

Leaves from an unwritten diary

S. Chandrasekhar: Reminiscences and reflections*

C. V. Vishveshwara

Summer of 1963. Boulder, Colorado in USA. Set amongst the lofty Rocky Mountains, surrounded by lush green vegetation, with clear blue skies and crisp fresh air, Boulder was just the opposite of dreary New York where I was studying. A graduate student at Columbia University aspiring to become a particle physicist, I was attending one of the famous annual summer schools at the University of Colorado. Lecture notes of that year would be dedicated to Professor George Gamow to commemorate his sixtieth birthday. One of the lecturers was William Fowler whose topic was 'Nuclear and Neutrino Processes in Stars and Supernovae'. Whereas Gamow had done pioneering work on the Big Bang cosmology, Fowler's sympathies were with the steady state universe. The Big Bang scenario is in a way akin to that of the Bible in that both have a moment of creation. Fowler began his lectures with the statement, 'There are rumours that George Gamow wears a halo, while I am a follower of the Anti-Christ. Let me put these rumours to rest once and for all'. And he went on to show a slide of himself being received by the Pope. As it transpired, Fowler was destined to share the Nobel prize after twenty years with one of the other lecturers, namely S. Chandrasekhar.

We had heard a great deal about Chandrasekhar. Yet, an aura of mystery surrounded him. I had come to know about the Chandrasekhar limit through Gamow's books. In his characteristic way, Gamow had drawn the celebrated mass-radius curve of white dwarfs adorned with Indian motifs and with terms written in Tamil! The impression Chandrasekhar made, as we listened to his first lecture, was striking displaying all the characteristics that have been described time and again over the years. Handsome, elegantly dressed in a dark

*Based on a public lecture arranged by the Indian Academy of Sciences on 13 December 1999.

Bust of S. Chandrasekhar

The public lecture by C. V. Vishveshwara was organized on the occasion of the unveiling of a bronze bust of Subrahmanyan Chandrasekhar by Mrs. Lalitha Chandrasekhar at the premises of the Indian Academy of Sciences and at the Raman Research Institute. The sculptor was Paul Granlund of Minneapolis in Minnesota, USA who had earlier made a similar bust of Srinivasa Ramanujan and which Chandrasekhar had presented to the Academy in 1985.



grey suit. Distant, as though making a brief visit from a world of his own. Eloquent with precise articulation and with the faintest hint of a charming lisp. Once in a while words came tumbling as though in competition with thoughts that rushed in faster. His lectures bore the formidable title, 'The higher order virial equations and their applications to the equilibrium and stability of rotating configurations'. It was an unfamiliar topic. But the logical way in which he developed the concepts and the formalism was impressive. It was a pleasure

just watching and listening to him. We were five Indian students in the summer school. Three had come all the way from India. Naturally we wanted to meet the great Indian physicist. Chandrasekhar enquired about where we were from and what we were interested in one by one. When my turn came, I told him that I was studying at Columbia University hopefully to become a particle physicist. 'Particle physics is not the main focus here,' Chandrasekhar pointed out, 'there is a summer school going on at the Brandeis University devoted entirely to the subject. Why didn't you go there?' 'I am attending this summer school,' I blurted out, 'because it is so beautiful around here!' To this day it is not clear to me why I said that. Truthfulness, stupidity, sheer nervousness or whatever. Chandrasekhar gave me one withering look and turned away. Some twenty years later, I recounted our first meeting to Chandra as I had come to call him by then. He looked at me steadily and said 'You see, people often think I get angry easily. I do not get angry'. He gave me the good old withering look, but did not turn away. He smiled. The stern look was probably a reminder as to how serious he was about seriousness. I ought to have been serious about either enjoying the



Limit of mass

Rockies or attending the summer school, not both, which meant neither. The smile was the result of a long-standing association. Over the years, I had come to appreciate his innate warmth and friendship buried beneath his outer shell of reserve. After all, one has to get close to the moon to see the other side. Such a closeness growing gradually over a period of more than three decades becomes part of one's own life. As Lord Tennyson wrote in his *Ulysses*,

I am a part of all that I have met,
 Yet all Experience is an arch
 wherethro'
 Gleams that untravell'd world whose
 margin fades
 Forever and ever, when I move.

Experience and passage of time create a composite image of a place or a person fusing together observation and inference. Such a subjective image of Chandra – all too human side of a profound scientist – is what I would like to present.

