Spring 2005

EMISSARY

Mathematical Sciences Research Institute

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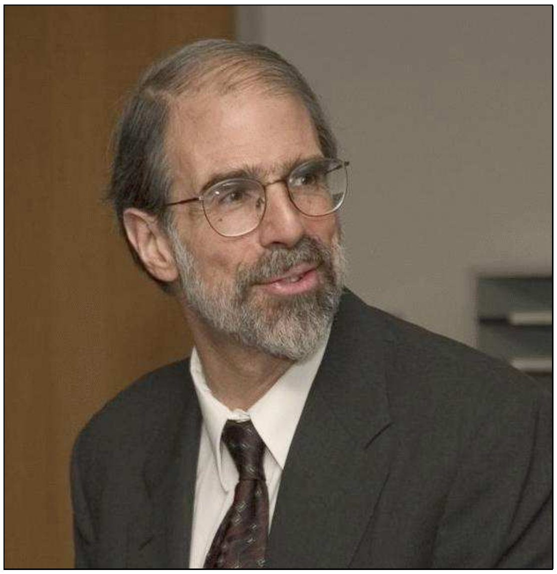
Notes from the Director

David Eisenbud



Sheila Newbery

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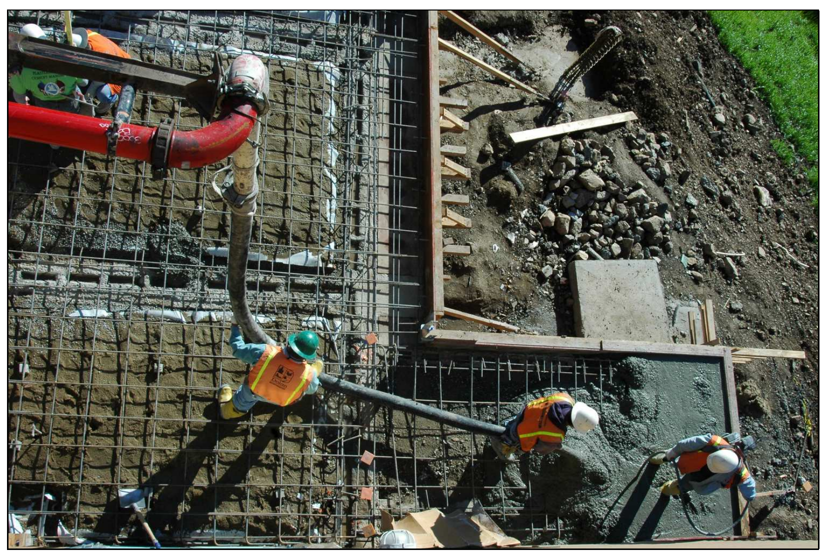

David Eisenbud

Views of construction site, March 2005. Top: the foundations of the new auditorium. Bottom: Pouring the concrete slab for the library extension. See also page 7.

MSRI Comes Out of the Ground

As many readers will know, we got a rude shock last June: the bids for construction of the MSRI addition came in 35% higher than predicted by estimators from two independent firms. We went back to the drawing boards to redesign a little, but still needed more money: the whole community generously took up the challenge and we raised an additional two million dollars in just a couple of months. We rebid and presto! — the bids came in right on the new target. The University, which, as owner of the land, is in charge of letting contracts and overseeing the building, promised to be "in the ground" — digging foundations — by December, and they were as good as their word.

Now it's mid-March — midspring in Berkeley — and the new wing of MSRI is rising out of the ground with the flowers. The foundations are almost complete and the shape of things to come is quite visible. By mid-April we should be in the framing stage, when things happen almost magically fast. You can watch it happen via our webcam, accessible from a link at www.msri.org.

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Notes from the Director

(continued from page 1)

Chern Passes Away

My joy in the start of building was tempered by sadness over the death of MSRI's founding director, Shiing-Shen Chern, in December 2004. Here's the email message I sent:

Dear Friends and Colleagues,

I'm sad to share with you what I just learned: Shiing-Shen Chern, cofounder and first Director of MSRI (1982–85), died yesterday after a brief illness in China. Chern was truly a towering figure in 20th century mathematics. Aside from his fundamental contributions in geometry (I use Chern classes every day — and that was just the beginning), he was mentor to many, many mathematicians both here (he taught at the University of Chicago and then, for most of his career, at Berkeley) and in China. His national celebrity in China was immense. A star was named for him. He had close ties to President Jiang Zhemin, and used them to benefit mathematics in many ways.

