state that Geib developed the dual-temperature sulphide process in Germany in 1943. Contemporaneously, the process was developed by J.S. Spevack at Columbia University[15]. This process became the basis of the post-war North American plants under the name of the Girdler Process, named after the company which first exploited it. North American scientists were not aware of Geib's work for many years after the war; Maloney *et al.* in their book "The Production of Heavy Water" (1955)[16 p 8] complain that relevant German wartime work was still classified.

Hurst[14] comments that although Chalk River's NRU reactor did not make money selling plutonium to the USAEC (p.85) in the sense of turning a profit, yet many millions of dollars of sales did occur.

Ontario Hydro purchased the Bruce heavy water plant in June 1973 - a few months after heavy water production had begun - not, as I stated, during construction[2].

The text of the article gives ridiculous dimensions for the Bruce $D_2O$ sulphide towers. The towers are, in fact, 75m high and 8.5m in diameter[2].

On p.86 I state that the SNO $D_2O$ has not been through a reactor and so the tritium content is not enchanced. In fact it is enhanced several-fold over the natural level by the water distillation process which forms part of the isotope separation procedure[2].

The NRX reactor at Chalk River was shut down in January 1992 for repairs. In April 1993 it was decided not to restart the reactor. NRX had been in service since 1947[4,17].

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# THE BEGINNINGS OF THEORETICAL PHYSICS IN CANADA

(Presentation made at the 1993 CAP Congress, Burnaby, B.C.)

by P. Wallace
Victoria, B.C.

## INTRODUCTION

The events I am going to talk about go back over 50 years. To remind myself how remote they are from the present generation of young physicists, I calculated that, to go back that far from my doctoral year of 1940 would take me to the 1890's, when the foundations of modern physics were not yet laid. I also realized to what degree the distant past, even for someone of my age, seems like another world, lived by another person.

I shall not pretend to rigorous historical accuracy; I am not qualified to be a professional historian. The picture I will convey to you will be more like an Impressionistic painting. I will not, and cannot, eliminate the personal bias. The picture I paint will be that of the world seen through my own eyes, coloured by my own experience. It will not be wilfully distorted, but it will be selective and inevitably somewhat personal.

## PRE-1940

I entered the University of Toronto in 1933, in the depth of the Great Depression. The choice of physics was somewhat accidental; I had contemplated medicine, which had to be foregone because of economic pressures; it was a long course, 7 years, and there were almost no scholarships available. I was fascinated by architecture, among many other things. Physics, as taught in the schools at that time, was a dreary subject; in my memory more time seemed to be devoted to changing from one system of units to another than to the understanding of how the world worked. This is not a unique experience of mine; it is shared by many of my contemporaries in our reminiscences about those times. Our teachers were scarcely aware of relativity or quantum mechanics, which were deemed to be the unique preserve of an esoteric coterie of brilliant but quite impractical minds.

One might have thought that, in times of such economic duress, career choices would lean toward the practical, and be determined by the prospects of secure jobs. But happily we were not much swayed by that sort of consideration, since the times were such that nothing was secure. Facing a dubious future and low expectations, we were driven back to a quite different criterion, - to choosing what seemed to be most personally satisfying. I suppose this is what explains the fact that, at a time when the University of Toronto had about 8,000 students, there were over 80 registered in the first year of mathematics and physics. (Of these, 16 survived to graduation).

Why then did I choose physics? Because relativity and quantum mechanics and cosmology were in the air, despite the schools. Because one could find in the public libraries books which tried to unravel their mysteries. There were fewer popularisers of science than now, though they were often given to as much hyperbole, exaggeration, wild speculation, and mystification as their modern counterparts[Fig. 1, Harris cartoon]. But there was awe there, and mystery and challenge. The figure of Einstein stood out as a model hero, not so much for his science, deemed incomprehensible to the ordinary mortal, but for the aura of nobility and humanity and humility that he radiated. The gurus of the popular press were Arthur Eddington and James Jeans, who wrote books whose philosophical "spin" took them well beyond the frontiers of traditional science. Their effect was not so much to make converts to their philosophy as to call attention to the intrinsic excitement of their subject.

As for physics in the Canadian universities, the most important features to note were the dominance of the pragmatic approach represented by Ernest Rutherford, and a strong adherence to the English, and particularly the Cambridge tradition.

Under the influence of the Rutherford tradition[1], theoretical physics was scarcely recognized at all in Canada.


**Fig. 1 Harris cartoon**

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[1] Some famous Rutherford quotes:
- Don't let me catch anyone talking about the universe in my department
- [In answer to Stephen Leacock's enquiry as to what he thought of Einstein's theory of relativity] Oh that stuff. We never bother with that in our work.
- [when asked why he always seemed to be on the crest of the wave in physics] Well, I made the wave, didn't I?
- the energy produced in the breaking down of the atom is a very poor kind of thing. Anyone who expects a source of power from the transformation of these atoms is talking moonshine

It sometimes hid itself in corners of mathematics departments, where it was in bad odour, or in oddball status in Physics departments (King, Watson, Barnes, Archibald...); or, under the guise of "Applied Mathematics" (Toronto).

Consider the contrast with the rest of the western world. Germany and Britain, and in fact pretty well all of Europe had already a long tradition of theory. Not that the situations were identifical everywhere. In England the tie between mathematics and physics tended to be very strongly oriented towards the applied. In France theoretical physics has not to this very day become strongly rooted as a distinct discipline, except in Paris and more recently Grenoble.

Still, theoretical physics very strongly controlled the agenda in Europe. Until the 1930s, Germany unquestionably held the dominant position; a working knowledge of German was considered a necessity for young physicists. In the United States, on the other hand, the pragmatic and technical had tended to dominate until the influx of European refugees fleeing from fascism and Naziism changed the picture in the leading centres.

In Canada, this mass movement of European refugees had relatively little impact, and the empirical tradition, represented by Rutherford but also penetrating by osmosis from the United States held a position of almost total domination. Theoretical physicists were thought of largely as long-haired, eccentric intellectuals, more akin to mathematicians than to real physicists, in general working at the esoteric limits of science and spinning incomprehensible theories outside the mainstream of "real" physics. The teaching of subjects such as atomic physics was considered daring, and stuck closely to classical images and methods; the Bohr-Sommerfeld atomic model was considered to be at the limit of sophistication, and a necessary prerequisite to setting sail on the stormy seas of Heisenberg's matrix mechanics. Relativity and quantum mechanics had not yet become simple subjects, suitable to be taught to undergraduates, but were understood to be technically complex and only marginally understandable.

If I may risk an aside, I would say that all that now survives from that day is the endless tedious argument about the "interpretation" of quantum mechanics, where essentially nothing seems to have changed in 60-odd years.

The Oxbridge influence manifested itself in various ways. The programs in honours physics in Canadian universities were based strongly on the Cambridge model; lots of problem solving, high demands on students (it was not unusual for programs to involve up to eight courses taken simultaneously), stiff examinations and strong links between mathematics and physics (though some French and American mathematicians were wont to say of the empirical tradition so strongly rooted in England "There is no real mathematics in England"). One might add, a fierce adherence to the classical roots of physics. When I was a student at Toronto, one had courses in Hydrodynamics, Elasticity, Hamilton's Physical Optics, and a strange hodge-podge called "properties of matter", to say nothing of Whittaker's classical dynamics, which pushed classical mechanics to its ultimate formal limits. Up to the early sixties there were normally courses in classical mechanics in each of the four years of an honours program.

Another manifestation of the English classical tradition was an irritating tendency to avoid vector notation, with the result of substituting three "component" equations for one vector one in subjects like hydrodynamics and electromagnetic theory.

The result was that, while a generation of young enthusiasts for physics soaked themselves in the popular literature about relativity and quantum theory and cosmology emanating from Arthur Eddington, James Jeans and others,- literature as often mystifying as edifying but certainly not lacking in glamour,- the universities were often still trapped in the confines of semi-classical models or even the morass of elastic aether theories and pervaded by the notion that these new-fangled ideas were deeply suspect. The chairman of the physics department at Toronto was still unabashedly teaching elastic aether theory to students of electricity and magnetism.

At that time in Toronto there was no course in honours physics alone; "mathematics and physics" formed a single package. By and large, if theory beyond the empirical level was used, it fell into the domain of departments of mathematics.

Looking at Toronto, the only theorist in the physics department was Colin Barnes, a clever man and excellent teacher with very little research output. The Applied Mathematics department had been created for the Irish mathematical physicist J.L. Synge, a man of wide interests and experience. Leopold Infeld came in 1937, the year I entered graduate studies, fresh from a year at Princeton under the patronage of Einstein. A.F.C. Stevenson, a Cambridge man, taught quantum mechanics as wave mechanics. Byron Griffiths, a mere lecturer, was the only native Canadian.

By arrangement, electromagnetic theory was taught from a book by Joos, by a member of the physics department, Grayson Smith, who succeeded in completely confusing me. I did not feel comfortable about it until, in my first year of teaching, I had to teach a course in it. At that point it became crystal clear. The necessity of teaching has a wonderful faculty of concentrating the mind; it is one of the best ways there is to learn.

A feature of those days was that professors with research pretensions were reserved for teaching the advanced and graduate courses, while elementary teaching was often relegated either to junior assistants or aging professors who were not doing and sometimes had never done research. The more "advanced" the teaching, the greater was the prestige attached to it. It was not until much later that academics realized the importance of bringing to the students in the early years a glimpse of the excitement that comes from working at the forefront of knowledge, and the insights that probing the depths of a subject generates. Happily, it is no longer a disgrace to teach at the elementary level.

One thing must be said to put the Canadian situation into context: Canada did not, unhappily, profit from the influx of prominent refugee theorists from Europe who, almost overnight, created American theoretical physics[2]. I do not mean, of course, that there were no native theorists,- but just that they were lone operators, not numerous enough to form an interacting community.

It is for this reason that, at the end of the war, theoretical physics, long thriving in Europe and charting the course of physics, was ready for rapid growth in the United States. In Canada, on the other hand, it was necessary to start almost from scratch, and in an atmosphere which ranged from sceptical to hostile.

It might be added that there was another handicap, arising from the economic conditions of the time,- the great Depression, which dominated all of life up to and into the war. There were few who could afford a year in the major centres in Europe; there were no government subventions or foreign-exchange scholarships. In truth, even to contemplate graduate studies in the elite American centres was beyond the range of possibilities of Canadian students. I myself, for example, dreamt of Princeton, and even got so far as an interview with the head of the physics department visiting in Toronto, but soon realized it was an empty dream. The financial resources were simply not available. Unlike in the postwar years, we were trapped in our neo-colonial and provincial isolation.

## THE WAR AND THE EMERGENCE OF THEORETICAL PHYSICS AS POWER

The prospects for aspiring Canadian theorists in Canada in 1939-40 were bleak indeed. Unfortunately, the misery of the world created opportunities for them which could never have been anticipated. Sometimes, in recent years, I have been tempted to say to frustrated or impatient young theorists, "Well, it was even worse in my day". But then I remember what made our situation better. Just as the War solved the problem of capitalist economies mired in depression, so did it open up the doors for us.

When I got my doctorate in 1940, J.L. Synge took me aside and said to me "People like you will be needed for war work, but things are as yet rather disorganized and unready. Take a job as a 'holding operation' and when the time comes, be ready when I call you". So I got a lectureship in the Mathematics Department of the University of Cincinnati, followed by one semester at M.I.T., when Synge wrote to say: "Pack up immediately, come to Montreal. There is a very important project which needs you; I can't even give you a hint as to what it is, but I hope you will agree to accept". So I did, and arrived in Montreal in December 1942 to become of the first members of what was to become the Canadian Atomic Energy Project.

Our first home was a big old house on Simpson Street; later, and for the rest of the war, we moved to a wing of the recently built but still unoccupied University of Montreal building on the north slope of Mount Royal, which we christened the "cheese factory". The group was an unusual one, patched together from loose ends in the Canadian physics community which had not been caught up in the urgent radar project. Radar, by and large, absorbed the Canadian physics establishment; we were the newcomers, the outsiders, and a motley crew of German refugees, Free French, English, and the odd American. It was not, at first sight, a very impressive lot of theorists who assembled under the leadership of Georges Placzek.

I must pause to pay a special tribute to Placzek who, even more than Infeld, introduced me to "big league physics". Placzek himself was, during the later thirties, a member of Bohr's institute in Copenhagen. He was closely involved with the problems opened up by the discovery of fission and the commotion it caused in the physics community, so he was an obvious choice to lead the theorists in Canada. His close contacts with Bohr, Peierls, Bethe, Weisskopf, Wheeler, Wigner and Franck as well as Heisenberg connected us to the very centre of activity in theoretical physics. A famous paper by Bohr, Peierls and Placzek was a major step in theoretical nuclear physics, known and quoted by everyone but never published!

However, aside from his brilliance as a scientist, Placzek was an exemplary and inspiring leader. He never criticized, was always enthusiastic about the work done by members of his group, and somehow contrived to make everyone feel important. If self-esteem is a necessary condition for creativity, it can be said to his credit that he instilled that quality in everyone who worked under him.

The original group comprised George Volkoff, fresh from a doctorate with Oppenheimer on the theory of what were later to become known as neutron stars; Carson Mark, a young mathematician from Manitoba and father of four, Jean Agnew, a mathematician from Vassar College, Boris Davisson, son of an English engineer who had been educated in the Soviet Union; two men seconded from the army: John Stewart and Hank Clayton; Ernst Courant, son of the famous mathematician of that name who later became a design of accelerators at Brookhaven; Bengt Carlson who became head of the computer group before moving on to the same job at Los Alamos; and Bob Marshak, a young New Yorker who was ultimately to become the most distinguished of the lot and a university president, and one of the leaders of American high-energy physics. Others came later; notable among them was Maurice Pryce, who had worked with Dirac,- a rather unique feat.

It would be pretentious of me to claim to be able to recount the history of the Canadian atomic energy project which evolved after the war into the Chalk River laboratories, because I was not an "insider", being barely more than a fresh Ph.D. A large part of our work was in the problems of neutron diffusion in reactors. We understood, of course, that bombs lurked in the background, but that was not the focus of the Canadian project, which was seen as directed toward the realization of a graphite-moderated reactor.

[2] Bethe, Wigner, Weisskopf, Einstein, Gamow, Szilard, Fermi, etc.

I think our understanding was that this would provide fuel for bomb construction, but largely the whole thing was a test of the feasibility of the nuclear reactor concept, and the determination of the nuclear constants which would provide necessary data for the job.

I cannot emphasize too strongly that the very recognition of the need for a substantial theory group represented a radical departure from the Canadian physics tradition and reflected the influence of the largely European élite who directed the project. (I do not use the word "élite" here in any pejorative sense). I think that it may be said that Canadian theoretical physics had its organizational roots here. For the first time in Canada theoretical physics was recognized as having a distinct identity. We had had no Princeton Institute, no Copenhagen school, no Göttingen. It is appropriate too, that it took place in a decidedly international context. From the start, the whole project was dominated by prominent figures imported from abroad. Thus, the original director was Hans Halban, from France. He was later succeeded by Cockcroft from England. Placzek of course led the theory group. Newell from England was the senior engineer. We had a substantial representation of Germans who had been interned at the beginning of the war, sent to Canada and released there; a very substantial "Free French" group including Pierre Auger, Gérin, and Goldschmidt and Kowarski, and Pontecorvo from Italy via the USA.

On the experimental side, there were two established Canadian nuclear physicists who had already worked in neutron physics, Bern Sargent from Queens and George Lawrence from NRC. The Canadian theorists were all young and relatively inexperienced in nuclear physics. Another factor, not insignificant, was sporadic contact, realized in visits, with two outstanding European physicists, Rudy Peierls who was a sort of scientific bridge between the English and American projects and Eugene Wigner from the Chicago wing of the American project. I was particularly impressed by Peierls, partly I think because while a graduate student at Toronto I had given a seminar based on a very lucid paper of Kapur and Peierls on nuclear reactions. Peierls visited us several times, accompanied by German émigré Klaus Fuchs and Tony Skyrme. (The presence of Fuchs, later to be famous for his espionage on behalf of the Soviet Union, was to have interesting consequences.)

That Canadian theoretical physics, like American, had its roots in Europe is beyond question. The "Canadian context" was therefore neither impressively strong nor numerous. We in the Canadian project were in many respects junior partners. The famous (or infamous) General Groves was quick to remind us of that fact.

Once things got going, the project established itself at the University of Montreal, occupying the wing immediately to the west of the tower. The University of Montreal campus, though built, I believe, in 1929, had not yet been occupied by the university. Science in French Canada was at that period woefully underdeveloped; its most distinguished contribution to our project was Pierre Demers, an expert in photographic emulsion techniques in cosmic rays, who could best be described at that time as an "original", a "character", sui generis. It is of interest to note that the term "Québecois" was not in use at that time; Pierre insisted that he was an authentic "canadien", which was not the same as Canadian.

Another feature of the "atmosphere" surrounding the nucleus of theorists in Atomic Energy was the fact that it was cast in a setting that involved it in a very practical way with its experimental counterparts. Theory was from the beginning recognized as having a distinguishable rôle but in no sense a separate one. Theorists were nurtured in an atmosphere of full partnership with the experimental groups within a framework of common goals.

My last experience at Atomic Energy had a determining influence on my subsequent career. The problem of graphite reactors included concern for what would happen to materials (in particular, graphite) under continued heavy neutron bombardment. Eugene Wigner, working in Chicago, was said to have determined that it should undergo shrinkage between the graphite layers. The Montreal lab undertook a search among its members to see whether anyone had had previous experience in solid state physics. They were not successful, so the next step was to ask whether anyone would undertake to acquire such expertise. Ever reckless, I volunteered, though my previous experience had been in relativity and nuclear physics. The result was that I was sent to N.F. Mott's lab in Bristol for four months of exposure to the fountain of wisdom in the field. Mott ran his lab in a remarkable way; he made the rounds daily of its members to enquire what progress they had made since the day before. In such a regime, it was guaranteed that one learned very fast. Mott also had a very intuitive, non-mathematical approach to the subject. This very flexible approach had its merits. He made a prediction in one of his lectures which was contradicted by an experimenter who showed evidence that it was wrong. Mott hesitated a moment or so, and then announced, triumphantly "Ah, I can explain that too". Obviously, Mott would have made a good economist!

As for graphite, I had the good fortune to meet Charles Coulson, a theoretical physicist-chemist-mathematician who was thinking about the properties of graphite. I wrote a seminal paper on its band structure in 1947. I returned to the subject once every ten years for a few decades afterwards. The first predicted, correctly, it turned out, that graphite would expand under intense radiation.

The consequence of this brief episode was to determine my subsequent course in physics. For the rest of my academic career, my primary focus of interest was in solid state physics, though I made occasional sorties into other domains.

## AFTER THE WAR

By August of 1945 the bomb had been successfully tested, bombs had been used on Hiroshima and Nagasaki, and the war had come to an end. Placzek had left for Los Alamos some time earlier, with Carson Mark, Bengt Carlson and Boris Davisson. Plans were well advanced to move the whole Canadian project to Chalk River. When I returned from Bristol in the spring of 1946, I went to Chalk River for the summer, decided that this was not the life I wanted. Having developed an attraction to Montreal, rather than go back to MIT, from which I was technically on leave, I took a post at McGill, not surprisingly in the department of Mathematics. Certain complications of academic politics followed, such as jurisdictional disputes over course assignments. Theoretical physicists were treated more or less as foreigners or rivals by at least a segment of the physics department.

The project had not only created the circumstances for a major change in Canadian physics, but also led to the reshaping of the National Research Council. While a gap opened between Chalk River and the universities, the Council itself, which had hitherto been little more than a bureau of standards with little interest in basic science, took on a much more ambitious role. It head, C.J. MacKenzie, an engineer by training, had a vision of turning it, after the war, into a major centre of scientific research which would take a leading rôle in the development of science in post-war Canada. Prior to the war, financial support for science by government had been minimal and spotty, largely directed toward small-scale projects of a practical nature. Under MacKenzie's astute leadership, it was to become the major base of science funding, and to build a network of world-class laboratories of its own. MacKenzie realized, I think, that the enhanced prestige with which science in general and physics in particular emerged from the war created the opening needed for him to realize his vision. It is only to be deeply regretted that, though he succeeded resoundingly,- a process which projected Canadian physics to the front of the world stage,- pygmies with smaller minds have in recent years undertaken to dismantle the fruits of this effort, along with numerous other institutions in which Canadians have justifiably taken pride.

In this enterprise, manifested in the creation of this extensive N.R.C. laboratories and in the accompanying system of government support for research in the universities, special tribute must be paid to two men who played leading rôles in the accomplishment: E.W.R. Steacie, who moved from the directorship of Atomic Energy to presidency of N.R.C., and Gerhard Herzberg, who is happily still among us. Both had a profound commitment to fundamental science, and more than a trace of distrust for politicians, largely legally trained, who considered themselves as more qualified to determine public policy with regard to science than scientists themselves. Both understood that science served society most profoundly through pushing back the frontiers of knowledge rather than pursuing exclusively short-term technological goals.

As for Atomic Energy, still a government agency, it remained for some time a wing of N.R.C. and not yet a corporation. In a manifestation of the principle that good ends are often realized in devious ways, it served as a model for government concern with science in the post-war world, but it also gave to scientists, and again most of all physicists, a greatly enhanced prestige,- possibly rather greater than they deserved. The modest Canadian project was the vehicle through which an obscure mathematician from Manitoba became the head of the theory division at Los Alamos, and a quiet Swedish-Canadian became the director of the pioneering computer facility there. All of us certainly has the opportunity to profit from the experience.

Despite this fact, just after the war one found the curious situation, at least for those who returned to academia, that they did not in general find themselves warmly welcomed by the academic physics establishment. The result was that theorists frequently found themselves courted by departments of mathematics, or were, as in Toronto, in limbo between mathematics and physics, like Infeld in the department of "Applied Mathematics" there.

George Volkoff, with whom I shared an office for a while during the war (until he succeeded Placzek as director of the theory group) went back to UBC, whence he had come, into an awaiting position in the physics department; the subsequent development of theoretical physics there can be largely attributed to him.

At McGill, I found myself with a back-breaking teaching load; 15 hours a week of teaching, including three graduate courses! I shudder when I think of what the quality of teaching was. There may be the odd aging physicist here who can testify to the justice of my misgivings. All the same, I have few regrets, for two of the courses addressed clienteles which I continued to serve for some years after: there was a course in quantum chemistry and one in mathematical physics for engineers. In the sense that one learns much from teaching, both of them served me well.

Engineering led me into new areas of experience, as did chemistry. I came to appreciate that a chemical viewpoint could provide useful insights into solid state problems.

Without administrative duties and with strong moral support from my (mathematics) department chairman, I began to accumulate colleagues; Bob Sharp, back from the air force, Ted Morris from Infeld's Toronto group and Dave Jackson, who has since risen to great heights in American physics. We tried to attract others; Walter Kohn actually committed himself to us at one point but later retracted; I was able to make an offer to Gerry Brown, a political exile from the US, who unfortunately did not accept. Meanwhile, we got some outstanding undergraduate students. One year we had Bernie Margolis, Lionel Goldfarb, a nuclear physicist who finished up in Manchester, and Ralph Logan, until recently at least a leader of an experimental group at Bell Labs. Another produced Kurt Gottfried and Sy Vosko. Later came Earl Lomon, for a few years a McGill faculty member, and Arthur Kerman, both now professors at MIT. At the graduate level, Bob Sharp was my first Ph.D. student. Later came Rudy Haering who did his doctorate with me in record time, and went on to bigger things. So it has gone at McGill ever since, right up to the present day. The "theoretical physics group", first in the mathematics department and then, after 1961, in physics, had no official status, and no "head", but an ever-growing and expanding collection of professors, post-doctoral fellows, and graduate students with a geographical location and a strong sense of solidarity.

On the national front, UBC was off the mark quickly in theoretical physics, recruiting primarily from Europe. Infeld continued to nurture excellent students at Toronto and, until the shameful crisis which forced him to leave to return to Poland in the early fifties, strove to realize his ambition to create a Canadian version of the Princeton Institute of

Advanced Studies where he had worked with Einstein. He also, however, worked under the banner of Applied Mathematics rather than physics. If one man were to be identified as the fountainhead of Canadian theoretical physics, it would have to be Infeld, who produced after the war a steady stream of exceptional students from Toronto.

While at Atomic Energy, I made the acquaintance of Harry Thode, who expounded on his ambitious plans to turn McMaster University from a minor Baptist College into a major scientific university. He urged me to consider joining him to work on building a theoretical group. It went to the point that I visited McMaster to scout the situation, but I came away feeling that the base was too weak to make the chances look promising. Here I made a bad error of judgment; much as I admired Harry I thought his chances of success were slim. All will testify how wrong I was.

In Toronto, as in McGill,- thus, in two of the major centres of theoretical physics (UBC being a happy exception),- the situation remained artificial and uncomfortable. More and more, in the post-war mathematical world, mathematicians were divorcing themselves from their physical roots, and were absorbed in axiomatics and abstract formal structures. To them, "applied mathematics" was not "real" mathematics, and they could not accord real respect to their "applied" colleagues.

Physics departments, however, viewed theorists in a different and rather patronizing light. Their concept of a theorist was a sort of mathematical technician who solved problems based on their personal experiments. Thus Dave Jackson, attaching himself to the Radiation Lab at McGill, found himself doing calculations of the slowing down of charged particles in matter. He left, after a sabbatical in Princeton, to work at the forefront of particle physics. On the other hand, alienation from experimental physics is debilitating to all but the most brilliant theorists. There are few Diracs in the world! It is experience in facing and resolving problems which hones the intuitions which drive most theoretical physicists.

Nevertheless, it was not until 1961 that the by then formidable theoretical group at McGill was finally integrated into the physics department. The reluctance at that time came not from the theorists' side, but from the elements in the physics department fearful of such drastic change. And it did indeed make a radical change, not always comfortable but stimulating to all. Theorists who may have feared second-class treatment were to do more than hold their own in the expanded department, due in large measure to their ability to command sizeable research grants from the N.R.C.

The physics department at Toronto showed itself more flexible, and gradually began to build its theoretical wing up to strength, a key element in the process being the acquisition of Jan van Kranendonk, whose international status gave him the necessary clout. Meantime, with the departure first of Synge and then of Infeld, Applied Mathematics faded away.

In a few cases "applied mathematics" survived; at the University of Western Ontario it has resisted integration into physics, but has been diluted by a broadening of the scope of "applied mathematics". A small group of theorists at Manitoba also stayed within the ambit of mathematics.

The still small numbers of Canadian theoretical physicists in the late forties and early fifties, having found themselves courted in some universities (like McGill and Toronto, for example) by the less conservative mathematics community, made the best of this association. Mathematician Lloyd Williams of McGill was the driving spirit of the Canadian Mathematical Congress, which readily took theoretical physics under its wing. The early international conferences held in Canada after the war were held under its auspices. An outstanding example was one in Banff in 1949 [Fig. 2 Conference pictures, 1949 and 1957] in which Dirac was a key speaker[3]. Another was the Indian theoretician Homi Bhabha. Laurent Schwarz, the French mathematician who invented the theory of "distributions" which gave mathematical respectability to Dirac's delta-functions, was still another. (Dirac himself took issue with that statement, insisting with some justice that, in his hands, they were already respectable).

I no longer remember the content of Dirac's lectures, which I believe made no permanent impact on physics. I do remember a huddled conference of some participants in the evening after one of his lectures, which reflected considerable puzzlement among his audience.

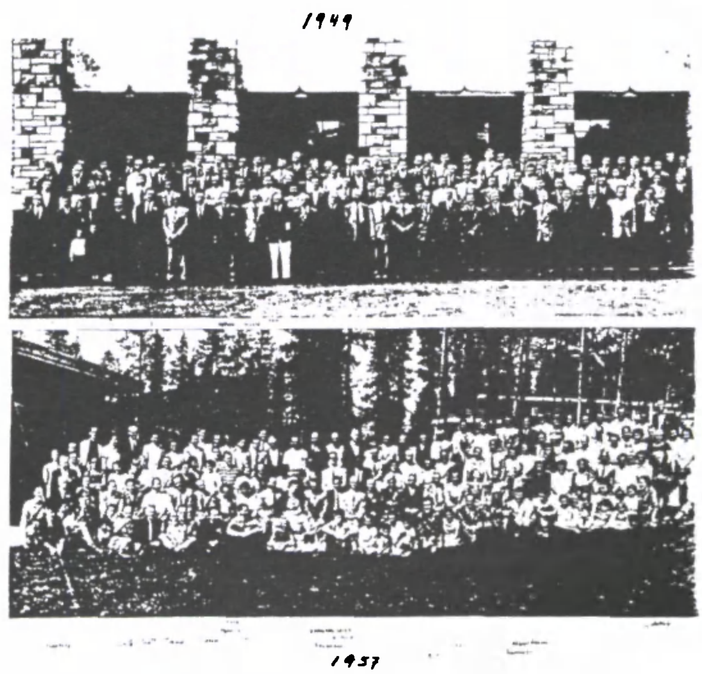


**Fig. 2 Conference photographs - 1949 and 1957**

[3] It is interesting to note that, in the 1957 picture, there are still more mathematicians than experimental physicists among the participants.

It was arranged that one of their number would question him at the start of his next lecture about a sticky point which troubled all of us; unfortunately, the questioner, unaware of Dirac's delightful forthrightness, put his "question" badly, saying "There is a point that I did not understand in your last lecture...". Dirac's reply was unhesitating: "That is not a question, it is a statement".

In the fifties, the Mathematical Congress also had summer research institutes at Queens University at which theoretical physics was an important element.

The immediate aftermath of the war and the bomb was that scientists became very much involved in politics,- a situation which has persisted ever since. In Canada this stimulated the formation of what was at first called the "Canadian Association of Professional Physicists". I think that the word "professional" was introduced in the hope of promoting physicists to the FINANCIAL status of doctors, lawyers, or engineers. However that may be, I was not impressed, having reverted, in the university milieu, to being somewhat of an academic purist. I felt that while medicine or law might be the preserve of their practitioners, physics, like cosmology, belonged to the world at large. It was not long, however, till it was decided that it would be expedient, if one were to secure widespread support among academics, to drop the qualifying word, and the Canadian Association of Physicists was born. One of its early activities was to organize occasional international conferences, and I found myself involved in organizing a conference of theorists. I believe that it was in this context that the idea was generated of creating a theoretical division. The late Bill Sharp of Chalk River was involved; so was Toronto theorist Dick Steenberg. The formation of the division coincided with the beginning of a period of rapid growth of theoretical physics in the country, and the division grew dramatically.

By 1957, the theory division of the fledgling CAP held its first summer school at Banff, with Julian Schwinger, Philip Morrison, Eugene Wigner, and John Bardeen as lecturers. Bardeen had just evolved the BCS theory of superconductivity, and we were among the first to hear it exposed directly by its founder (unfortunately, Bardeen, genious and likeable person though he was, was not the world's most lucid lecturer, and it remained for others to make the picture clear). But we were there with the best and the brightest.

By the mid 1960s, physics departments were expanding rapidly, and a new generation of theorists was developing; Canadian theoretical physics had finally come of age.

It occurred to me that it would be appropriate to end with some quip or anecdote which would show how much more sober and modest physicists were about their work in those earlier days than the present generation, and I recalled Vicki Weisskopf's story about the skits they used to do at the Bohr Institute in Copenhagen. I quote his "Joy of Insight": "Naturally, we revived the tradition of a comic session at the institute. Those of us who wrote the skits and put together the comic evenings before the war, to the great amusement of the older generation, had looked forward to the day when we would sit in the first row and see a show put together by a younger generation poking fun at us. But it did not turn out this way. Once again (we) had to think up the ideas and produce the skits. We had a wonderful time taking off on our own generation. Among our favourite targets were the scientists who quickly invented theories to explain observations that were still doubtful. For example, we showed a completely blank picture supposedly taken by a bubble chamber, an instrument that shows colliding and decaying particles. Casimir imitated the voice of a well-known theorist announcing importantly "This is an event which has not yet taken place. But it is not too early to draw the following conclusions...".

And then I realized that Weisskopf had said "Taking off on our own generation". I could only conclude that the moral was not the one I had imagined. It seems rather to suggest that in some respects at least, plus ça change, plus c'est la même chose.

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# *Physics and Education*
# *La Physique et l'éducation*

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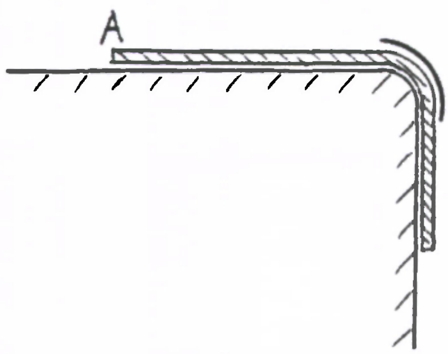
# The 1993 CAP Undergraduate Prize Examination

Answer as many questions as you can. The values of the questions are shown on the paper. Marks total 188. The only aid permitted is a hand calculator. To help ensure fairness to those writing at the various locations, you are requested to not ask for clarification or interpretation of the questions.

**Question 1** (Value 20 marks)




A uniform rope of length L lies on a horizontal table with part of it, of length D, over the edge, where it is constrained to hang vertically by a piece of tubing. The rope is released from rest. Assume no friction. Find the time for the rope to leave the table (i.e. the time for A to reach the edge).

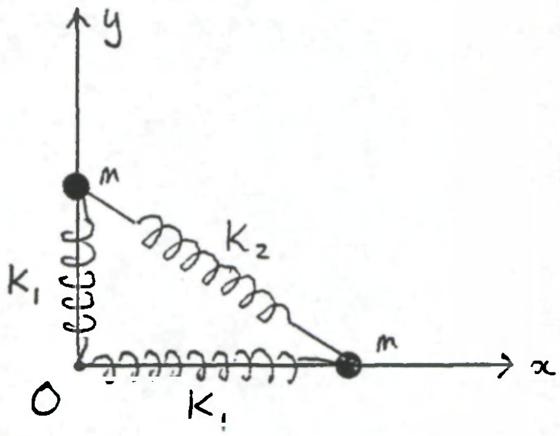
**Question 2** (Value 20 marks)

A sphere of radius r rolls without slipping in a hemispherical bowl of radius R. It is released from rest with the line between its center and the center of curvature of the bowl making an angle $\theta$ with the vertical.

(a) What minimum coefficient of friction enables it to roll without slipping?

(b) What is the translational velocity of its center at the lowest point in its motion?

**Question 3** (Value 20 marks)




Two particles of mass m are constrained to move without friction along the x- and y-axis respectively and are connected to a fixed point O by three springs as shown. At equilibrium, the springs are unstretched. Assume the unstretched lengths of springs $k_1$, $k_2$ are b and $\sqrt{2}b$ respectively.