Though he returned to China in 1999, Chern remained a strong supporter of MSRI. His major gift sparked MSRI's successful campaign to expand its building, and when he was honored this year with the Shaw Prize for Mathematics, he gave MSRI a large additional gift from the proceeds.

You can find a brief biography of Chern that MSRI put together on the occasion of a Symposium in his honor in 1998 at http://www.msri.org/chern_04.pdf. (Editor's note: see also http://www.berkeley.edu/news/media/releases/2004/12/06_chern.shtml.)

I feel personally honored to have known this great man, and to have had his help, friendship and tutelage at MSRI. We will all miss him greatly.

In sorrow,

David Eisenbud

I can now add: over 10,000 people attended his funeral in China.

A few weeks ago UC Berkeley and MSRI jointly sponsored a memorial, to which Chern's children May and Paul came, along with other family members and of course many old friends and colleagues (see page 6). Warm memories were recounted, as was Chern's amazing influence on mathematics, and his tremendous stature as a scientist. To paraphrase a line by W. H. Auden: To us he is no more a person, but a whole climate of mathematics. May this climate govern MSRI for many, many years!

Two Countries Become Three

MSRI, representing the US, and the Pacific Institute of Mathematics (PIMS) and MITACS (which stands for Mathematics of Information Technology and Complex Systems), both representing Canada, collaborated to create BIRS, the Banff International Research Station for the Mathematical Sciences, which opened in March 2003. BIRS has now hosted more than eighty five-day workshops and numerous other programs, leading to well over 3000 visits by mathematicians, scientists, engineers and educators. The program has been exceptionally broad, and the facility has gotten glowing reviews. Now it's already time for renewals, a process complicated (at least in some senses) by the multiplicity of supporters: the NSF, NSERC, ASRA, PIMS, MITACS, and more. The picture shows some of the leaders of PIMS, MITACS, and BIRS, together with me, on the steps of Corbett Hall. This is one of the buildings BIRS occupies in the Banff Centre, long a center for art, music and theater — and now mathematics. Though the outcome of the site visit won't be known for a few months, I feel very optimistic that the Station will continue, and perhaps even extend its operation from 40 to 48 weeks per year.

Although BIRS only celebrated its second birthday this month, it is turning three in a different sense: Mexico has joined Canada and the US in this extraordinary collaboration, being represented by the Mathematics Institute of UNAM (Universidad Nacional Autónoma de México), whose director, Jose Antonio de la Peña, can be seen on the photo. Adding Mexico to the partnership was something that we discussed from the start, but in the first application it seemed complex enough to manage funding from just two countries. With BIRS going strong we extended an invitation to our Mexican colleagues. Both UNAM and CONACYT, the Mexican analogue of the NSF, reacted very favorably and UNAM has joined MSRI, PIMS, and MITACS in the new application. I'm proud that MSRI is a partner in this collaboration, which has given North America an Institute like Oberwolfach in Germany and Luminy in France — I think that BIRS (or simply Banff, as I prefer to call it) is worthy of the comparison in every sense.

Kind Stranger

Left to right: Arvind Gupta, Alejandro Adem, Ivar Ekeland, Nassif Ghoussoub, and David Eisenbud at the Site Visit for the renewal of the Banff International Research Station, March 21.

Puzzles Column

Joe P. Buhler and Elwyn Berlekamp

Some Olympic Questions

The Bay Area Mathematical Olympiad (BAMO) exam is given once a year to middle school and high school students, located mostly in the Bay Area. MSRI has provided financial and logistic support from the beginning, and has played an important role in nurturing this exam as well as weekly Math Circles meetings in Berkeley. Links to information on these can be found on the MSRI web site, or at mathcircle.berkeley.edu.

This year's BAMO, on February 22, is the seventh such exam. Participation continues to be strong, and by now former winners (some in graduate school) are involved in generating problems for the current exam. In honor of BAMO, we start with two problems from this year's exam. We thank two of the exam organizers, Zvezda Stankova and Paul Zeitz, for their help in getting these problems to us.

1. Prove that if two medians in a triangle are equal in length, the triangle is isosceles.

2. There are 1000 cities in the country of Euleria, and some pairs of them are linked by dirt roads. It is possible to get from any city to any other city by traveling along these dirt roads. Prove that the government of Euleria may pave these roads so that every city will have an odd number of paved roads leading out of it.

3. (a) Place four integers at the corners of a square. At the center of each edge, write the absolute value of the difference between the integers. In algebraic language, the cycle (a, b, c, d) leads to the cycle $(|a-b|, |b-c|, |c-d|, |d-a|)$. Repeat this operation. Prove or disprove: any starting sequence of integers leads to the all-zero square in finitely many iterations.

(b) Same problem with arbitrary positive real numbers allowed as starting values.

Note: The operation of replacing a square by the square of differences is sometimes called a "difference box," or "diffy box," and has been reportedly used for arithmetic practice in elementary schools. Part (b) seems to be much harder, and seems to originate in the article "The convergence of difference boxes," A. Behn, C. Kribs, and V. Ponomarenko, to appear in *American Mathematical Monthly*. This article gives several sources for the idea of a diffy box — Professor Juanita Coplesy of the University of Houston, her grandmother, a WWII prisoner of war diversion (see Peter Winkler, *Mathematical Diversions*, p. 17), and a google search for "Ducci's problem" reveals a number of other possible origins. We thank Stan Wagon for bringing this problem to our attention, and note that he used it recently in his problem-of-the week at Macalester.

4. Prove or disprove: For all positive integers n,

$$\left\lceil \frac{2}{2^{1/n}-1} \right\rceil = \left\lfloor \frac{2n}{\log 2} \right\rfloor .$$

About that Promise...

The authors of this column have periodically promised the Emissary editors that they would post solutions on the MSRI web site. We have come to the belated realization that this commitment grows with each column that we write for which we don't also write solutions.

So we have decided to start decreasing our backlog, and hope that solutions to some of the problems posed over the last 5 years will appear on the MSRI web site by the time that you read this. Readers wishing to contribute or make comments are urged to contact the authors.

As a teaser, we briefly discuss a problem from last time that generated a lot of correspondence. We asked whether the function

$$f(x) = x - x^2 + x^4 - x^8 + x^{16} \pm \cdots, \qquad x \in (-1, 1)$$

has a limit as x approaches 1 from below. From the functional equation $f(x) = x - f(x^2)$ it is clear that if the limit exists, it is equal to $1/2$.

Surprisingly, the limit does not exist. This result first appeared in a paper by Hardy, "On certain oscillating series", *Quarterly J. Math.* **38** (1907), 269–288 (in the sixth volume of Hardy's collected papers, pp. 146–168), where he comments that no completely elementary proof seems to be known. Noam Elkies posed the problem to us — see abel.math.harvard.edu/~elkies/Misc/sol8.html; Tanguy Rivoal brought the reference to Hardy to Elkies' attention. In addition, a number of people wrote us with interesting comments or elaborations on the problem, including Herb Wilf, Neil Calkin, Jon Keating, William Kahan, and others. In particular, Poisson summation can be used to give a very precise understanding of the behavior of $f(x)$ as x approaches 1; e.g., see "Summability of gap series," J. P. Keating and J. B. Reade, *Proc. Edin. Math. Soc.*, **43** (2000), 95–101. In fact, as x goes to 1, the function $f(x)$ oscillates around $1/2$ with an amplitude of approximately 0.00275; an interesting graph to this end can be found on Elkies' web site. In due course, our web page will contain a discussion of some of these, and other, ideas on this problem.

The easiest proof of nonconvergence that we know can be found on Elkies' web page. Since f satisfies the functional equation

$$f(x) = x - x^2 + f(x^4),$$

just finding *one single* $u < 1$ for which $f(u) > 0.5$ shows that the desired limit does not exist, because the values of f at u, $u^{1/4}$, $u^{1/16}$, $u^{1/64}$, ... keep increasing (note that $x - x^2 > 0$). Now, modern numerical engines (or even tedious hand computation) can verify $f(0.995) = 0.50088\ldots > 0.5$. Hardy himself gave similar elementary arguments to show that $x - x^a + x^{a^2} - x^{a^3} + x^{a^4} \pm \cdots$, for integer $a > 2$, has no limit as x approaches 1 from below; his assertion that no such elementary argument seemed feasible for $a = 2$ might have been due to an aversion to calculation.