**(a)** Write the equation of motion for the particles, assuming small oscillations.

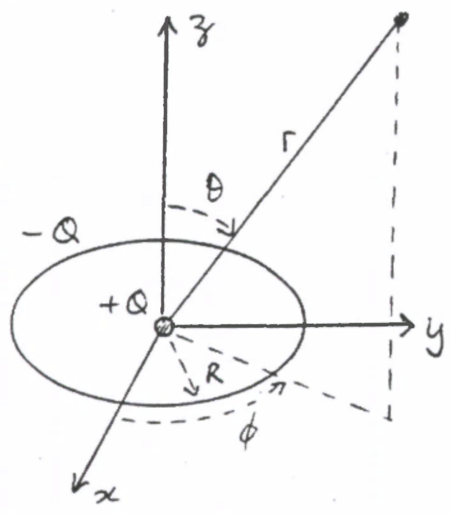
**(b)** Find the normal frequencies of small oscillations in terms of m, $k_1$ and $k_2$.

**(c)** Find the initial conditions that would set off the system vibrating in <u>each</u> of its normal modes.

**Question 4** (Value 12 marks)

Three equal conducting spheres are placed at corners of an equilateral triangle. When their potentials are $V_0$, 0 and 0, the charges are $Q_0$, $Q_1$ and $Q_1$ respectively. Show that when each sphere is at potential $V_1$, each has a charge $(2Q_1 + Q_0)V_1/V_0$. Find the potentials when the charges are $Q_2$, 0 and 0.

**Question 5** (Value 20 marks)




A charge distribution has a point charge +Q at its center and a charge -Q distributed uniformly around a circle of radius R lying in the (x,y) plane. Show that the first non-zero term in the expansion of V, the electrostatic potential for $r \gg R$ is

$$\frac{Q}{4\pi\epsilon_0 r} f(\theta,\phi) \, (R/r)^2$$

and find $f(\theta,\phi)$.

**Question 6** (Value 15 marks)

(a) Three identical bodies, of constant heat capacity 500 J/K each and at temperatures 3000 K, 300 K and 100 K, respectively, are used as reservoirs for heat engines or refrigerators. Show that the maximum amount of work that can be extracted for these bodies is about 38 kJ. What is the final temperature of the three bodies?

(b) Starting once again from the beginning, with the initial temperatures of the three bodies were 300 K, 300 K and 100 K, find the maximum temperature to which any one of them can be raised without exchanging heat or work with the surroundings. What are the final temperatures of the other two?

**Question 7** (Value 15 marks)

A simple model of a paramagnetic material solid is a net of N non-interacting paramagnetic atoms, each with a spin 1/2 and magnetic moment, $\mu$, fixed on a lattice. When placed in a magnetic field H, the single particle energy levels are $E_1 = -\mu H/2$ and $E_2 = \mu H/2$ for spins aligned and anti-aligned with the field.

**(a)** If there are $n_1$ atoms in the $E_1$ state and $n_2 = N-n_1$ in $E_2$ state, show that the degeneracy of this state is

$$g(n_1) = N! / [n_1! (N-n_1)!] .$$

**(b)** Determine the partition function in closed form by evaluating the sums.

**(c)** Determine the entropy of the system, take its limit as $T \rightarrow 0$ and compare to Boltzmann's principle, i.e. S(ground) = k ln[g(ground)].

**Question 8** (Value 15 marks)

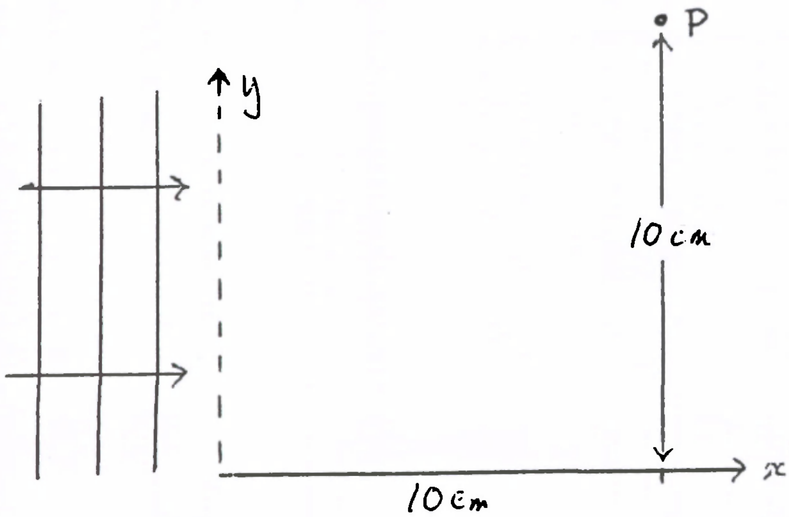
A particle of mass m confined to one dimension is in a potential well defined by $V(x) = 0$ for $0 < x < a$, $V(x) = V_0$ (a positive value) for $x > a$, and $V(x) = +\infty$ for $x < 0$. Assume a non-relativistic solution, find the criterion for there to be at least one bound state.

**Question 9** (Value 15 marks)

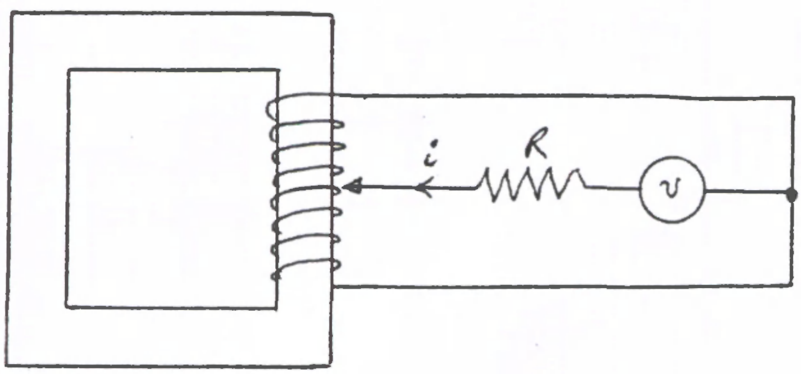
Why was the neutrino postulated to help explain $\beta^+$ and $\beta^-$ decay? Describe the energy spectrum of $\beta^+$ and $\beta^-$ particles emitted in nuclear decay. Describe the effect on the $\beta$ spectrum of a possible non-zero neutrino rest-mass. $^{41}Ca$ decays to $^{41}K$ by orbital electron capture. Describe the energy spectrum of the emitted neutrinos. The masses are $^{41}Ca$ = 40.962274, $^{41}K$ = 40.961815, electron mass = 0.000542 all in atomic mass units (u).

**Question 10** (Value 12 marks)

A plane monochromatic wave (wavelength 500 nm) is incident normally as shown on a grating consisting of parallel lines perpendicular to the XY plane having a spacing which is a function of position (y). As a result, the light converges on a line in the vicinity of P. Attributing this to +1 order diffraction, what would be the grating spacing as a function of position y on the grating? Describe the result of the -1 order diffraction. Use ray diagrams for both.

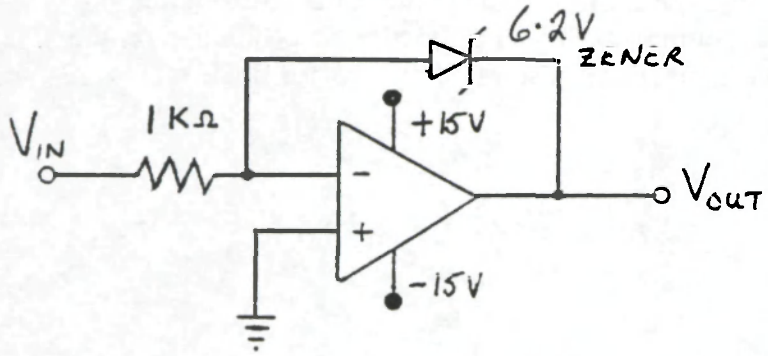


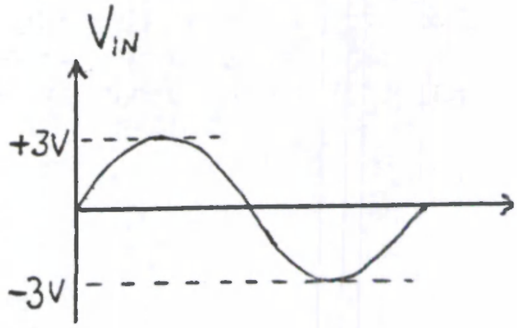

**Question 11** (Value 12 marks)



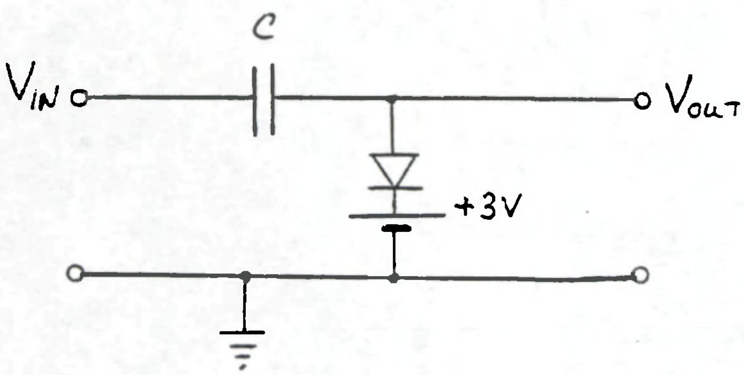

The diagram shows an ideal transformer with one winding and a sliding contact (assume many turns, N). The voltage source is ideal and is given by $v(t) = V \cos(\omega t)$. Find an expression for the current i as a function of the number of turns in the lower part of the winding.

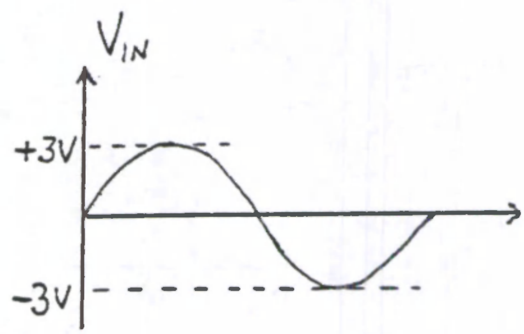
**Question 12** (Value 12 marks)




**(a)** Explain the operation of the circuit shown above and draw its output as a function of time. Assume the amplifier has a large open-circuit gain.



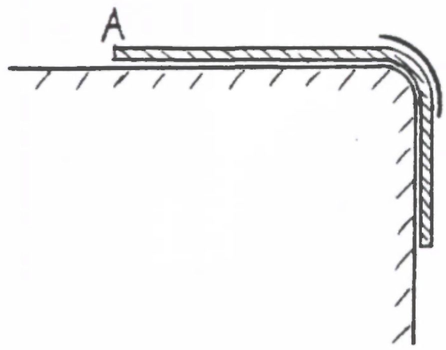

**(b)** Explain the operation of the circuit shown above and draw the output waveform. Assume an ideal diode.

## Concours universitaire de l'ACP, 1993

Répondez à autant de questions que possible. La valeur de chaque question est indiquée dans l'examen. La valeur totale de l'examen est 188 points. Le seul aide permit est une calculatrice de poche.

Pour s'assurer que les mêmes conditions soient présentes à chaque location, s'il vous plait ne demandez aucunes explications ou clarifications à propos des questions.

**Question 1** (Vaut 20 points)




Une corde de densité uniforme et de longeur L repose sur une table avec un bout de corde, de longeur D, qui dépasse le rebord de la table. Ce bout de corde est suspendu verticalement à l'aide d'un tube. S'il n'y a pas de friction, combien de temps faudra-t-il pour que la corde quitte la table. ( pour que le point A atteigne le rebord de la table)

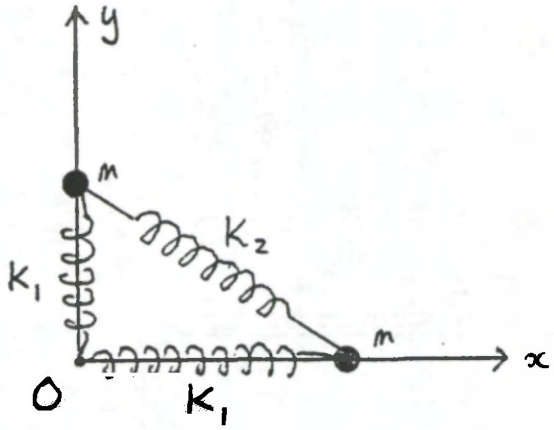
**Question 2** (Vaut 20 points)

Une boule de rayon r roule, sans glissement, a l'intérieur d'une coupe hémisphérique de rayon R. La boule est mise en mouvement à partir d'une position où une droite tirée entre le centre de la boule et le centre de courbure de la coupe fait un angle avec la verticale.

(i) quel est le plus petit coéfficient de friction necessaire pour que la boule de roule sans glissement?

(ii) quelle est la vitesse du centre de masse de la boule au point le moins élevé de son mouvement?

**Question 3** (Vaut 20 points)




Deux particules de masse m sont attachées à un point, O, à l'aide de trois ressorts (voir le dessin). Les particules sont limitées a des mouvements le long de l'axe X ou bien de l'axe Y respectivement. Lorsque le système est en équilibre les ressorts ne sont pas etirés et les longeurs des ressorts $k_1$ et $k_2$ sont b et respectivement.

(a) Ecrivez l'équation du mouvement pour les particules pour des oscillations à petite amplitude.

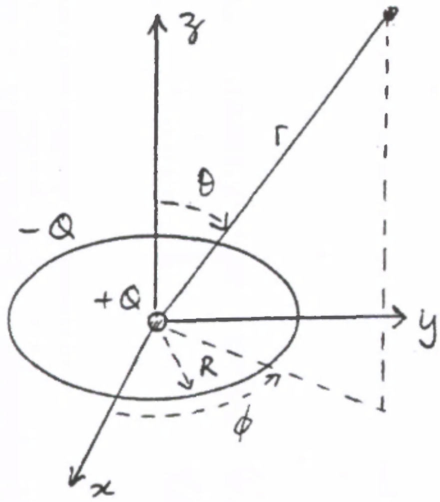
(b) Trouvez les modes normaux de vibrations en fonction de m, $k_1$ et $k_2$.

(c) Quelles sont les conditions initiales qui produiront chaque mode de vibration normale?

**Question 4** (Vaut 12 points)

Trois sphères conductrices identique sont placées chacunes à un des sommets d'un triangle équilatéral. Le potentiel électrique de chaque sphère sont $V_0$, 0 et 0 lorsque les sphères portent les charges $Q_0$, $Q_1$ et $Q_1$ respectivement. Montrez que si chaque sphère a un potentiel $V_1$, alors la charge de chaque sphère doit être $(2Q_1+Q_0)V_1/V_0$. Quel sera le potentiel électrique du système si les charges sont $Q_2$, 0 et 0?

**Question 5** (Vaut 20 points)




Considerons une distribution de charge dans le plan x,y où une charge -Q est distribuée uniformément le long d'un cercle de rayon R et une charge -Q est concentrée en un point au centre du cercle. Montrez que dans le développement du potentiel électrostatique, V, le premier terme différent de zéro pour $r \gg R$ est

$$\frac{Q}{4\pi\epsilon_0 r} f(\theta,\phi)\,(R/r)^2$$

Trouvez une expression pour $f(\theta,\phi)$.

**Question 6** (Vaut 15 points)

(a) Trois corps identique de capacité thermique 500J/K et températures 3000K, 300K et 100K respectivement, sont utilisés comme réservoir de chaleur. Montrez que le travail maximum qui peut être effectué a l'aide de ces corps est 38 KJ. Quel est la température finale des corps?

(b) Si les mêmes trois corps ont des températures respective de 300K, 300K et 100K quelle sera la température maximale qu'un des corps pourra atteindre s'il n'y a pas déchange de chaleur ou travail avec le milieu environent? Quelle sera la température finale des deux autres corps?

**Question 7** (Vaut 15 points)

Un modèle d'un solide paramagnétique consiste d'un réseau de N atomes paramagnétiques découplés ayant un spin ½ et moment magnétique $\mu$. Lorsqu'un champ magnétique H est appliqué, 2 états sont possibles pour chaque atome, $E_1 = -\mu H/2$ et $E_2 = \mu H/2$ pour les spins parallèles et anti-parallèles aux champs magnétique.

(a) Si $n_1$ atomes sont dans l'état $E_1$ et $N-n_1$ atomes dans l'état $E_2$, montrez que la dégénéréscence pour cet état est

$$g(n_1) = N!/[n_1!(N-n_1)!].$$

(b) Calculez la fonction de partition à partir des sommes.

(c) Trouvez l'entropie du système, calculez sa valeur dans la limite $T \to 0$ et discutez le résultat vis à vis le principle de Boltzman ( S(fondamental) = k ln(g(fondamental) ).

**Question 8** (Vaut 15 points)

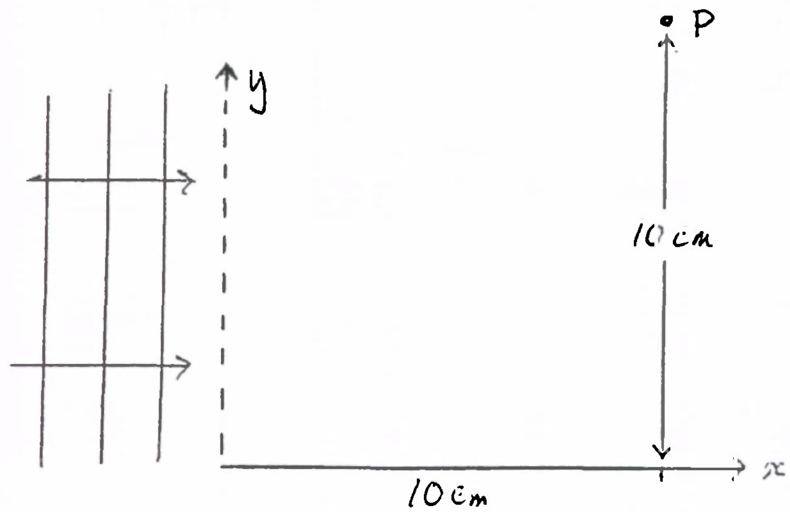
Une particule de masse m dans un espace à une dimension est soumise a un puit de potentiel, $V(x) = 0$ pour $0 < x < a$, $V(x) = V_o$ ( $V_o > 0$ ) pour $x > a$ et $V(x) =$ pour $x < 0$. Dans le cas d'un mouvement non-relativistique, trouvez le critère necessaire pour avoir au moins un état lié.