Complex Hyperplane Arrangements

Michael Falk, Northern Arizona University
Alex Suciu, Northeastern University

We were fortunate to spend the 2004 fall semester in residence at MSRI, participating in the program on Hyperplane Arrangements and Applications. It was an intense, stimulating, productive, enlightening, eventful and most enjoyable experience. It was especially so for us long-timers in the field because the program truly marked a coming-of-age in the evolution of the subject from relative obscurity thirty years ago. We had an opportunity to introduce the wonders of arrangements to a group of graduate students during the two-week MSRI graduate school in Eugene in early August, and to an impressive group of postdocs and many other unsuspecting mathematicians during the program. We are glad to have this chance to bring some of the ideas to a wider audience. For further reference, we suggest the reader consult the books and survey articles listed on the summer school web page, www.math.neu.edu/~suciu/eugene04.html.

In its simplest manifestation, an arrangement is merely a finite collection of lines in the real plane. The complement of the lines consists of a finite number of polygonal regions. Determining the number of regions turns out to be a purely combinatorial problem: one can easily find a recursion for the number of regions, whose solution is given by a formula involving only the number of lines and the numbers of lines through each intersection point. This formula generalizes to collections of hyperplanes in $\mathbb{R}^\ell$, where the recursive formula is satisfied by an evaluation of the characteristic polynomial of the (reverse-ordered) poset of intersections. The study of characteristic polynomials forms the backbone of the combinatorial, and much of the algebraic theory of arrangements, which were featured in the MSRI workshop on Combinatorial Aspects of Hyperplane Arrangements last November.

From the topological standpoint, a richer situation is presented by arrangements of complex hyperplanes, that is, finite collections of hyperplanes in $\mathbb{C}^\ell$ (or in projective space $\mathbb{P}^\ell$). In this case, the complement is connected, and its topology, as reflected in the fundamental group or the cohomology ring for instance, is much more interesting.

The motivation and many of the applications of the topological theory arose initially from the connection with braids. Let $\mathcal{A}_\ell = \{z_i = z_j\}_{1\le i<j\le \ell}$ be the arrangement of diagonal hyperplanes in $\mathbb{C}^\ell$, with complement the configuration space X_ℓ. In 1962, Fox and Neuwirth showed that $\pi_1(X_\ell) = P_\ell$, the pure braid group on ℓ strings, while Neuwirth and Fadell showed that X_ℓ is aspherical. A few years later, as part of his approach to Hilbert's thirteenth problem, Arnol'd computed the cohomology ring $H^*(X_\ell, \mathbb{C})$.

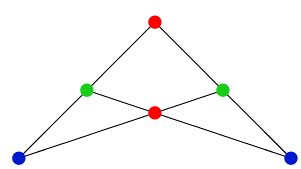
For an arbitrary hyperplane arrangement in $\mathbb{C}^\ell$, the fundamental group of the complement, $G = \pi_1(X)$, can be computed algorithmically, using the braid monodromy associated to a generic projection of a generic slice in $\mathbb{C}^2$. The end result is a finite presentation with generators x_i corresponding to meridians around the n hyperplanes, and commutator relators of the form $x_i\alpha_j(x_i)^{-1}$, where $\alpha_j \in P_n$ are the (pure) braid monodromy generators, acting on the meridians via the Artin representation $P_n \hookrightarrow \mathrm{Aut}(F_n)$.

The cohomology ring $H^*(X, \mathbb{Q})$ was computed by Brieskorn in the early 1970's. His proof shows that X is a formal space, in the sense of Sullivan: the rational homotopy type of X is determined by $H^*(X, \mathbb{Q})$. In particular, all rational Massey products vanish. In 1980, Orlik and Solomon gave a simple combinatorial description of the $\Bbbk$-algebra $H^*(X, \Bbbk)$, for any field $\Bbbk$: it is the quotient $A = E/I$ of the exterior algebra E on classes dual to the meridians, modulo a certain ideal I determined by the intersection poset.

For each $a \in A^1 \cong \Bbbk^n$, the Orlik–Solomon algebra can be turned into a cochain complex (A, a), with i-th term the degree i graded piece of A, and with differential given by multiplication by a. The *resonance varieties* of A are the jumping loci for the cohomology of this cochain complex:

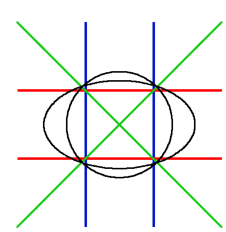
$$R^i_d(A) = \{a \in A^1 \mid \dim_{\Bbbk} H^i(A, a) \ge d\}.$$

The case of a line arrangement in $\mathbb{P}^2$ is already quite fascinating. The subarrangements that contribute components to $R^1_d(A)$ have very special combinatorial and geometric properties. To be eligible, the incidence matrix for the lines and intersection points must have null-space of dimension at least two, with full support. In addition, the subarrangement must have a partition into at least three classes such that no point p is incident with one line of one class, while all other lines incident with p belong to a second class. Such partitions are termed *neighborly*. The simplest nontrivial example is provided by the braid arrangement $\mathcal{A}_3$:



In this figure the points represent hyperplanes and the lines correspond to the points of multiplicity greater than two. This is a diagram of the matroid associated with the arrangement.