**Question 9** (Vaut 15 points)

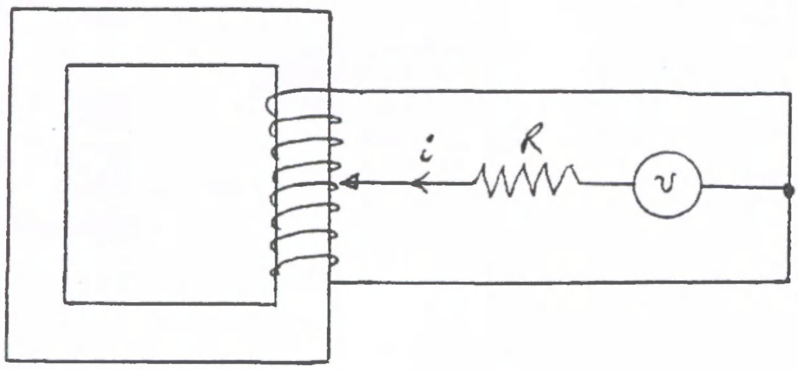
Pourquoi fut-il necessaire de postuler l'existence du neutrino pour expliquer l'émission des particules $\beta^+$ et $\beta^-$? Quel est le spectre énergétique des particules $\beta^+$ et $\beta^-$ produitent lors d'une désintégration nucléaire. Décrivez comment le spectre des particules $\beta$ serait modifié si le neutrino avait une masse au repos qui n'est pas zéro. Pourquoi $^{41}Ca$ doit il capturer un électron orbitale plutôt que d'émettre une particule $\beta^+$ lors de sa transformation en $^{41}K$? Décrivez le spectre énergétique des neutrinos émis, les masses etant $^{41}Ca$ = 40.962274, $^{41}K$ = 40.961825 et l'électron = 0.000549 en unité de masse atomique.

**Question 10** (Vaut 12 points)

Une onde plane monochromatique (longeur d'onde de 500 nm) frappe un réseau de diffraction à une incidence normale. Le réseau consiste de lignes parallèles qui sont perpendiculaire au plan XY et ont une séparation qui dépend de la position (y). Si l'image produite est une ligne dans le voisinage de P et est attribuée à l'ordre +1, quelle est la séparation des lignes (le long de y) dans le réseau ?. Decrivez l'image produite par l'ordre -1, utilisez une analyse par rayons pour chaque réponse.



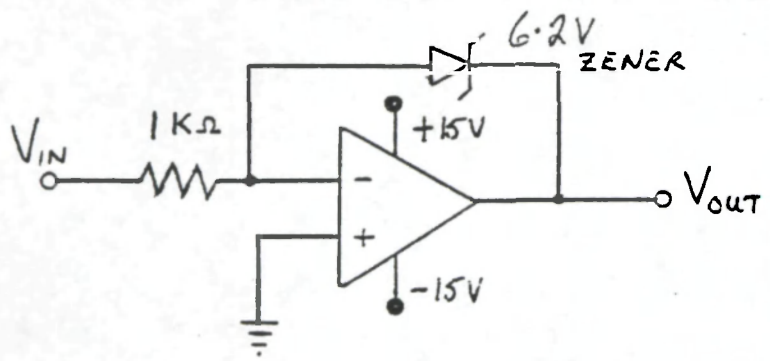

**Question 11** (Vaut 12 points)

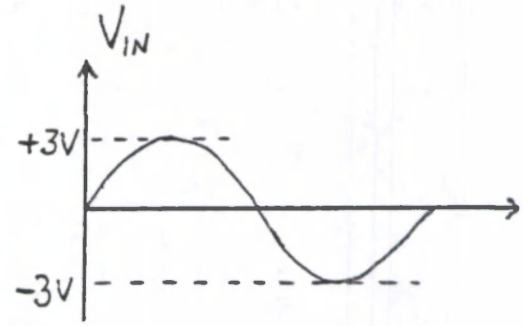



Le circuit dans le schéma suivant consiste d'un transformateur idéale (1 bobine de N tours, N est très grand), un contact coulissant et une source de tension idéale. Trouvez la fonction décrivant le courrant dans la partie inférieure du circuit, i(t), en fonction de N, si le voltage est $V(t) = V \cos \omega t$.

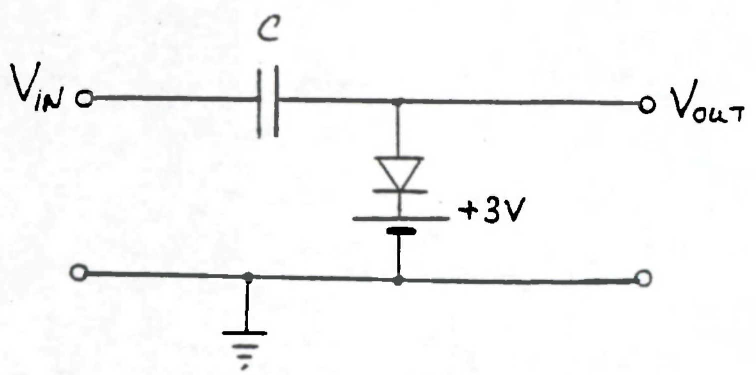
**Question 12** (Vaut 12 points)

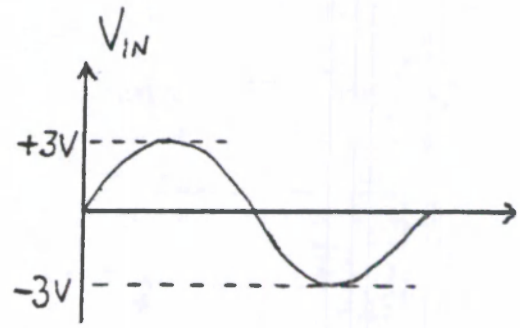
(a) Expliquez le fonctionement du circuit suivant et tracez la courbe de $V_{OUT}$ en fonction du temp. Présumez que l'amplificateur a une très grande amplification en circuit ouvert.




(b) Expliquez l'opération du circuit suivant et tracez l'onde résultante, présumez une diode idéale.



# FIRST PICOSECOND TIME-RESOLVED keV SPECTROSCOPY OF PLASMAS PRODUCED BY SUBPICOSECOND LASER PULSES

(1993 Lumonics winner at the CAP Congress, Simon Fraser University)

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**ABSTRACT**

We present the first temporally and spectrally resolved study of ultrashort plasmas produced by a subpicosecond laser at the terawatt level. For various laser conditions, time-resolved keV spectra have been obtained with an X-ray streak camera featuring a 2ps temporal resolution. This gives the ability to follow the ionization dyanamics for the first time on the picosecond timescale.

**INTRODUCTION**

The recent developments in laser technology[1] allow the production of very short (≤500 fs) and very intense (up to $10^{17}$ W/cm$^2$) laser pulses which are used to generate ultrashort gradient scalelength plasmas[2,3]. These short-lived plasmas are well-suited for the production of ultrafast X-ray sources[4] which can be of great interest for several applications like the study of molecular dynamics, time-resolved X-ray diffraction, and X-ray photoexcited lasers. A time-resolved characterization of these ultrashort plasmas is needed for a better understanding of the ionization dynamics and of plasma cooling. The study of these basic processes is very important since they control the X-ray pulse duration.

In this paper, we present the first experimental study of the ionization dynamics in near-solid density plasmas. We discuss time-resolved keV spectra obtained when the 500 fs INRS Table Top Terawatt laser is focused at intensities up to $10^{17}$ W/cm$^2$ on solid material. These results ($\lambda$=7.5 - 8.5 Å) have been obtained with a 2 ps temporal resolution. We also discuss time-resolved results obtained with two very clean collinear pulses separated by an adjustable time delay, allowing the control of the brightness and duration of the X-ray emission on a picosecond timescale.

**EXPERIMENTAL**

The experiments were conducted at INRS using the INRS Table Top Terawatt laser. By the mean of the chirped-pulse amplification technique, this laser system is capable of producing 800 mJ in 500 fs at a wavelength of 1.053 $\mu$m. The $10^{-6}$:1 contrast ratio has been measured at 1 $\mu$m with a third-order autocorrelation technique. The laser pulse is focused on solid aluminum targets at normal incidence with a f/6 fused-silica lens. A vacuum beam tube has been installed between the compression gratings and the interaction chamber in order to minimize nonlinear wavefront distortion in the focusing optics. The 60 $\mu$m focal spot diameter (1/e$^2$) for 1 $\mu$m irradiation has been measured at high power with a pinhole camera filtered with 25 $\mu$m of Be. Thus, the pulse has a maximum intensity of $1\times10^{17}$ W/cm$^2$ with a prepulse at an intensity of about $1\times10^{11}$ W/cm$^2$.

This prepulse plays a very important role in the interaction with the target by creating a preplasma. When a prepulse is present, the emission is produced at low density ($10^{21}$ cm$^{-3}$). To produce a high-density plasma, the laser pulse must be very clean (no prepulse). It is therefore useful to double the frequency of the laser using a KDP crystal which approximately squares the contrast ratio. At 2$\omega$, the maximum energy is 250 mJ leading to a maximum intensity on target of about $5\times10^{16}$ W/cm$^2$ without any significant prepulse. A Michelson interferometer has also been used in some experiments to split this 0.5 $\mu$m pulse into two very clean collinear pulses separated by a variable time delay.

Time resolution is obtained with the C850X X-ray streak camera designed by CEA[5], coupled to a Von Hamos spectrometer using a RbAP (2d=26.12Å) curved crystal. The detection geometry is described elsewhere[6]. The streak camera which is working with a bilamelar tube with a quadrupole electrostatic lens, was operated with potassium bromide (KBr) photocathodes and the images were recorded on Kodak 2484 film. This camera has a temporal resolution of about 2 ps and the images are free of any distortion or lagging effects. KeV emission has also been monitored by using two PIN diodes with 55 $\mu$m and 110 $\mu$m Be filters.

**RESULTS**

In Figure 1, we show a time-resolved spectrum between 7.7Å and 8.4Å obtained with a single 1$\mu$m shot on a flat aluminum target at an intensity of $5\times10^{16}$ W/cm$^2$ with a prepulse intensity of $7\times10^{10}$ W/cm$^2$. We observe interesting new features. First, the He$_\alpha$ emission ($\lambda$=7.76 Å) is longer (8-10 ps FWHM) than the Li-like ($\lambda$=7.85 Å) and Be-like ($\lambda$=7.95 Å) emission which are respectively 5 ps and 3 ps long. The cold K$_\alpha$ emission ($\lambda$=8.34 Å) is surprisingly long (~8 ps FWHM). The risetime of the different emission lines is about 4 ps.

The long decay time of the He$_\alpha$ line ($\lambda$=7.76 Å) suggests that three-body recombination could have an important contribution. The cold K$_\alpha$ emission ($\lambda$=8.34 Å), if created by long range hot electrons, should only be present during the laser interaction (500 fs).

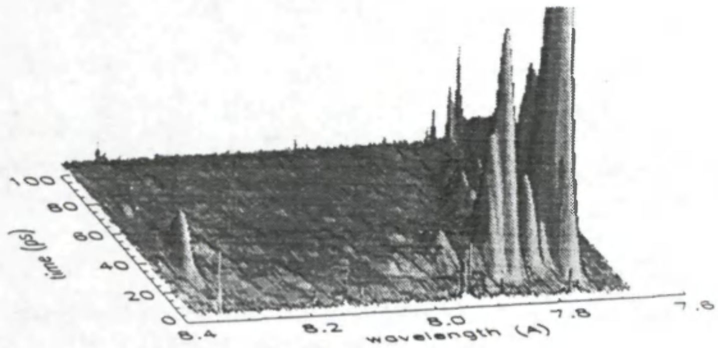


**Fig. 1** **Time-resolved aluminum spectrum between 7.7 Å and 8.4 Å obtained with a 1 $\mu$m laser pulse at an intensity of 5x10$^{16}$ W/cm$^2$ with a prepulse intensity of 7x10$^{10}$ W/cm$^2$. This image is not corrected for the time lag due to the variation of the optical path with the wavelength. The saturated HE$_\alpha$ has been cut to show the weaker lines.**

The duration of the $K_\alpha$ emission suggests some other mechanisms like lateral transport and photoionization by more energetic emission.

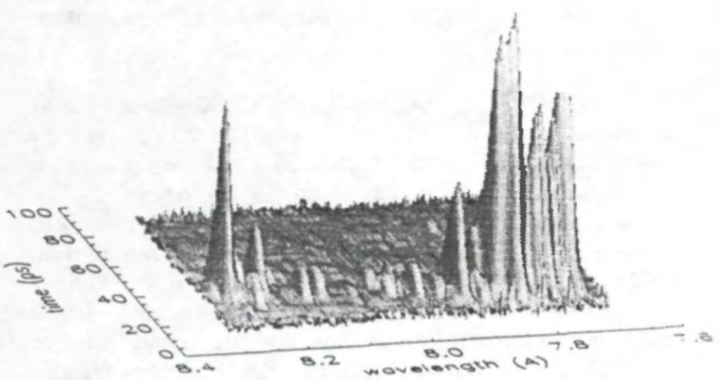


**Fig. 2** **Time-resolved aluminum spectrum between 7.7 Å and 8.4 Å obtained with a 0.5 $\mu$m laser pulse at an intensity of 2x10$^{16}$ W/cm$^2$ without any prepulse. This image is not corrected for the time lag due to the variation of the optical path with the wavelength. The saturated HE$_\alpha$ has been cut to show the weaker lines.**

Figure 2 shows a similar spectrum now obtained with a single 0.5 $\mu$m shot on a flat aluminum target at an intensity of about 2x10$^{16}$ W/cm$^2$. In the absence of any prepulse one sees that the X-ray emission produced in a higher density plasma is shorter. We also observed, for the first time, the picosecond time-resolved "hot" $K_\alpha$ emission which is generated in various ionization states.

These results indicate that by controlling the emitting plasma density, we can control the X-ray pulse duration. We therefore performed two-pulse experiments where the first pulse creates a preplasma and the time delay allows to control the gradient scalelength and consequently, the density at which the second pulse emission is produced.

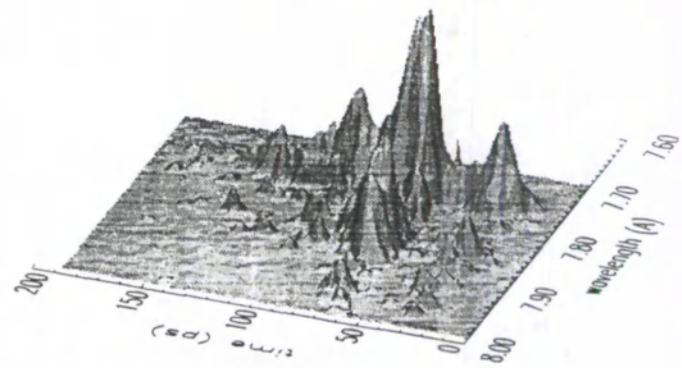


**Fig. 3** **Time-resolved aluminum spectrum between 7.7 Å and 8.0 Å obtained with two very clean 0.5 $\mu$m collinear pulses at an intensity of about 1x10$^{16}$ W/cm$^2$. This image is not corrected for the time lag due to the variation of the optical path with the wavelength.**

Figure 3 shows a time-resolved spectrum between 7.7 Å and 8.0 Å obtained with two 0.5 $\mu$m collinear pulses on a flat aluminum target at an intensity of about 1x10$^{16}$ W/cm$^2$ for each pulse; the two pulses were separated by 40 ps. One can clearly see the two distinct emission bursts produced by the two collinear laser pulses. The first spectrum is characteristic of a high density plasma emission. The $He_\alpha$ emission is much longer and much stronger for the second pulse than for the first one. Also, the intercombination ($\lambda$=7.81 Å) on $He_\alpha$ ($\lambda$=7.76 Å) line ratio, which is a qualitative measurement of the electron density of the emission zone, is stronger for the second X-ray burst. Then, we demonstrate the the brightness and the duration of the second $He_\alpha$ burst can be controlled by choosing the time delay between the laser pulses thus creating an adjustable ultrafast X-ray source.

## CONCLUSION

We have obtained the first picosecond time-resolved spectrum including $He_\alpha$ and cold $K_\alpha$ emission of aluminum in low and also in ultrahigh density plasmas thus opening the way to a better understanding of the time history of the plasma parameters (density, temperature and ionization). We have also presented the first picosecond time-resolved spectrum obtained with two very clean 0.5 $\mu$m collinear pulses separated by an adjustable time delay, allowing the control of the brightness and duration of the X-ray emission on a picosecond timescale.

## ACKNOWLEDGEMENTS

The authors would like to thank M. Nantel and Z. Jiang for fruitful discussions and technical assistance. This work has been supported in part by NSERC and by Ministère de l'Éducation du Québec.

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# OPTICAL SWITCHING BETWEEN BISTABLE SOLITON STATES OF THE SECOND KIND

(1993 Lumonics winner at the CAP Congress, Simon Fraser University)

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**ABSTRACT**

Bistable optical soliton solutions of the first kind (BISOL1) to the generalized nonlinear Schrödinger equation were first described by Kaplan, Enns, and co-workers. Low and high state solitons can be used to represent zeros and ones in binary notation, making BISOL1 potentially important for high speed communications, switching, and logic operations. Recently, Gatz and Herrmann have introduced an alternate definition of bistability (BISOL2), with the intention of being able to use relatively simpler materials than those for which BISOL1 exist. This paper focuses on the latter bistable solitons of the second kind, for two different models of fiber nonlinearity which qualitatively mimic the features of known classes of materials. Optical switching between high and low BISOL2 states is demonstrated numerically when the amplification of the input solitons is suitably adjusted. The numerical amplification study is supplemented by a variational approach which sheds considerable light on the dynamics of the observed numerical behaviour, although it is not able to predict switching.

## INTRODUCTION

Bistable soliton solutions to the generalized nonlinear Schrödinger equation (GNLSE) were first described several years ago by Kaplan, Enns, and co-workers[1,2]. For certain types of optical nonlinearity, it was shown that two (or more) solitons could exist with the same energy $P$ but different propagation parameters $\beta$. The energetically degenerate solitons are characterized in general by substantially different amplitudes and widths. We refer to the Kaplan-Enns bistable solitons, characterized by U-shaped or N-shaped $P(\beta)$ curves as *bistable solitons of the first kind*, or more succinctly BISOL1. BISOL1 corresponding to N-shaped $P(\beta)$ curves are potentially important for high speed optical communications, optical switching[3], and logic operations. Solutions corresponding to the positive (negative) slope legs of the N are stable (unstable). The low (high) state solitons associated with the lower (upper) positive slope legs can represent zeros (ones) in binary code, and the unstable intermediate regime ensures that the zeros and ones are truly distinct. The search for materials which support BISOL1 continues. The fabrication of such materials has been discussed by Enns and Edmundson[4].

Very recently, Gatz and Herrmann[5,6] have introduced an alternate definition of bistability with the idea that simpler classes of materials might be used than those that support BISOL1. According to their definition, bistable solitons have the same pulse *duration*, $\tau_o$, but *different* amplitudes, $A_o$. We refer to the Gatz-Herrmann bistable solitons as *bistable solitons of the second kind*, or BISOL2. Typically, when $A_o$ is plotted against $\tau_o$ the curve is C-shape, with both legs of the C corresponding to stable solutions. In a system of binary logic where low-state solitons correspond to zeros and the high state solitons to ones, the lower (upper) leg of the C could serve as the low (high) state. If the legs are sufficiently far apart and the chosen solitons are sufficiently far from the bend, the difference in amplitude may be such that the zeros can be easily distinguished from the ones despite the lack of the unstable gap which occurs naturally for BISOL1. This paper concentrates on the behaviour of BISOL2 after amplification, and the possibility of switching between distinctly different BISOL2 states.

## PROCEDURE

To find BISOL2, the generalized nonlinear Schrödinger equation (GNLSE) must be solved. For anomalous dispersion, the GNLSE can be written in normalized soliton units as follows:

$$i\frac{\partial U}{\partial \xi} + \frac{1}{2}\frac{\partial^2 U}{\partial s^2} + f(|U|^2)U = 0 \qquad (1)$$

where $U$ is proportional to the electric field amplitude; $\xi \propto z$, the distance coordinate in the direction of propagation; $s \propto (t - z/v_g)$, where $t$ is time and $v_g$ is the group velocity; and $f$ is proportional to the intensity dependent part of the refractive index.

We outline the solution of the GNLSE which was originally found by Cowan et al.[7], and more recently described by Herrmann[8], for

$$f(I \equiv |U|^2) = I - \alpha I^2 \qquad (2)$$

with $\alpha > 0$. Certain metallic vapours[8] and other materials have a nonlinearity of this form.

Herrmann used the normalization of the pulse width to determine a transcendental relationship (the soliton line) between the soliton amplitude, $A_o$ and the parameter $\alpha$, which is inversely proportional to the square of the pulse duration. Over a certain range of $\alpha$, the relation $A_o(\alpha)$ (and, hence, $A_o(\tau_o)$) is double-valued. There exist solitons with the same duration and different amplitudes, or BISOL2.

A similar analytical solution (from Krolikowski and Luther-Davies[9]) can be found for the GNLSE with the nonlinearity

$$f = \frac{1}{2}\frac{I(\gamma I + 2)}{(1+\gamma I)^2}, \qquad (3)$$

which qualitatively represents the nonlinearity of a saturable medium[10]. The relation $\rho_o(\gamma)$, given by a transcendental equation, is double-valued over a range of $\gamma$. Since $\gamma$, like $\alpha$, is inversely proportional to the square of the pulse duration, BISOL2 exist for this model also.

Although the GNLSE with the nonlinearities (2) and (3) can be solved exactly, the variational approach of Anderson[11] is useful in predicting the behaviour of amplified pulses, which in general do not lie on the soliton line. Anderson used this variational approach to obtain an approximate solution of the NLSE with a Kerr nonlinearity ($f \propto |U|^2$). We use a similar technique to solve the GNLSE (1).

The GNLSE (1) can be shown to result from the variational equations corresponding to the variational principle

$$\delta \int\int L\left(U, U^*, \frac{\partial U}{\partial \xi}, \frac{\partial U^*}{\partial \xi}, \frac{\partial U}{\partial s}, \frac{\partial U^*}{\partial s}\right) d\xi\, ds = 0 \qquad (4)$$

where the Lagrangian $L$ is given by

$$L = \frac{i}{2}\left(U\frac{\partial U^*}{\partial \xi} - U^*\frac{\partial U}{\partial \xi}\right) + \frac{1}{2}\left|\frac{\partial U}{\partial s}\right|^2 - F(|U|^2), \qquad (5)$$

with

$$F(I) = \int_0^I f(I')dI'. \qquad (6)$$

Following Anderson, we choose a trial wavefunction of the form

$$U(\xi, s) = A(\xi)\,\mathrm{sech}\left(\frac{s}{a(\xi)}\right)\exp\left(ib(\xi)s^2\right) \qquad (7)$$

with the amplitude, $A$, complex and with width, $a$, and chirp parameter, $b$, real. The resulting variational equations provide us with a system of ordinary coupled differential equations for $A$, $A^*$, $a$, and $b$. Solving the system of equations gives, among other results, an equation for the normalized pulse width $y = a/a(\xi = 0)$:

$$\frac{1}{2}\left(\frac{dy}{d\xi}\right)^2 + \Pi(y) = 0, \qquad (8)$$

where we assume $dy/d\xi = 0$ at $\xi = 0$. Eq. (8) is analogous to the equation of motion for a particle starting from rest at $y = 1$ in a potential well described by $\Pi(y)$. For the model $f = I - \alpha I^2$, we analyse equation (8) to reveal regions of $A_o$ and $\alpha$ in which the behaviour of an amplified soliton pulse is expected to be qualitatively different. In one region, the pulse is expected to broaden and disperse, in another the pulse is expected to oscillate after first becoming broader, and in a third the pulse is expected to narrow and oscillate. A similar analysis is possible for the saturable nonlinearity (3), but is not carried out in the paper.

The predictions of the variational method, for $f = I - \alpha I^2$, can readily be compared with the numerical simulation of the GNLSE, which is carried out using an explicit 3-step scheme. For each numerical experiment, a point was chosen from the appropriate soliton line. The input pulse was formed by using the chosen $\alpha$ and $A_o$ in the analytical form of the soliton solution, $U(s, \xi = 0)$, and amplification was achieved by multiplying $U$ by an amplification factor $K$.

The dispersive and oscillatory behaviour which is observed numerically agrees with the predictions based on analysis of equation (8). Variational analysis can be seen to be a helpful tool for predicting the general behaviour of pulses whose initial $\alpha$ and $A_o$ values do not lie too close to the edges of the behavioural regions it delimits. These boundaries are derived from approximations, and thus cannot exactly rpedict where changes in amplified soliton behaviour will occur. Pulse behaviour near the line $\alpha I = 1$ is also more complex than the variational method predicts, since the nonlinearity $f$ becomes negative for $I$ above this line.

Switching from a zero to a one and vice-versa are necessary operations for a binary logic system. Switching, using amplification techniques as well as evanescent coupling between adjacent fibers, has been demonstrated by Enns et al. (see Ref. [3] and references therein) for BISOL1. In this paper we demonstrate similar switching operations for BISOL2.

For the nonlinearity $f = I - \alpha I^2$, both upswitching from the low to the high soliton state (after amplification with $K > 1$) and downswitching (after amplication with $K < 1$) were observed numerically. In many cases, the difference in amplitude between the initial and final states was quite large, a necessary prerequisite for the existence of distinct zeros and ones.

Enns et al. have observed that, for BISOL1, it was not generally possible to switch back and forth between high and low states without hysteresis (see [3] and references therein). By contrast, back and forth switches with essentially no hysteresis appear to be possible between certain of the BISOL2 states for the nonlinearity $f = I - \alpha I^2$.

Similar numerical experiments were also performed using saturable nonlinearity. Here, too, it is found that both upswitching and downswitching are possible. There is also evidence of an essentially hysteresis-free back-and-forth switching between certain of the high and low states . For the saturable model, the nonlinearity $f(I)$ is always positive, so the difficulties that arose for $f = I - \alpha I^2$ when the amplitude of a pulse was above the line $\alpha I = 1$ do not exist here. As a result, the saturable model allows for switching between low and high states with more widely disparate amplitudes than does the other model, suggesting that saturable materials are good candidates for solitonic switches.

The variational method, although generally a good predictor of numerical behaviour, is not able to predict the switches which are observed, because it is based on the assumption that the pulse shape does not change.

In typical switching runs, the pulse shape changes dramatically, with radiation being shed in the form of small side pulses.

## CONCLUSIONS

We conclude that switching between bistable soliton states of the second kind is possible for both models studied. Back-and-forth switches may be accomplished without noticeable hysteresis, and the initial and final states are different enough to be feasible as ones and zeros in binary logic operations. The variational method is useful in predicting oscillatory behaviour of amplified solitons, but does not predict switching.

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# SIZE DISTRIBUTIONS OBTAINED FROM INTEGRATED LIGHT SCATTERING SPECTROSCOPY

(1993 Lumonics winner at the CAP Congress, Simon Fraser University)

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## ABSTRACT

Traditionally particle size intensity distributions and number distributions through particle form factor corrections have been successfully obtained from dynamic light scattering (DLS) spectroscopy. However experimental data obtained by integrated light scattering (ILS) spectroscopy yield more information about particle and interparticle structure. For the case of solid spherical scatterers much of the structural information obtained from either technique is the same. On the other hand, for hollow spheres, sensitivities to the lumen refractive index as well as the coat thickness allow for analysis of other structural parameters. Clearly though, the best understanding of any scattering system comes from data obtained from both experiments being run concurrently.

The uniqueness associated with this ILS spectrometer[1] is the use of fibre optics to direct the scattered light into a single photomultiplier tube. By fixing all of the optics and selecting each fixed scattering angle by way of a stepper-motor controlled iris, very reproducible results are generated. A right-angled prism used to deflect the beam after it has passed through the sample cuvette reduces the unwanted flare which can make up a substantial percentage of the signal at smaller scattering angles. The intensity of the scattered light as a function of scattering angle is stored at I(Q) vs. Q for further data analysis.

The scattering vector, **Q**, is defined as

$$\mathbf{Q}=\mathbf{k}_0-\mathbf{k}_s \tag{1}$$

where $\mathbf{k}_0$ is the incident wave vector and $\mathbf{k}_s$ is the scattered wave vector. Its magnitude can be expressed as

$$Q=\frac{4\pi n_0}{\lambda_0}\sin\frac{\theta}{2} \tag{2}$$

where $n_0$ is the solvent refractive index, $\lambda_0$ is the wavelength of the light in vacuo and $\theta$ is the scattering angle. Wyatt, using the Rayleigh-Gans-Debye (RGD) approximation, determined I(Q) for a coated sphere with vertically-polarized incident light to be

$$I(Q)=\left[\frac{(m_2-1)}{2\pi}\frac{(4\pi r_2^3)}{3}\left[\frac{3J_1(x)}{x}+f^3\frac{(m_1-m_2)}{(m_2-1)}\frac{3J_1(fx)}{fx}\right]\right]^2 \tag{3}$$

where $m_1 = n_1/n_0$, $m_2 = n_2/n_0$, $f = 1 - t/r_2$ (t is the thickness of the coat) and $J_1(x)$ is the first-order Bessel function with $x=Qr_2$. The variables $n_0$, $n_1$, and $n_2$ are the refractive indices of the medium, lumen and coat and $r_1$, $r_2$ are the inner and outer radii respectively. It is clear for the limiting case where the relative refractive indices $m_1$ and $m_2$ are equal that I(Q) reduces to the expression obtained for that of a solid sphere.

On the other hand the scattered intensity from a coated sphere system using Mie theory for vertically-polarized incident light is given by

$$I(Q)=\frac{I_0}{kr^2}|S_1|^2 \tag{4}$$

where k is the wave number, r is the distance between the scattering particle and the point of the intensity measurement and

$$S_1(\cos\theta)=\sum_{n=1}^{\infty}\frac{2n+1}{n(n+1)}(a_n\pi_n+b_n\tau_n)\ . \tag{5}$$

The angle-dependent functions are

$$\pi_n=\frac{P_n^1(\cos\theta)}{\sin\theta} \quad \text{and} \quad \tau_n=\frac{dP_n^1(\cos\theta)}{d\theta}$$

where $P_n^1(\cos\theta)$ is the associated Legendre polynomial and the scattering coefficients $a_n$ and $b_n$ are given elsewhere[2].

Comparisons between DLS and electron microscopy with both RGD theory and Mie theory with the inclusion of polydispersities gave evidence that size distributions could be obtained by ILS spectroscopy[2]. These encouraging results led to the motivation to create a fitting program which would generate size distributions from the I(Q) v. Q data. Other work has been recently done to also obtain size distributions. One method fits different types of distributions by varying the appropriate parameters[3] and another performs the inversion of both simulated and experimental data (using both the maximum entropy and a constrained regularization method, Contin) on unimodal, bimodal and trimodal distributions[4]. The latter producing abnormally narrow and sometimes spurious distributions. This latter program performs a least squares fit over a fixed range of radii on the RGD and Mie equations described above. The ILS technique is significantly faster in terms of both data collection and analysis and number distributions are the immediate result. These reasons along with sensitivities to changes in particular to the lumen refractive index makes ILS spectroscopy an attractive alternative in the studying of loaded vesicle systems.

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# A CHRISTMAS BOX OF ECCENTRIC SCIENTISTS

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"What I like about scientists", said John Wilmott, Minister of Supply 1945-47 in the United Kingdom government, "is that they are a team so that one need not know their names". It is perhaps from public statements of this kind that the public gets the predominant impression of the scientist as a colourless, odourless, passionless pioneer who works continuously and unemotionally in the far-off corner, of some dreary and aseptic laboratory. Scientists are different but not different from each other. Scientists can communicate but only to each other. Scientists may be necessary to society but often seem not to be a part of that public.

In discussing eccentric scientists there is a deliberate attempt to introduce the cult of personality into this bland arena. Are there eccentrics in the world of science? Do they exhibit irregular, anomalous or bizarre behaviour? Do they do it only occasionally, or do they often participate in such actions? The purpose of this short paper is to identify several scientists from a variety of disciplines within physical science who seem, in retrospect, to have fallen far short of what John Wilmott might have expected of them. They not only have names, but their names became, in many cases, household words. Their behaviour was so unusual and noteworthy that historians and society made note of them at the time and have commented on them since. They have all contributed notably to their disciplines and fields of study and in most cases the interaction and impression on the public was not only significant but remarkable. For example take the case of William Rowan Hamilton.

The appointment of Hamilton as a director of Dunsink Observatory at the early age of 22 was a tribute to his excellence as a scientist and an academic but also to his ability to operate effectively and efficiently in an atmosphere of some isolation. Everyone knows of Hamilton's equations, a derivative of the Lagrange equations of motion which stand as his best known contribution to mechanics. But above all, scientists recall his famous moment of insight when he discovered what we now recognize as vector algebra and in an amazing moment of enlightenment, scrawled on the underside of Broome bridge on the Royal Canal in Dublin the elements of non-commutative algebra and of the mystic relationship between quaternions. Now why, you may ask, would an eminent scientist want to scawl original scientific discoveries on the underside of a bridge on the Royal Canal in Dublin? The answer is comparatively simple.

Hamilton, as well as being a genius, was also an inveterate scribbler and often without either the means with which to write or the material on which to compose. Various of his contemporaries have written of his capacity to get ideas at the breakfast table which, in the absence of writing material, he would scrawl on his egg and then take it to work for his secretary to transcribe onto paper. At times he would make brief notes of the lectures he was about to carry out on his fingernails and then whenever he was lost for logical thought, he would refer to the writing on his fingernails as the stimulus for further discussion. Because of these facts it is not surprising that whenever the great idea of vector algebra occurred to him while walking along the canal, he would be without writing material but fortunately not without a bridge on which to write. So he adroitly in the cause of science picked up a stone and patiently scrawled the recipe on the underside of the parapet for posterity to view and for himself to remember.

These, of course, were not the only occasions on which Hamilton exhibited unusual behaviour. The Irish Astronomical Journal in the issue commemorating the bicentary of the Dunsink Observatory (1985) records that in his early days, Hamilton was somewhat of a jogger as we would now describe it and used to entertain or perhaps alarm the local residents of the area of Dublin around Dunsink by hopping on one foot around the high balustrade of the Observatory, a non-trivial exercise at the best of times. He was clearly a man devoted to his work but perhaps out of touch with much of society and everyday life. It is recorded that after his marriage he was totally surprised to find that his sister left the house and no longer made meals for him.