When $\Bbbk$ has characteristic zero, the Vinberg classification of generalized Cartan matrices implies an even more exceptional situation. One can assign multiplicities to the lines so that the partition is into classes of equal size d, with the same number of lines from each class containing each "inter-class" intersection point. This partition gives rise to a pencil of degree d curves which interpolates the completely reducible (not necessarily reduced) curves formed by the classes in the partition. The pencil that corresponds to the preceding figure consists of the curves $ax^2 + by^2 + cz^2 = 0$, with $a + b + c = 0$, and looks like this:



The singular fibers are given by $a = 0$, $b = 0$, and $c = 0$. A nonreduced example is provided by the arrangement of symmetry planes of the cube with vertices $(\pm 1, \pm 1, \pm 1)$, with the coordinate hyperplanes having multiplicity two. This multi-arrangement is interpolated by a pencil of quartics. Such pencils often yield (nonlinear) fiberings of the complement by punctured surfaces, showing in particular that the complement is aspherical.

There is also an apparent connection between the cohomology of (A, a) and critical points of certain multi-variate rational functions. A resonant degree-one element a is represented (up to a scalar) by a logarithmic de Rham one-form $d \log \Phi$, where Φ is a product of the defining linear forms of the hyperplanes, raised to integral powers. The dimension of $H^i(A, a)$ is related to the number of components in the critical locus of Φ of codimension i. In particular we expect Φ to have nonisolated critical points when a is "generically resonant." This is known to be the case for certain high-dimensional arrangements with certain weights, and was established for arrangements of rank three during the Fall program. A precise description of this relationship in general is a topic of current study.

In our example of the $\mathcal{A}_3$ arrangement, $d \log \Phi$ is resonant precisely when

$$\Phi(x, y, z) = (x^2 - y^2)^{\alpha}(y^2 - z^2)^{\beta}(z^2 - x^2)^{\gamma},$$

with $\alpha + \beta + \gamma = 0$. The critical set $d\Phi = 0$ is given (projectively) by

$$[x^2 - y^2 : y^2 - z^2 : z^2 - x^2] = [\alpha : \beta : \gamma].$$

It is not a coincidence that these critical loci are curves in the pencil shown in the previous figure.

Through the connection with generalized hypergeometric functions, the critical locus of Φ is of interest in relation to the Bethe Ansatz in mathematical physics. This was a major topic of discussion in the MSRI workshop on Topology of Arrangements and Applications last October. Somewhat serendipitously, the same problem for $\Bbbk = \mathbb{R}$ is of interest to the combinatorialists studying algebraic statistics, who were well-represented in Berkeley last fall.

The *characteristic varieties* of a space X are the jumping loci for the cohomology of X with coefficients in rank 1 local systems:

$$V^i_d(X) = \{\mathbf{t} \in \mathrm{Hom}(\pi_1(X), \mathbb{C}^*) \mid \dim_{\mathbb{C}} H^i(X, \mathbb{C}_{\mathbf{t}}) \geq d\},$$

where $\mathbb{C}_{\mathbf{t}}$ denotes the abelian group $\mathbb{C}$, with $\pi_1(X)$-module structure given by the representation $\mathbf{t} \colon \pi_1(X) \to \mathbb{C}^*$.

Now suppose X is the complement of an arrangement of n hyperplanes. By work of Arapura, the irreducible components of the characteristic varieties of X are algebraic subtori of the character torus $\mathrm{Hom}(\pi_1(X), \mathbb{C}^*) \cong (\mathbb{C}^*)^n$, possibly translated by unitary characters. It turns out that the tangent cone at the origin to $V^i_d(X)$ coincides with the resonance variety $R^i_d(A)$. Consequently, the resonance varieties are unions of linear subspaces; moreover, the algebraic subtori in the characteristic varieties are determined by the intersection lattice. Even so, there exist arrangements for which the characteristic varieties have components that do not pass through the origin; it is an open question whether such components are combinatorially determined.