One of the most unusual figures in science in the last number of centuries is perhaps Robert Hooke, a man for which I have considerable sympathy and admiration. Without examining his early life in any significant way, he was a graduate of Westminster School and entered Oxford University at the time at which Sir Isaac Newton was first making his name. He came from a poor family on a scholarship, and was generally derided by his colleagues for that reason. However, because of his technical ability, he became the first curator of the royal Society and survived for many years on the basis of a small stipend paid to him by the Society in order to carry out two or three experiments per week for members in order to keep them in touch with modern scientific trends. Today, Robert Hooke is remembered largely because of his discovery of what is now called Hooke's law. It was, however, Hooke also who managed to rebuild part of the City of London after the fire of 1666 in conjunction with his friend Christopher Wren. It was he who made the first fundamental discoveries in the field of biology, using the compound microscope, who discovered one of the early binary stars and developed the first theory of earthquakes on which significant later geophysics has been built. Unfortunately, however, Robert Hooke was greatly disliked by everyone with whom he worked. Many believe him to have been essentially the equal of Isaac Newton but because he was a man of somewhat gross appearance, continually ill with one malady or another, and walked in a peculiar stooped and rapid manner, not unlike a scientific Richard the Third, he was rejected by most of his colleagues and peers despite the excellence of his technical knowledge and academic ability. Many eminent scientists of the time, such as Edward Boyle, would never have attained their stature as scientists had it not been for the technical excellence of Robert Hooke. It is, of course, not uncommon to be disliked because of your appearance, gross habits and the rest. On the other hand, there is little doubt that Hooke was a somewhat unusual character as a man and as a scientist. He was apparently always trying to deal with his medical condition in fairly interesting and unscientific ways. He alleviated his distresses with blood-letting, minor surgery, senna, rhubarb, iron, mercury, laudanum, and sulphur. It was almost the case of the cure being worse than the disease, and the perpetual headaches that apparently he endured were very evident to his colleagues. Indeed, Robert Boyle has recorded that a sure tried and tested headache cure of blowing powdered human dung into the eyes was one that Hooke adopted with some regularity. So the first impression that Hooke would have made on his contemporaries was far from normal. Michael Shortland, in his recent biography, indicated that Robert Hooke is the most eminent scientist never to have had a portrait made. As Samuel Pepys apparently recorded after meeting Hooke in 1665, "Hooke is the most but promises the least of any man in the world that I ever laid eyes upon".

In summary, Shortland states that perhaps here is the clue to one of the most interesting, brilliant, and neglected characters in the history of modern science.

A more recent scientist, of whom I have some second-hand knowledge, is Geoffrey Hardy, the mathematician at Oxford whose textbook on pure mathematics was compulsory study for many undergraduates in the 1940-1960 period. A lifelong bachelor, Hardy lived with his sister in Oxford and in addition to pursuing his studies and supervision in Oxford, had several graduate students which he advised at the University of Bristol. Anecdotes relating to Hardy's career are many and some of them have been repeated and attributed to others at a later date, both in England and in Canada, but the vignettes which follow relate directly to Hardy and have been communicated to me by students of his and people who supervised me in early stages of my career. As this is the Christmas edition of ***Physics in Canada***, it is perhaps appropriate to begin with the tale of Hardy's visit to Bristol in early December. Normally he would have visited Bristol by train but on this occasion his sister imagined that she would like to do some Christmas shopping in Bristol while Jeffrey was at work at the University. So they travelled to Bristol by car. As a result, Hardy took part in activities at the University while his sister was shopping in downtown Bristol. It should be noted here that Hardy's visits to Bristol were not infrequent and that on most occasions one of the students that he was supervising would whisk him down to the railroad station at around 4 p.m. so that he might get the appropriate train back to Oxford to get him home for dinner. On this particular occasion, when the hour of four was approaching, one of his students again suggested that he rush him down to the railroad station so that he might get home in reasonable time. Hardy accepted with alacrity, was driven down to the railroad station, took the train and arrived home only to be horrified to find that his sister had not prepared dinner nor was she anywhere to be seen. According to the story, the police were alerted and chaos ensued until a frantic telephone call from Bristol made it clear that his sister was still there waiting to be driven home.

Absentmindedness, of course, is not peculiar to professors, scientists, or any other section of the community. Hardy, however, seems to have had many lapses of concentration that turned out to be an embarassment. It is also clear that he disliked the automobile intensely and would go out of his way to avoid using it. On one occasion, when he was obliged to drive through the narrow streets of Cambridge from his rooms, he was forced to brake abruptly because of a young student who had dropped her books in the middle of the road. Being both a mathematician and a gentleman, he immediately leapt out of his car, picked up the student's books and carried them for her to the side of the road where her bus to college was waiting. Being a bus stop which he frequently used, Hardy not only helped this student onto the bus but followed her himself, leaving behind a road blocked by his car, engine running, doors open, and without a driver.

A student of professor Hardy's who taught me at Queen's University at Belfast some years ago also recalled the occasion on which Hardy was giving a mathematics lecture to third year students on analysis and was generating a proof of some theorem such as 'a continuous function of a continuous function is itself continuous'. Whatever the proof was intended to be, construction was completed and then for 'proof' Hardy wrote the one word 'obvious' for the students to read. On writing the word 'obvious', Hardy clearly had some problem to elucidate and left the room immediately. Some fifteen minutes later when he had not returned, one of the more venturesome of his students went over the window to look outside and see if there was any sign of Hardy in the quadrangle. He was immediately able to recognize him dashing with flowing gown out of the library, hurrying across the quadrangle to the lecture room, and coming up the stairs. When he entered the classroom it was therefore not a great surprise that he went over to the blackboard, looked at the word 'obvious' under the heading, 'proof', and then put a tick beside it to indicate that such was indeed the case. Whether one regards Hardy as being eccentric or not he was certainly an interesting character.

A more recent scientist, who made somewhat of a name for himself in experimental circles, despite being a theoretical physicist, was Wolfgang Pauli, an Austrian who is best remembered, perhaps, for the Pauli principle but also, among many, for the Pauli 'effect'. Pauli was a clumsy experimentalist and a notably poor lecturer but was a brilliant theoretician. The Pauli effect arose from the coincidence that many experimentalists observed between his visits to national and other laboratories and a total breakdown in local experimental facilities. In the late 40s and early 50s, therefore, laboratories went out of their way to ensure that the theoretical assistance they needed from Wolfgang Pauli was obtained not on site but on the scientist's home ground. If this sounds too much like magic for the scientist then so be it. Nonetheless, I personally know of at least one laboratory that went to great lengths to postpone and eventually cancel a visit from the eminent theoretical physicist. If it appears that the bizarre behaviour in this particular case is attributable to the hosts rather than to the guest, that has perhaps some truth to it. However, Pauli occasionally would exhibit anomalous behaviour in his own right being known to leap at graduate students, hold them by the collars, and shake them while asking them what they meant by whatever they had just said.

From a technical point of view, one of the more unusual characters of recent times was William Parsons Rosse, the Irish astronomer who, in 1841, succeeded to his father's earldom and was later chosen to sit as an Irish representative in the House of Lords. Rosse's love was the construction of a giant reflecting telescope. In 1845 he built a 72-inch telescope called Leviathon, his 'dream instrument' as it has been described by Isaac Asimov, which at that time cost him personally £30,000. It is frightening to think what this telescope would have cost today. The work that he undertook in assembling this device has been described as particularly quixotic because the weather conditions in that part of Ireland where he built it were so poor that it was rarely possible to use the instrument. In addition to that, it took a minimum of four people to operate it and it is a tribute to irresponsibility that he continued to attempt to make observations. Having said that, on the few non-dreary days in which he was able to operate the instrument at great cost, he observed spiral shapes of objects that came to be known as galaxies and one in particular, observed in 1848, was given the name of the 'crab nebula' which it has retained every since. In that year he was elected to the Royal Society of England. In 1908 the great telescope was taken apart because it had grown too rickety and dangerous to operate. I guess in the sum total of time it had achieved little under difficult circumstances but it was still the largest telescope in existence when it was finally dismantled.

In conclusion to this small compendium of scientists of some eccentricity it is important to recognize that there are outstanding scientists of whom only the most eccentric behaviour is remembered. Lord Rutherford's booming voice would ensure that all modern electronics of the time would fail to function after a visit and so an early warning system had to be put in place to ensure that the arrival of the great man was controlled by a sign that said **speak** softly **please**. J.J. Thomson, the discoverer of the electron was apparently so inept as an experimentalist that his technical staff had to band together to ensure that he did not get anywhere near his apparatus. It is also recorded that several contemporary scientists are noted for the attempts that they have made to discover the author of work that they themselves have generated. 'In this world, but not of it' is an epitaph that might be ascribed to some of our closest colleagues. Let us be encouraged by the fact that whether they work in teams or as individuals, whether they work in Canada or elsewhere, many of our colleagues are free thinkers, non-conformists, and as eccentric as the next man or woman in society.

A Merry Christmas and a Happy Hanukkah to all our readers.

# INNOVATION - A WAY OF LIFE

(Banquet address given at the 1993 Canadian Undergraduate Physics Conference, Regina, SK)

by Mr. Dennis Johnson
Pakwa Engineering Ltd.

Thank you Trina. Coordinator Karl, distinguished guests, faculty - and most especially - physics students from across the country.

I'm sure those of you from other Universities have already been officially welcomed to Saskatoon. But it never hurts to say it twice. We are indeed pleased that you have come here and we hope your stay has been a rewarding one.

To the organizing committee, Beth and I offer our thanks for the invitation to dinner this evening. When I consider the calibre of the people who have spoken to you over the last couple of days I consider it a great honour to be here.

Unfortunately I was not able to take in any of the lectures, but I understand that they have been very good. Now maybe after three days of heavy physics, you'd like to turn your attention to other matters. I hope so, because I am not going to talk about Physics.

In her introduction, Trina was too polite to say it, but she might have noted that I'm kind of a physics groupie. I spend a lot of time hanging out with physicists. When I was your age I took Engineering Physics, and that was one of the best decisions I have ever made. It prepared me well for a career I have truly enjoyed. But I must confess, I didn't practice as a physicist. Rather I practiced as an engineer. However, I have remained closely associated with Physics, especially space science. Many of the instruments I have worked on have been space science instruments. And that is how I spend most of my time these days, designing instrumentation for space science.

But, as I said, I am not going to talk about physics tonight. And I am not going to talk about instruments for space science. An after dinner speaker a few days ago reminded me that there are two things an after dinner talk should be -- not too heavy, and not too long. So if you'd like to lean back, relax, and enjoy your coffee, I'd like to share with you some thoughts on a favourite topic of mine. Innovation.

Now, if I may, I'm going to address myself primarily to the undergrads here tonight. I hope those of you who are not undergrads don't mind. In particular, I want to talk about the role that those of you who will be graduating in the next year or two can play in bringing your innovative energies to bear on the task of building a better Canada.

After you get your degree, what then? Perhaps go on to graduate studies. Get a job. Perhaps get married. Buy a house in the suburbs. Have 2.3 kids and live happily ever after.

Some or all of those things will be in your future. And whatever you choose I wish you success and I wish you happiness. But there is something else I wish for you. And that is the ability to be innovative. To be truly creative.

Most of you have been going to school for 15 or 16 years or so. You've been preparing yourself for the day when you say to the world, "Here I come!" Although you may not feel in control, you now have all the tools you need to make a big impact on that world out there. You may not have much experience yet, but don't ever let that hold you back. What you do have are the tools, the skills, the energy and the spunk to look at problems with a fresh approach. You already know, I hope, that most truly revolutionary ideas come from young people. Most of you are around twenty. You are just entering the most creative decade of your whole life. Madame Curie was in her twenties when she did the spade work that led to her discovery of radium. Einstein was in his twenties when he first stated his theory of relativity. You, too, are at the prime of your creative life.

And that's what I want to talk about. Creativity. Technical creativity. In common jargon it's called innovation.

When someone mentions innovation, what do you think about? Perhaps you think of inventions. Perhaps it conjures up images of wild eyed bushy haired scientists with test tubes and funny machines - and lab coats. They always have lab coats. Actually, I had a boss like that once. He wore a white lab coat. When we went for coffee he could never find a piece of paper to make notes on so he would draw electrical schematics and write equations all over his lap -- on the lab coat. With ball point pen. When he got up, his lab coat was decorated with all these upside down diagrams. Over a period of months it became a veritable work of art. Well, sometimes lab coats and funny machines are part of the innovation process, but only a small part. Innovation is really the process of looking at whatever you're doing and asking, "Is this the best way to do it?" There is almost always a better way, and the world belongs to those who find it.

And let's be clear. This isn't limited to revolutionary breakthroughs like inventing the transistor or the laser. And it isn't limited to the Madame Curies and the Albert Einsteins of the world. It's for you and me. It's for everything we do. Innovation is a process, but not just a process. It's a way of life. It's an attitude, an approach to solving everyday problems.

The point is that we all have the opportunity, and the need, to be innovative - but some people are much better at it than others. How can each of us improve our ability to be creative - to innovate?

What do you do? Do you just wake up some morning and say, "I'm going to innovate today". Probably not. It doesn't work that way. There is no simple recipe for innovation. You can't just turn it on and off. I suspect there are as many approaches as there are innovators.

Having said that, I also believe that there are some guidelines that would serve you well. I'm going to suggest three. They are very simple. You might well say they are obvious - maybe even silly. In self defence, I would just like to note that this world is full of simple truths that we often ignore - to our own detriment.

Here we go!

First of all. You've got to know what you're looking for. You've got to define the problem. Remember learning about the Scientific Method way back in grade 5 or so. The first step was to state the problem. As clearly as possible. Our Grade Five teachers were right. Reduce the big vague problem to a smaller, clearer one.

Remember Archimedes? He's the guy who jumped out of the bath and ran naked down the street shouting, "Eureka! Eureka! I've found it. I've found it."

The popular conception is that some great new idea had just popped into his head. I suggest that isn't what happened at all. Indeed, a great new idea had come into his head. But it didn't just pop in. He was actively searching for it and he knew what he was looking for.

Let's recall the story. Archimedes was a mathematician. Actually, if he were alive today, we'd probably call him a physicist. But historians have labelled him as a mathematician -- and so be it. He lived in Sicily in the third century B.C. The king had ordered a new crown from his goldsmith and the goldsmith had delivered it. Apparently it looked very good! But the king had an uneasy feeling. He was convinced he was being cheated. He had paid for a solid gold crown, but he had a strong suspicion that the goldsmith had alloyed the gold with silver to reduce the cost. It looked like gold. But was it pure gold as the king had ordered? The task given to Archimedes was to find out if the crown was pure gold or not. Now, remember, Archimedes was a mathematician, a physicist, with a flair for mechanical things. He had a good understanding of the laws of physics. He used the skills that were his strength - physics and math. He knew the density of pure gold. If the density of the crown was less than that, it would mean that the crown was not pure gold. He could easily weigh the crown. If only he could determine the volume of the crown, he could compute its density and see if it was, indeed, equal to that of gold. But how do you figure out the volume of something with a shape as complex as a crown.

Notice how he defined his problem. He reduced it from "How do you tell if it's gold" to "how do you measure the volume of an irregular shape". He had defined the problem in terms that matched his expertise. That's when he took his famous bath. He apparently filled the tub full to the brim. That doesn't sound too smart, but maybe he was a bit absentminded. Creative people often are, perhaps because they are thinking about other things. If you tend to be absentminded, take heart. You're in good company. Anyhow, when he stepped into the tub, the water overflowed and Archimedes suddenly realized that the volume of water that flowed out of the tub must be equal to the volume of his body. Eureka, he had found it - a way to measure the volume of an irregular shape. And off he ran!

History doesn't tell us when, or even if, he thought of putting some clothes on. But in his excitement he filled a large jar with water. He placed the crown in the water and measured how much water overflowed. Now he knew the volume of the crown. He weighed the crown, calculated the density and compared it to the density of pure gold.

Sounds simple doesn't it. To us it is, because we have been shown how. In 300 B.C., when it had never been done before, it was a fantastic breakthrough. A masterful piece of innovation. And note how simple the result was. Most good ideas are very simple. If you define your problem clearly enough, and simply enough, you have a much better chance of hitting on that marvellously simple solution.

Achimedes used the expertise he had. If he had been a chemist, he almost certainly would have posed the problem differently. Since silver was the most likely foreign material, he may have asked, "What will react with silver but won't react with gold." And, if he had been proficient with AutoCAD, he may well have created a drawing of the crown and let the computer do the arithmetic. He didn't do any of those things. He used the science that he was strongest in. An obvious corollary would state that the broader your range of knowledge, the more likely you are to find that innovative solution.

I get a little newpaper called The Canadian R&D Manager. Among other things, it profiles Canadian entrepreneurs. Entrepreneurs are always interesting people. A year or so ago, they featured a Canadian software entrepreneur by the name of Jack Grushcow. During the 80's when spreadsheets were mushrooming in popularity, he recognized that, along with their ability to do calculations very rapidly and very repeatedly, spreadsheets also brought the potential to make mistakes, very rapidly and very repeatedly. After you've built a big spreadsheet, how do you know it's right? His response? He developed a program called Auditor. It does an audit on your spreadsheet exposing errors and potential errors. I gather he sold it for quite a bit of money.

Because he has been successful, reporters ask him the inevitable question, "To what do you attribute your success?" His reply? "The best innovations come from multidisciplinary people". He went on to say that, "innovation comes at the boundaries between different disciplines. The more you know about different things, the greater the opportunity to create." Doesn't that remind you of our friend Archimedes? He was a mathematician and a physicist. He was also a pretty good mechanical engineer. Had he been only one of those, the history of mechanics probably would have been quite different.

This concept of innovation being fostered by the multidisciplinary approach isn't true just of hi-tech. When I was about your age, I spent my summers on a construction crew, building houses. An older carpenter who kind of took me under his wing said to me once, "It doesn't matter how good your hammer is, sometimes you have to use a saw." I now realize he was saying, in language that made sense to him, that the more tools you have, the more talents and skills that you bring to bear on a problem, the more likely you will be to achieve success.

The point is that each of us is proficient in some areas and less so in others. Our chances of finding a novel solution are best if we look in areas where we know the most. So when you're tackling a problem, seek the essence of the problem and try to define it in terms that are meaningful to you using your particular range of expertise.

You people are very fortunate. The training you are receiving gives you a solid foundation in how things work. You are among the privileged few to really understand - at least to partially understand - the laws on which this universe operates. You are uniquely positioned to use that knowledge to make your own contribution.

Oh yes. We forgot about the crown. Was it gold or had the goldsmith alloyed the gold with some silver? When Archimedes did his experiment - dunking the crown in the jar full of water, etc., he found that the density was, indeed, less than the density of pure gold. The king was right. The goldsmith had cheated him. He had mixed silver in with the gold. The king was not amused. We are told that the goldsmith and his head soon parted company. As for Archimedes, he was rewarded. And as you know only too well, he went on to develop those ideas about levers and pulleys, that stuff that drove you crazy in first year mechanics class.

If I may digress a bit, I should tell you that there is a social price to be paid if you are going to be an innovator. Innovative people are not always well received. They are always trying to change things, and some people don't like things to change. They like things just as they are, thank you. Some months ago I visited an R&D lab. We walked down the corridor to the lab area. As we reached the doorway, I saw a large sign over the door. It was a quotation by George Bernard Shaw. It said "All progress is made by unreasonable people. Reasonable people adapt to the environment around them. Unreasonable people try to change it." Innovators are inherently 'unreasonable people'. Be prepared to be unpopular at times.

So, to be an innovator, my first guideline is to know what you're looking for and define the problem in simple terms that are meaningful to vou.

Then what? You've got your problem and you're searching for a solution. My second point is that you have to know when you haven't found it. That's right, you have to know when you have not found the answer. Sounds kind of silly, but I'm serious. Let's look at it.

When faced with a problem, we usually have several alternatives available to us. Perhaps due to our inherent laziness there is a strong temptation to grab one of these ideas and say "That's good enough". Sometimes, it will be good enough. A standard "text-book" answer may be all that's needed. But there are very few problems that call for textbook answers. Most call for some innovation. And, I believe firmly that there is a market for excellence. For doing things the best possible way. For doing them better than anyone else.

Employers know, or at least are learning, that our survival in this technological world depends on our ability to compete with the best. We have to come up with better products, processes, methods. Everything we do in the workplace has to be more cost effective than it is now. Design, production, administration, marketing ... we need the best ideas. Why? Because, whether we like it or not, the competitor isn't just someone across the street doing things the same way we are. It's probably someone across the ocean. And, be they in Europe, Asia, or elsewhere, they are working hard to expand their business and, in simple terms, that may mean they will take away ours.

So why am I telling you this? Because you are the people best equipped to do something about it. You've got the brains, the technical tools, and the energy to make things happen here in Canada. So when I say you have to know when you haven't found the answer, I mean don't accept mediocrity.

Realistically, you can only explore so many possibilities. The time you spend chasing mediocre ideas is time you won't have available to work on that really good idea when it comes along. As each new idea comes to you, take a close look at it. Is this really an idea that has promise or is it just another mediocre solution that isn't worthy of your time? Be willing to discard ideas. Give yourself the right to be wrong. Being wrong is just a stepping stone on the road to being right.

OK, so the first step is knowing what you're looking for and the second step is knowing when you haven't found it. What's next?

My third guideline is that you have to know when you have found it. Now, again, that sounds awfully simple. Notice how all three of these suggestions are very simple. Innovation is usually just a matter of putting several simple things together in a novel way. In this high-tech age we tend to confuse innovation with complexity. The converse is true. The simpler you keep the process, the more likely you are to succeed.

It's amazing how some folks apparently have good ideas, but don't recognize them. Have you ever noticed, when someone comes up with a good idea -- how often someone else will say, "I thought of that a long time ago". Well, if they did, they apparently didn't recognize the value of their idea. They didn't do anything with it. And an idea laying around not being used is no good to anyone.

The real trick is to know when you are on to something good. Knowing the difference between a mediocre idea and a good idea is not always easy. Sometimes you have to do analysis, or experimentation. That's when you put the academic stuff you've been absorbing for the last few years to work. The important thing is to put some mental energy into evaluating your idea. Is it good, or isn't it?

Now here comes the kicker. How do we know when an idea is good? In my case, it's often my stomach that makes the decision. After working with an idea for a while, I literally get a feeling in the pit of my stomach. I used to be too embarassed to talk about it because thoughts are supposed to come from the head, not the stomach. Then I learned that Thomas Edison once said, "I listen from within". He, too, apparently had some part of his body that spoke to him. And hey, if it's good enough for Thomas Edison, it's good enough for me.

I think each of us has the ability to "sense" when we are on to something good. We just have to be aware of that "voice from within". If an idea feels good or sounds good to you, stick with it. Work on it. If the feeling isn't good, don't waste time. Keep on looking for that innovative approach that will give you, your company, and your country a competitive edge.

Throughout this talk I keep saying, "Know this. Know that. Know what you're looking for. Know when you haven't found it. Know when you have found it". You're probably saying, "How I am supposed to know these things? It's like expecting me to know the answer before I even know the question."

Try this. As you go through the three steps I've given you, pause every now and then. Just stop whatever you're doing.

> First ask, "Do I really know what I'm looking for". Try putting it into words. A few words. State the problem out loud. The person at the next desk may think you're wierd, but I warned you about that. If you don't like the way it sounds, do it again. Until you really know what it is you are looking for.

> For the second and third steps - know when you haven't found it and know when you have -- I suggest you just go quiet. Do as Thomas Edison did. Listen from within. Tune in to how you feel. You might be amazed. Deep down, something will tell you when you are on the right track. And please, be patient with the process and be patient with yourself.

Why am I dumping all this on you? Simply because I have very high expectations for you. The world needs you, Canada needs you.

There is a host of problems to be addressed. Some created by greedy businessmen. Some created by short sighted politicians. And, let's face it, some created by bad use of science. The decade of the 90's promises to be the start to the healing process, repairing some of the damage to our world. Your job is to put technology to work to solve that ever so difficult problem. The problem of:

> Ensuring the survival of this earth as a place to live while maintaining a standard of living that makes living worthwhile.

That is not an easy task. But it is an exciting one. Don't expect someone else to do it. Don't complain that it's not your problem ... you didn't create the mess. True, but the fact is it's your world. It's your future that's at stake. And you are the fortunate ones with the skills necessary to help make it a better place.

It calls for all of your innovative skills to be put to use. And that means

> Know what you're looking for
> Know when you haven't found it, and
> Know when you have found it

Thank you, and may God, by whatever name you know Him, bless each one of you.

Good night.

## Books Received/Livres reçus

The following books have been received for review. Readers are invited to write reviews, in English or French, of books of interest to them. Books may be requested from the book review editor G.R. Hébert -- BITNET: "PHYSCAN@SOL.YORKU.CA" or at Department of Physics and Astronomy, York University, 4700 Keele St., North York, Ontario, M3J 1P3. Tel: (416) 736-2100, ext. 77753.

Les livres suivants nous sont parvenus pour la critique qui peut être faite en anglais ou en français. Si vous êtes intéressé de nous communiquer une revue critique sur un ouvrage en particulier, vous êtes invités de vous mettre en rapport avec le responsable de la critique des livres; G.R. Hébert via INTERNET: "PHYSCAN@SOL.YORKU.CA" ou au: Département de physique et d'astronomie, l'Université York, 4700 Keele St., North York, Ont., M3J 1P3; Téléphone: (416) 736-2100, ext. 77753.

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### 00: GENERAL

**CHANDRA, A BIOGRAPHY OF S. CHANDRESEKHAR,** by Kameshwar, C. Wali, The University of Chicago Press, 1991, pp x + 341. ISBN 0-226-87055-3; QB36.C46W35. Price: $19.50 pbk.

**CHAOS AND FRACTALS, New Frontiers of Science,** by Heinz-Otto Peitgen, Hartmut Jürgens, Dietmar Saupe, Springer-Verlag, 1992, pp vi + 984. ISBN 0-387-97903-4; QA614.86.P43. Price: $49.00 hc.

**LONG-RANGE CASIMIR FORCES, THEORY AND RECENT EXPERIMENTS ON ATOMIC SYSTEMS,** edited by Frank S. Levin, David A. Micha, Plenum Press, 1993, pp xv + 357. ISBN 0-306-44385-6; QC680.L63. Price: $75.00 hc.

**ORIGIN AND EVOLUTION OF THE ELEMENTS,** edited by N. Prantzos, E. Vangioni-Flam, M. Cassé, Cambridge University Press, 1993, pp xvi + 545. ISBN 0-521-43428-9. Price: $69.95 hc.

**THE QUANTUM THEORY OF MOTION, AN ACCOUNT OF THE de BROGLIE-BOHM INTERPRETATION OF QUANTUM MECHANICS,** by Peter R. Holland, Cambridge University Press, 1993, pp xix + 598. ISBN 0-521-35404-8. Price: $120.00 hc.

**THE GOLEM, WHAT EVERYONE SHOULD KNOW ABOUT SCIENCE,** by Harry Collins, Trevor Pinch, Cambridge University Press, 1993, pp xii + 164. ISBN 0-521-35601-6; Q125.C5.52. Price: $19.95 hc.

**THE QUANTUM DICE,** by L.I. Ponomarev, transl. from the Russian by A.P. Repiev, I.O.P. Publ. Ltd., 1993, pp 255. ISBN 0-7503-0251-8 (hc); 0-7503-0241-0 (pbk). Price: $110.00 hc; $35.00 pbk.

### 10: THE PHYSICS OF ELEMENTARY PARTICLES AND FIELDS

**THE PRINCIPLES OF CIRCULAR ACCELERATORS AND STORAGE RINGS,** by Philip J. Bryant, Kjell Johnsen, Cambridge University Press, 1993, pp xxv + 357. ISBN 0-521-35578-8; QC787.P3B79. Price: $100.00 hc.

### 20: NUCLEAR PHYSICS

**ALGEBRAIC APPROACHES TO NUCLEAR STRUCTURE, INTERACTING BOSON AND FERMION MODELS,** Contemporary Concepts in Physics, v. 6, edited by Richard F. Casten, Harwood Academic Publishers, 1993, pp xv + 554. ISBN 3-7186-0538-4; QC793.3.S8A38. Price: $38.00 pbk.

**SIMPLE MODELS OF COMPLEX NUCLEI, The Shell Model and Interacting Boson Model,** Contemporary Concepts in Physics, vol. 7, by Igal Talmi, Harwood Academic Publ., 1993, pp xx + 1074. ISBN 3-7186-0550-3; QC173.T26. Price: $52.00 pbk.

### 30: ATOMIC AND MOLECULAR PHYSICS

**POLARIZATION BREMSSTRAHLUNG, Physics of Atoms and Molecules Series,** ed. by V.N. Tsytovich, I.M. Ojringel, Plenum Press, 1992, pp xxvi + 370. ISBN 0-306-44-217-5; QC484.3.P65. Price: $89.50 hc.

### 40: FUNDAMENTAL AREAS OF PHENOMENOLOGY

**DEVELOPMENT OF NEW NONLINEAR OPTICAL CRYSTALS IN THE BORATE SERIES,** (Laser Science and Technology, An International Handbook, vol. 15), by C.T. Chen, Harwood Academic Publ., 1993, pp vii + 74. ISBN 3-7186-5351-6; QD491.C4.813. Price: $40.00 pbk.

**THEORIES ON DISTRIBUTED FEEDBACK LASERS,** (Laser Science and Technology, An International Handbook, vol. 14), by F.K. Kneubühl, Harwood Academic Publ., 1993, pp ix + 94. ISBN 3-7186-5350-8; TA1677.K59. Price: $45.00 pbk.

**THERMODYNAMIQUE APPLIQUÉE, avec 80 exercises et 25 problèmes résolus,** par H. Guénoche, C. Sèdes, (Collection Enseignment de la Physique), Masson éditeur, 1993, pp xvii + 333. ISBN 2-225-84230-2. Prix: 260 F, broché.

### 70: CONDENSED MATTER: ELECTRONIC STRUCTURE, ELECTRICAL, MAGNETIC, AND OPTICAL PROPERTIES

**COMPOUND AND JOSEPHSON HIGH-SPEED DEVICES,** edited by Takahiko Misugi, Akihiro Shibatomi, Plenum Press, 1993, pp xii + 306. ISBN 0-306-44384-8; TK7874.7.C66. Price: $69.50 hc.

**PHASE TRANSITIONS IN FERROELASTIC AND CO-ELASTIC CRYSTALS,** Cambridge Topics in Mineral Physics and Chemistry, Student Ed., by E.K.H. Salje, Cambridge University Press, 1990, pp xiv + 229 + (L App. + 2 pp index). ISBN 0-521-42936-6. Price: 34.95 pbk.

**NEGATIVE DIFFERENTIAL RESISTANCE AND INSTABILITIES IN 2-D SEMICONDUCTORS,** NATO ASI Series B: v. 307, edited by N. Balkan, B.K. Ridley, A.J. Vickers, Plenum Press, 1993, pp ix + 443. ISBN 0-306-44490-9; QC611.6.H67N44. Price: $115.00 hc.

**SPIN GLASSES,** Cambridge Studies in Magnetism, by K.H. Fischer, J.A. Hertz, Cambridge University Press, 1991, pp x + 408. ISBN 0-521-44777-1; QC176.8.S68F57. Price: $34.95 pbk.

### 80: CROSS-DISCIPLINARY PHYSICS AND RELATED AREAS OF SCIENCE AND TECHNOLOGY

**ELECTRON BEAM TESTING TECHNOLOGY,** Microdevices, Physics and Fabrication Technologies, Edited by John L. Thong, Plenum Press, 1993, pp xvi + 462. ISBN 0-306-44360-0. Price: $89.50 hc.

**FIELD GUIDE TO THE BIRDS OF NORTH AMERICA,** 2nd Ed., National Geographic Society, pp 464, 1993. ISBN 0-87044-692-4; QL68.1F53 (1987). Price: $27.50 Can. pbk.

**CELLULAR COMMUNICATION IN PLANTS,** Proceedings of the Twenty-first Steenbock Symposium: Cellular Communication in Plants, held in May-June, 1992, in Madison Wis., edited by Richard M. Amasino, Plenum Press, 1993, pp x + 181. ISBN 0-306-44415-1; QK725.C392. Price: $149.50 hc.

**ORGANIC PHOTORECEPTORS FOR IMAGING SYSTEMS,** by Paul M. Borsenberger, David S. Weiss, Marcel Dekker, Inc., 1993, pp xvi + 447. ISBN 0-8247-8926-1; TR1045.B67. Price: $135.00 hc.

**QUANTUM CHEMISTRY,** by John P. Lowe, Academic Press, 1993, pp xx + 711. ISBN 0-12-457555-2; QD462.L69. Price: $59.95 hc.

**THE MEASUREMENT OF GRAIN BOUNDARY GEOMETRY,** (Electron Microscopy in Materials Science Series), by V. Randle, I.O.P. Publ., 1993, pp xi + 169. ISBN 0-7503-0235-6. Price: $120.00 hc.

## *Book Reviews / Revues des livres*

**COHERENT RADIATION GENERATION AND PARTICLE ACCELERATION,** edited by Prokhorov, AIP, New York, 1992, pp 528. ISBN 0-88318-926-7; LC92-82562. Price: $120.00 hc.

Edited by Nobel Laureate A.M. Prokhorov of the Russian Academy of Sciences, this book is based on an invited Symposium organized by the La Jolla International School of Physics, Inst. for Advanced Physics, La Jolla, California, in February 1991. It covers theoretical, experimental, and technological problems addressed by prominent researchers from around the world. Contributors in the series - all of whom were invited - were encouraged by the organizers to go beyond the narrow confines of their work and reflect on broader issues. This is reflected in the incisive essays which review critical issues, critique the field's status, and point the way toward new avenues and trends in research. V. Stefan of the Institute for Advanced Physics Studies, who is the series editor, has put together an excellent volume which documents the latest thinking and future trends in physics research.

The topics covered in these essays are free electron lasers, microwave generators, relativistic beam physics, radiation and energy physics, as well as accelerators and synchrotron radiation physics.

The first part of this book covers topics in coherent radiation generation with a review by Bratman and colleagues on the methods to obtain single mode operation in high power microwave generators. The cyclotron autoresonance MASER amplifier is discussed by Danly and colleagues, with possible applications as an RF source in the next generation of linear colliders. There are a number of important discussions on free electron lasers relating operating parameters to scaling laws and the subject of chaos in free electron lasers. Non-linear interaction of ultrashort relativistically strong laser pulses with plasmas is analyzed by Bulanov and colleagues and the optical guiding of such pulses is discussed by Litvak and colleagues.

The second part of the book covers topics on particle acceleration with lasers and plasmas. Three topics are well covered here. Work on the laser plasma beatwave acceleration is discussed in detail and recent progress in this area reported from laboratories in Europe (Dyson), Japan (Kitagawa), and Canada (Ebrahim). Work on particle acceleration in plasma wakefields is discussed, including the excitation of nonlinear wakefields in a plasma by Breizman and colleagues, and the problem of electromagnetic pulse self-focusing in wakefield generation by Garuchava and colleagues, as well as Tsintsadze. Recent experimental work on plasma wakefield acceleration and plasma lens is discussed by Ogata.

From the material presented in this volume, it is clear that the goal set by the symposium organizers was met. The symposium brought together some of the most prominent researchers from around the world. Their discussions indicate the status of some of the areas covered and the future trend in these fields. The interdisciplinary nature of the material will make this book valuable to both veteran researchers and those new to the field.