Counting certain torsion points on the character torus, according to their depth with respect to the stratification by the characteristic varieties, yields information about the homology of finite abelian covers of the complement. This approach gives a practical algorithm for computing the Betti numbers of the Milnor fiber F of a central arrangement in $\mathbb{C}^3$. It has also led to examples of multi-arrangements with torsion in $H_1(F)$. There are no known examples of ordinary arrangements with this property.

The tangent-cone theorem, and the linearity of resonance components, both fail over fields of characteristic $p > 0$. There is evidence that this failure is related to the existence of nonvanishing Massey products over $\mathbb{Z}_p$. In addition, there is an empirical connection between translated components of characteristic varieties over $\mathbb{C}$ and resonance varieties over fields or rings of positive characteristic. The study of resonance varieties in prime characteristic leads naturally to the theory of line complexes and ruled varieties. The counter-example to the linearity question is a singular, irreducible cubic threefold in $\mathbb{P}^4$ ruled by lines, in characteristic three. The underlying arrangement is the Hessian arrangement of 12 lines determined by the inflection points on a general cubic.

As noted by Rybnikov, the fundamental group of the complement, $G = \pi_1(X)$, is not necessarily determined by the intersection poset. Even so, the ranks $\phi_k(G)$ of the successive quotients of the lower central series $\{G_k\}_{k \geq 1}$, where $G_1 = G$ and $G_{k+1} = [G, G_k]$, are combinatorially determined. Indeed, by a classical result of Sullivan, the formality of X implies that the graded Lie algebra $\mathrm{gr}(G) = \bigoplus_{k \geq 1} G_k/G_{k+1}$ is rationally isomorphic to the holonomy Lie algebra $\mathfrak{h}_A$ associated to $A = H^*(X; \mathbb{Q})$. Furthermore, it was recently shown that the Chen Lie algebra, $\mathrm{gr}(G/G'')$, associated to the lower central series of G/G'', is rationally isomorphic to $\mathfrak{h}_A/\mathfrak{h}''_A$, and so the Chen ranks $\theta_k(G)$ are also combinatorially determined.

Much effort has been put in computing explicitly the LCS and Chen ranks of an arrangement group G. It turns out that both can be expressed in terms of the Betti numbers of the linear strands in certain free resolutions (over A or E):

$$\prod_{k=1}^{\infty}(1 - t^k)^{\phi_k(G)} = \sum_{i=0}^{\infty} \dim \mathrm{Tor}^A_i(\mathbb{Q}, \mathbb{Q})_i \, t^i,$$

$$\theta_k(G) = \dim \mathrm{Tor}^E_{k-1}(A, \mathbb{Q})_k, \quad \text{for } k \geq 2.$$

When the arrangement is of fiber-type (equivalently, the intersection lattice is supersolvable), A is a Koszul algebra. The first formula immediately above, together with Koszul duality, yields the classical LCS formula of Kohno and Falk–Randell:

$$\prod_{k=1}^{\infty}(1 - t^k)^{\phi_k(G)} = \mathrm{Hilb}(A, -t).$$

In a survey paper from 2001, one of us (Suciu) made two conjectures, expressing (under some conditions) the LCS and Chen ranks of an arrangement group in terms of the dimensions of the components of the first resonance variety. Write $R^1_1(A) = L_1 \cup \cdots \cup L_q$, with $\dim L_i = d_i$. Then, conjecturally,

$$\prod_{k=2}^{\infty}(1-t^k)^{\phi_k(G)} = \prod_{i=1}^{q} \frac{1-d_i t}{(1-t)^{d_i}}$$

provided $\phi_4(G) = \theta_4(G)$, and

$$\theta_k(G) = (k-1)\sum_{i=1}^{q}\binom{k+d_i-2}{k}$$

for k sufficiently large.

The inequality $\geq$ implicit in this second formula has been proved by Schenck and Suciu. The reverse inequality has a compelling algebro-geometric interpretation in terms of the sheaf on $\mathbb{C}^n$ determined by the linearized Alexander invariant. Equality in both of the formulas just given has been verified in a number of papers for two important classes of arrangements: decomposable arrangements (essentially, those for which all components of $R^1_d(A)$ arise from sub-arrangements of rank two), and graphic arrangements (i.e., sub-arrangements of the braid arrangement).

Many of the results and observations reported on here represent joint work (or work in progress) with our friends and collaborators: Dan Cohen, Graham Denham, Dani Matei, Stefan Papadima, Hal Schenck, Sasha Varchenko, and Sergey Yuzvinsky. Our thanks go to them. In addition, we are grateful to many other unnamed participants in the MSRI program last Fall, for the countless hours spent in helpful and stimulating conversations about arrangements.

News from the International Mathematical Union

The International Mathematical Union publishes a bimonthly electronic newsletter, IMU-Net, which reports not just internal activities but also major international mathematical events and developments, and on other topics of general mathematical interest. To subscribe and also to view past issues, go to http://www.mathunion.org/IMU-Net with your Web browser.

You may also want to visit the Electronic World Directory of Mathematicians, which replaces the paper World Directory of Mathematicians published for many years by the IMU. You are encouraged to register your own home page at http://www.mathunion.org/MPH-EWDM/.

The House that Chern Built

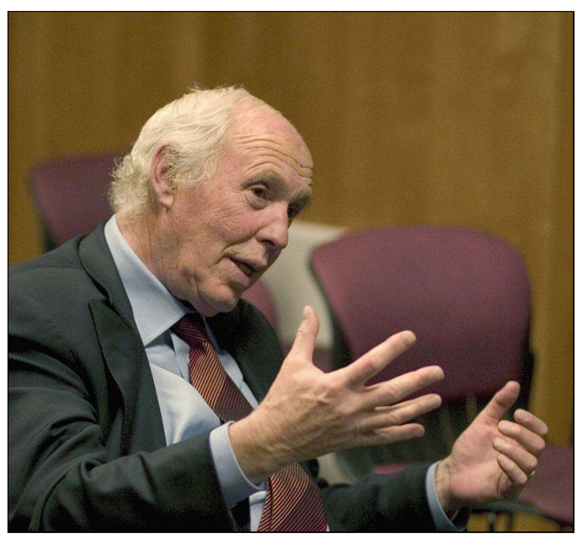
MSRI and UC Berkeley organized a memorial for Shiing-Shen Chern on February 13, 2005, at the University, followed by a reception at MSRI. Among the speakers were MSRI cofounders Isadore M. Singer and Calvin Moore; the Chinese Consul General, Peng Keyu; MSRI Director David Eisenbud and other members of the UCB mathematics department, Robert J. Birgeneau, UCB Chancellor; and Jim Simons and Robert Uomini, whose generosity has greatly benefited MSRI and UCB. Here is the text of Eisenbud's remarks, slightly edited for the Emissary:

Many of us here, many on this platform, can claim it in some figurative sense; but I think that I have the strongest claim to say that I live in "The House that Chern Built": MSRI.

Of course it was one of several houses — research institutes — which Chern founded, in this case with the intense collaboration of Is Singer and Cal Moore. But for American mathematics, its founding was a truly momentous event. The triumvirate headed by Chern beat out more than a dozen university consortia to obtain funding from the NSF around 1980; the first program was in 1982.

The Institute grew phenomenally in those first three years, while Chern was its director. The seed of the National Science Foundation's idea of having an additional math institute came from the model of the Institute for Advanced Study in Princeton, the three founders immediately embraced a bold new model, that of an Institute without permanent faculty, supported by a wide range of US universities, assembling each year an unparalleled strength in a couple of carefully chosen fields of intense mathematical endeavor. As one small measure of its success, MSRI has since proven a model for new institutes in Canada, England, Russia, Singapore, New Zealand... to name a few.

Unlike many of the speakers who will follow me on this platform, I met Chern only rather recently, in 1997. He proved to be warm, modest, and extremely helpful. I was hired as MSRI director with the mandate to raise private money for the Institute — something I had only the vaguest idea how to do! He took me under his wing, and made many introductions. He asked his old friend, Chang-Lin Tien, who was just stepping down as Berkeley Chancellor, to be nice to me and help me out in finding my way in fundraising, and that was very important: Tien joined MSRI's board of trustees, where he served until his tragic stroke.



Sheila Newbery

Jim Simons, a mathematical collaborator of Chern's and the President of Renaissance Technologies, played a key role in making possible the construction of MSRI's new Chern Hall. He spoke at the Chern memorial event and relaxed afterward at the MSRI reception.