Nizar Ebrahim
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Chalk River

**COLD FUSION, The Making of a Scientific Controversy,** by F. David Peat, Contemporary Books, 1990, pp ii + 204. ISBN 0-8092-4085-8; QC791.735.P43. Price: $12.00 pbk.

Cold fusion is not the hot topic it once was, and this book, written in 1989 and "updated" in 1991, is more than a little out of date. "Cold Fusion -- The Making of a Scientific Controversy" has a bit of the look of something thrown together quickly to reach bookstores before its subject disappeared from newspaper headlines. In fact, though, it is a fairly carefully researched and well presented account, in layman's language, of the first year or so of cold fusion mania that followed Pons and Fleischmann's announcement that they had observed nuclear fusion in an electro-chemical cell. Peat explains the physics of fusion in very simple terms, and in a style that should be accessible to the average reader of supermarket tabloids. Facts are repeated -- sometimes three times on a single page -- presumably to ensure that they are absorbed by the reader. Peat paints a detailed picture of the activities of, and interactions among, the scientists involved in the cold fusion controversy, giving the reader an interesting look at how science was done in this rather atypical case. He also discusses how a cheap and easy energy source -- like cold fusion -- would affect society, and presents a few very simplistic scenarios for a cold-fusion-based world.

I would have preferred a somewhat more critical discussion of the various results, while Peat is totally uncritical. He states unambiguously that so-and-so "observed fusion", when in fact what they observed was something else -- heat, or neutrons or, more likely, statistical fluctuations -- which they interpreted as being the result of fusion. He then states that another so-and-so saw nothing. All of this must leave the reader a bit confused about the validity of scientific work --- but then, this is cold fusion we are talking abouti

On the whole, I found this book amusing reading. It is obviously not aimed at scientists but rather at the lay public and, given this, I think it is successful.

John de Bruyn
Memorial University

**DIMENSIONAL MAN**, by John Cape, Random House of Canada Ltd., 1992(?). ISBN 0-224-02714-X. Price: $29.95 Can pbk.

**DIMENSIONAL MAN** by Daniel Pelham is not a book in the purely technical sense. However, it does portray, in life size, a 3-dimensional study of the human body. The "chart" comes wrapped in transparent plastic and has the dimensions of about 78 cm in length, by 31 cm in width. Directions for unfolding and setting up the chart are quite explicit and clear. Once hung, **Dimensional Man** is life size, and opens up out of the plane to about 15 cm in the head and torso areas. It provides an excellent and fascinating introduction to basic anatomy. The chart reveals the locomotor, the cardiovascular, the respiratory, the digestive, and urogenital systems of the human body. A separate numerical index lists the names of individual bones, muscles, organs, arteries, and veins. The corresponding 304 numbers are printed on (and within) the figure itself. I would have preferred to have had some way of attaching this index-list to the chart itself; it is included as a separate chart.

**Dimensional Man** would have proved quite useful to me when I studied Anatomy and Physiology many years ago. It should prove to be quite helpful to the beginner of such studies today. Further, many of our readers who would enjoy reviewing basic knowledge of the human body might find that **Dimensional Man** just fits the bill at a reasonable price.

Gérard R. Hébert, Emeritus
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**QUANTUM MECHANICS**, by Leslie E. Ballentine, Prentice-Hall, 1990, pp 486. ISBN 0-13-747932-8. Price: $56.00 hc.

Leslie E. Ballentine (Simon Fraser University) offers his readers a senior undergraduate or beginning graduate level text in quantum mechanics that he claims takes "into account the developments in the foundations of the subject that have taken place in the last few decades". His intention is to incorporate "firmly established results" in the theory of measurement which "have not been taken into account in previous textbooks". (Remarks from Preface, p xiii). My main intention here is to comment on whether this book really does succeed as a sound introduction to foundational issues.

Leslie Ballentine has for some years vigorously and eloquently advocated his version of the ensemble interpretation of quantum mechanics, according to which the state vector or density operator represents not an individual quantum system (such as a single pair of correlated electrons) but an ensemble of similarly prepared systems. On this view, measurement involves merely the selection of a subensemble from the total ensemble; there is no "collapse" of the wavefunction. While Ballentine's views are certainly cogent, it would be very difficult to say that they are regarded by those who concern themselves with foundational issues in quantum mechanics as "firmly established". And yet, Ballentine uses an intermediate text to showcase his personal reading of some of the most problematic aspects of quantum theory, making almost no mention of the fact that such matters as the viability of the collapse postulated, the measurement problem, or the interpretation of the quantum state are still subjects of active research and debate. (A glance through recent issues of **Phys.Rev.A** would confirm this). One would think that a text that claims to be foundationally adequate would clearly distinguish between those matters that really are more or less firmly settled, and those that remain open.

Ballentine's inclination to indulge at every opportunity in polemic against the collapse postulate leads him to the border of outright error in his discussion of the "watched-pot paradox" or "quantum Zeno effect", as it is sometimes known. If a quantum system, which undergoes a transition or decay from one state to another, is observed while in the process of transit, there is a probability that the observation will "collapse" the state of the system back to its original state (if I may be pardoned the conventional way of speaking). If the system is repeatedly observed at sufficiently short intervals, its decay may be indefinitely postponed. (This brings to mind the old adage that "a watched pot never boils"). Ballentine (section 12-2) heaps scorn on this prediction, treating it as a 'reductio ad absurdum' of the collapse postulate, and describing it as "... of course, false". Unfortunately for Ballentine, the quantum Zeno effect has been unambiguously observed -- although, in fairness to him, in work reported since his book was published. (See R. Pool, **Science**, v. 246, p. 888, 1991, for a succinct review).

This much having been said, let us note the real merits of this book as a text and reference, especially for those who might be interested in foundations. Ballentine has taken care to cover a number of topics not always found together in introductory and intermediate texts: rigged Hilbert spaces, properties of composite systems (the classificaiton of correlated and uncorrelated states, pp. 162-165, is especially useful), the Bohm theory, Herbert's Inequality, a very thorough introduction to probability theory, the Aharonov-Bohm effect, symmetry properties, and much more. The problems are excellent and well keyed to the accompanying text.

In spite of my annoyance at this book's general tendentiousness, I have found myself repeatedly going back to it for clarification of such matters as the structure of partial state operators, or the derivation of Bell inequalities. It really is a useful book; but it should be presented to student by a teacher experienced in foundational questions, who can pilot its readers past the occasional rocky shoals, and remind them that some long-standing conundrums of quantum mechanics are not quite as easily dismissed as its author believes.

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**ELEMENTS OF PHYSICS**, by Marcel Wellner, Plenum Press, 1991, pp xiii + 693. ISBN 0-306-43354-0; QC21.2.W437. Price: $49.50 hc.

Comme l'indique l'auteur dans sa préface, ce manuel est la réponse à un besoin ressenti par des étudiants en sciences ou en génie qui ont à suivre des cours techniques de base requérant des connaisances dans l'ensemble de la physique. Les 28 chapitres, passablement développés et orientés sur la continuité des sujets traités, ont été planifiés pour être couverts en deux ou trois sessions. Le livre couvre les mêmes sujets que dans un cours collégial normal (mécanique, électromagnétisme, optique physique, et géométrique, physique moderne) et avec, en plus, l'étude des fluides et de la chaleur. Le niveau mathématique dépasse celui d'un cours comme le Physical Science Study Committee (PSSC) par exemple, car il introduit les notions de base de calcul différentiel et intégrale. Mais la puissance de ce calcul est laissée de côté la plupart du temps, au profit des concepts physiques introduits et de leurs compréhension. Sous cet aspect donc, les manuels utilisés dans un cours collégial sont de niveau supérieur mais ils sont destinés à une clientèle différente.

Le manuel couvre bien l'ensemble des concepts normalement vus dans un tel cours: ils sont expliqués succintement (nous laissant parfois sur notre faim) mais clairement. L'auteur les illustre abondamment de dessins, schémas, et graphiques explicites. Il ramène parfois des approches anciennes (lignes de champ, pôles magnétiques). Pour favorisér la continuité de l'approche, les digressions sont renvoyées en fin de chapitre, où l'on rencontre également un résumé des principales équations de chapitre. On y trouve également un grand nombres de questions ◄Vraie ou faux?► et de problèmes, practiques et très bien illustrés, dans lesquels l'auteur a cherché à eviter à l'étudiant un travail technique trop élaboré ou fastidieux. Les responses à toutes les questions, les reponses et/ou des indices à plusieurs problèmes sont fournis en fin de chaque chapitre.

Tout au long du volume, en plus des tables généralement présentées dans un manuel de ce genre, l'auteur a parsemé des échelles logarithmiques donnant les ordres de gandeur d'un grand nombre de variables physiques (forces, pressions, moment angulaire, intensité de champs, transparence de l'atmosphere, etc.), de façon à en donner des exemples rencontrés dans notre environnement plus ou moins immédiat: l'auteur a aussi pris soin d'en faire un liste en annexe pour que la lectuer puisse les retrouver plus facilement.

Mentionnons en dernier lieu que dans les annexes, nous retrouvons une table de conversion en unités SI, d'anciennes unités encore parfois utilisées ici et là pour diverses raisons (carat, BTU, gallon, etc.); une liste de tables et de spectres utilisés dans l'ouvrage et un index bien développé. En résumé, l'auteur a bien atteint le but qu'il s'était fixé et son livre peut aussi servir d'ouvrage de référence pour d'autres clientèles de niveau collégial.

Michel Paradis
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Petit Séminaire de Québec

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**QUERY:** A new subsection of Book Reviews.
We will publish questions about help and advice on finding suitable texts for certain academic courses or for certain subject matters as requested by you, our readers. Answers, again from our readers, will be published in a subsequent issue of PiC. We will maintain anonymity if so requested.

Q3: Can one of you readers suggest a good, suitable, textbook for a 2nd course on Fluid Dynamics?

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## *RESUMES ON FILE*

This is a new initiative undertaken by the CAP to assist its members who are currently searching for employment opportunities. Interested employers should contact the CAP in writing and quote the appropriate resumé number.

**Resume No. 1** - Fully bilingual (French/English) Canadian citizen with Ph.D. in solid state physics (1983). Upgraded skills through computer science courses in 1987, 88, and 93. Primary skills include software design, development and testing. Experienced in spectroscopy (optical, infrared, Raman), lasers, recorders, plotters, cryogenics, photon counting systems. Experienced in software analysis, the design review process, writing software documentation and user manuals. Familiar with NASA standards, practices, and procedures.

**Resume No. 2** - M.Sc. (1976); 5 ans comme conseiller scientifique à la commission de contrôle de l'énergie atomique; 5 ans d'enseignement de la physique; 5 ans de recherche en sylvichimie et en biomécanique. Découvertes: Détermination des niveaux excités du $Co^{55,57}$, découverte de la meilleure vis à os spongieux, découverte d'un procédé de blanchiment de la pâte ne polluant pas.

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Canada H3C 3J7

e-mail: JEREMIE@LPS.umontreal.ca
téléfax: (514) 343-6215; tél: (514) 343-6729

## AVADH BHATIA WOMEN'S POST-DOCTORAL FELLOWSHIP

The Department of Physics invites applications for the Avadh Bhatia Women's Post-doctoral Fellowship. This award, established by Mrs. June Bhatia in memory of the late Professor Bhatia, is awarded to a recently graduating Ph.D. female who has demonstrated potential for excellence in research. Active fields of research in our Department are astronomy, laboratory astrophysics, geophysics (including space physics), condensed matter physics, experimental particle physics, medical physics, theoretical physics (condensed matter, cosmology, field theory, mathematical physics, particle physics, intermediate energy physics, plasma physics).

This is a one-year appointment with the possibility of renewal for a second year. Salary is $27,000 per annum.

All applications should be mailed to the Avadh Bhatia Women's Post-doctoral Fellowship Committee, Rm. 410, Avadh Bhatia Physics Lab, Department of Physics, University of Alberta, Edmonton, Alberta, T6G 2J1.

**Application deadline is January 15, 1994.**

The University of Alberta is committed to the principle of equity in employment. The University encourages applications from aboriginal persons, disabled persons, members of visible minorities, and women.

*University of Saskatchewan*

**Research Associate Position in Physics**

Applications are invited for an appointment at the Research Associate level with the Saskatchewan Accelerator Laboratory at the University of Saskatchewan. Applicants must have a Ph.D. in Physics and postdoctoral research experience. Applicants should possess a strong theoretical background in intermediate energy electromagnetic interactions, preferably in the theory of photo- and electroproduction of pions (or mesons in general) and Compton scattering. An interest in both threshold and resonance region reactions would be an asset. Applicants should also show an active interest in QCD. The successful appointee will be expected to collaborate with both the theoretical and experimental members of the Laboratory. Applications, a curriculum vitae and the names of at least three referees should be sent before January 31, 1994 to:

Dr. D.M. Skopik, Director
Saskatchewan Accelerator Laboratory
University of Saskatchewan
Saskatoon, Saskatchewan
S7N 0W0 Canada

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Dr. G.P.Raaphorst, Head, Dept. of Medical Physics
Ottawa Regional Cancer Centre
190 Melrose Avenue, Ottawa, Ontario, Canada, KIY 4K7

Department of Physics and Engineering Physics
University of Saskatchewan

## ASSISTANT PROFESSOR

Applications are invited for an appointment to a tenure stream position in the Department of Physics and Engineering Physics, University of Saskatchewan (subject to budgetary approval), at the rank of Assistant Professor. Duties will include undergraduate/graduate teaching and research responsibilities at the Plasma Physics Laboratory. Candidates must hold a Ph.D. degree or equivalent and have experience in magnetic fusion research, preferably in tokamak research. Applications with a curriculum vitae and the names of at least three referees should be sent before February **1, 1994** to:

Head, Department of Physics and
Engineering Physics
Physics Building
University of Saskatchewan
Saskatoon, Saskatchewan S7N 0W0
Canada

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada. The University of Saskatchewan is committed to the principles of employment equity. Women candidates, candidates of aboriginal descent, and candidates from other minority groups are especially encouraged to apply.

## POSITION - ASSISTANT PROFESSOR

## ACADIA UNIVERSITY

The Department of Physics invites applications for a tenure-track position (position #21004) at the rank of Assistant Professor up to grid step 4, effective 1 July 1994. There being no graduate program in Physics at Acadia, the primary responsibility of the successful applicant will be undergraduate teaching, and it is expected that a component of the applicant's research would involve the training of undergraduate students.

The current research interests of the Department are in areas of applied physics, such as plasma physics including Langmuir probes, thin film devices including electrochromics, and the electrical breakdown of gases. A Ph.D. in Physics is required along with a strong background in electronics, computer usage and solid state physics.

*Acadia University is an equal opportunity employer. In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents. The University reserves the right not to fill the position.*

Letters of application and a complete curriculum vitae should be sent to Dr. Cyrus MacLatchy, Department of Physics, Acadia University, Wolfville, NS, B0P 1X0. Applicants should arrange to have three referees send letters of reference to the same address. The names, telephone numbers and addresses of the referees should be included with the application. The deadline for receipt of applications and letters of reference is 1 February 1994.

## Experimental Research Associate Positions

### Centre for Subatomic Research
### University of Alberta

The Subatomic Physics group at the University of Alberta has several openings for experimental Research Associates in Intermediate and High Energy physics. The group's present activities include: the HERMES nucleon spin structure function measurements at HERA; the OPAL collaboration at LEP; the ATLAS project for the LHC at CERN; the E787 rare kaon-decay tests of the Standard Model at Brookhaven; parity violation in *pp* scattering, *np* charge symmetry breaking, and nuclear reaction studies at TRIUMF; and photonuclear studies at the Saskatchewan Accelerator Laboratory.

Several appointments will be made for candidates who have received their degrees within the last two years. The successful candidates will have some freedom to define their research activities but a major contribution in those projects is expected. Salary will be commensurate with experience.

Given satisfactory on-going performance, new Research Associates are normally appointed for a three-year period, but we are also seeking a more experienced candidate and may fill a position without fixed term. For this latter position we are particularly looking for physicists with hardware experience in detector design and construction and/or fast trigger electronics.

Candidates should send their resume and names of at least three references to: **Research Associate Search Committee, Centre for Subatomic Research, University of Alberta, Edmonton, Alberta T6G 2N5.**

**Applications should be received by 15 February 1994.**

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APPLICATIONS are invited for research associate position with the ZEUS project. The successful applicant will help to run the ZEUS detector, and develop software for the analysis of physics data. Applicants must have a recent Ph.D. in experimental particle Physics. Send application, including curriculum vitae, details of hardware and software experience to: Department of Physics & Astronomy, Petrie 128, York University, 4700 Keele Street, North York, ON, M3J 1P3. Applicants should have 3 referees send letters of recommendation under separate cover. In accordance with Immigration regulations, this advertisement is directed to Canadian citizens and permanent residents.

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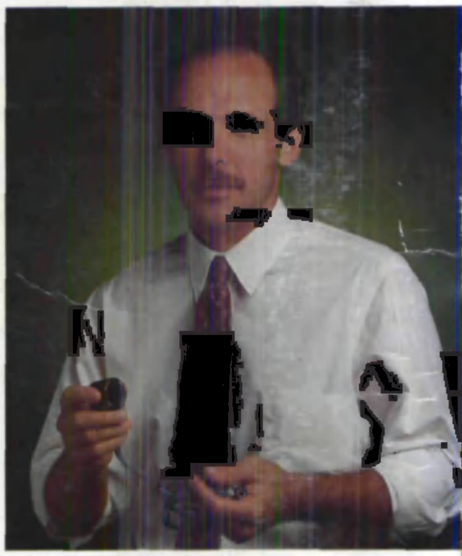

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