Even after Chern could no longer walk he remained lively mathematically, and MSRI held a workshop on his current passion, Finsler geometry, with his close collaborator David Bao. But he also remained active on behalf of mathematics. I'll never forget the audience he organized with Chinese president Jiang Zhemin for me and a number of other visiting mathematicians to support the International Congress of Mathematicians. When the congress took place, with tremendous success, Zhemin came and presented the Fields medals. Imagine trying to get the US president to do something like that! Seeing Chern at the meeting, I asked whether I could have a few minutes of his time for a chat. To my surprise, he cleared lunchtime, and we went together for a long talk to a local restaurant. I treasure the photos from that day and the advice he gave me.

Now, with the generous financial and moral support of Chern himself and many here, including Chern's family, to whom I'm very grateful, the fundraising has been a success and I'm delighted to report that the concrete foundation piers for a greatly enlarged MSRI were poured just last Friday! The new building will bear the most appropriate name: Shiing-Shen Chern Hall. I'm delighted to have had a small hand in this development, but I can say (as no-one else can know so intensely): not only MSRI as we know it would not exist without Chern, but the building project that is now underway would never have been realized without his warm support and enthusiasm.

David Eisenbud

In Memory of Shih-Ning Chern (1915–2000)

Doreen Liang is the niece of Professor S.-S. Chern — her mother is his younger sister. She wrote to tell us a bit about Mrs. Chern, her aunt.

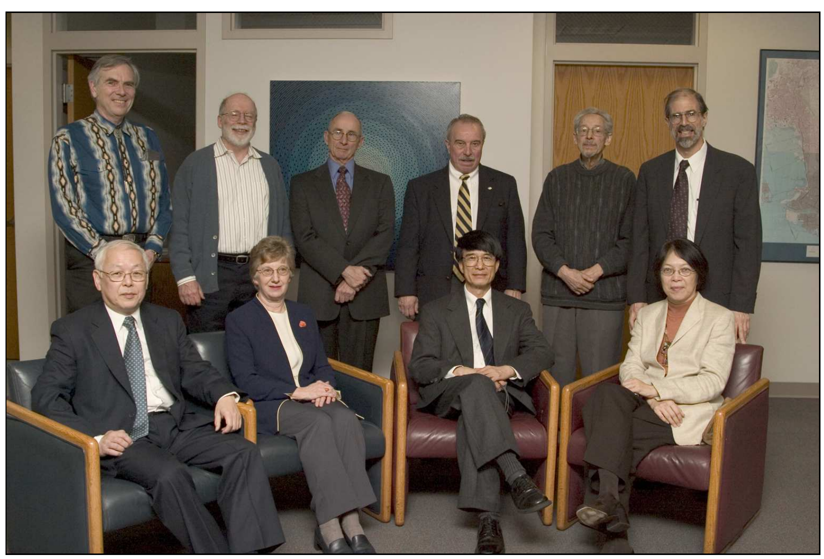
Shih-Ning Chern was the daughter of Professor Tsen Tong-sun of the Department of Mathmatics, Qing-hua University, Beijing, China in the 1930s when my uncle was a student there. Professor Tsen foresaw a brilliant future for the young student and allowed his daughter to marry him.

My aunt majored in biology but gave up her career and many interests to take care of her husband, the household and their two children. Whatever my uncle wanted done, she would be the one responsible for the planning and logistics. For example, if my uncle wanted to entertain colleagues and students, she did the cooking and took good care of everyone. My uncle did not have to spend any time worrying about day-to-day activities, and could devote himself completely to thinking about his math problems.

Both my aunt and uncle had a broad range of interests, but his major interest was math, and she repressed hers for the sake of the family. It was in her later years that she took up pottery, spent more time gardening and allowed herself to follow her own road. But even then, my uncle came first. One time, my aunt wanted to go skiing. My uncle told her that before she left, she had to cook three months' worth of food for him in case she broke her leg. My aunt didn't go skiing.

My aunt gave her husband her complete support during their entire married life. I believe my uncle appreciated very much what his wife had done for him. He named his house in Nankai University in Tianjin "Ning Yuan" (ning-garden). Most people assume that this comes from "ning-jing-zhi-yuan" (attaining profound enlightenment with serenity and tranquility). However, by using my aunt's name Ning my uncle was expressing his love and appreciation.

We all should admire my uncle's achievements, while being aware that many of them would not have happened without the unwavering love and support he had from my aunt.



Sheila Newbery

Sitting: Chern's son Paul, daugher-in-law Susan, son-in-law Paul Chu and daughter May Chu. Standing: Some past and present MSRI directors and deputy directors (Megginson, Kirby, Rossi, Moore, Osserman, Eisenbud).

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