The next encounter with Chandra took place at the University of Maryland in College Park. I had moved from Columbia University to work with Charles Misner in the general theory of relativity. This was a total change of interest from particle physics. One day we heard the exciting news that Chandra would be visiting us. We knew that he was getting seriously interested in general relativity. And Maryland was one of the most active centres in the field. Our excitement was further boosted up by the announcement that John Wheeler would be coming down from Princeton to meet Chandra. Wheeler, a towering figure in physics, well known for his work with Niels Bohr, had been going around with missionary zeal drumming up in-

terest in gravitational collapse and the ultimate fate of a massive star. He was yet to coin the name 'Black Hole' for this bizarre end product of stellar evolution. Wheeler drove down from Princeton accompanied by three of his graduate students who have over the years distinguished themselves in relativity – Uri Gerlach, Robert Geroch and Kip Thorne. I vividly remember Chandra sitting at the head of the long seminar table, Misner on his right and Wheeler on his left, and all of us students gathered round trying to catch every word that was exchanged. And were they exchanged! Words, facts, concepts, ideas ranging over a wide variety of areas – stars, mass limits, collapse, end points and so on. I have often wondered why this event seemed to be of such overwhelming importance. It was more than a meeting of giants. It was a symbol of the union between two disciplines, namely astrophysics on the one hand and general relativity on the other that would eventually open up new vistas in astrophysics and cosmology. At the end of the day, Lester Edelstein, another student of Misner, and I presented to Chandra, with some hesitation, the set of equations governing the perturbations of the Schwarzschild black hole which we had recently derived. Chandra accepted them with many thanks assuring us that he would be interested in them sometime in the future. Little did we realize that eventually perturbations of black holes were to become a passion with him. For the moment, however, he was just knee deep in the water, preparing himself to dive to the depths of the ocean. Still a novice, not yet the maestro.

It was as a recent entrant to the field that he appeared at the historic summer school in general relativity that was held in Cornell University, Ithaca, in the year 1965. The names of the participants of that school read like an honour list in general relativity. The lecturers included Freeman Dyson, Jurgen Ehlers, Charles Misner, Roger Penrose, Ivor Robinson, Engelbert Schucking, Joseph Weber and so on. Roy Kerr was there. He had discovered his exact solution, but its full importance to black hole physics was yet to be established. Among the student

participants were Brandon Carter and Stephen Hawking. Hawking's wife Jane cooked for them and invited me to join them. But, I was too bashful to accept her invitation.

Chandra gave lectures on post-Newtonian approximation in general relativity. He attended all lectures by the others assiduously. Sometimes Lalitha, whom I met for the first time, appeared to be taking notes. If Chandra was undecided about the importance of a seminar, he would listen for a few minutes standing at the back accompanied constantly by a graduate student who was also dressed in a formal grey suit. If the seminar was interesting, Chandra would sit down. Otherwise, he would signal to the student by cocking his head like a gangster in a Hollywood movie and off they would go to do their own calculations.

In those days Ithaca was a sleepy little campus town. The downtown area close to the university was not the vibrant haunt of the students as it is today. There was a theatre specializing in horror movies with bizarre advertisements like, 'Blood, blood, blood! Frankenstein spills it, Dracula drinks it'. The only American restaurant around was too expensive for us students. However, there was an inexpensive Chinese restaurant which we frequented. On one occasion, while some of us were having a boisterous lunch, I walked Chandra and Lalitha as a hush fell over our group. They did not see us and took the alcove next to ours. A brave member of our group even peeped over the divider to get a periscopic view of the famous couple. We were extremely curious to know what kind of special vegetarian Chinese food they would order. Perhaps they knew some exotic dishes we were ignorant of. As we strained our ears to catch their words, they ordered tossed green salad and cottage cheese with green tea! What a disappointment.

The frugal vegetarian diet of the Chandrasekhars has become quite well known. On one of my visits to Chicago, I was invited to lunch at their home. After a long chat about black holes, science, and science education, Chandra took me home in his car. 'It is a short distance to drive. I am *not* go-

ing to wear the seat belt,' explained Chandra looking at me defiantly, 'of course, feel free to wear your seat belt if you wish'. Their home was impeccable. White walls, white upholstery, white carpets – all white except for the three of us. Chandra's study was disgracefully tidy for a theoretician. On the desk was a neatly stacked sheaf of bond paper with a black, old-fashioned pen placed across it and a single book of reference next to it. In the corner was Chandra's proud possession, the bust of Ramanujan. Chandra asked me to sign the visitors' book. I thumbed through it and put it down. It looked like an international who-is-who. Some of the names there were incredibly famous. I did not want to be a who-is-not-who in it. I flatly refused to sign it. 'Why not?,' queried Chandra, a bit puzzled. 'To be among those guys will give me an incurable inferiority complex,' I explained. He laughed and added seriously, 'You are our honoured guest just like all our visitors. There is no difference. Please sign it'. I had to sign the book again on my next visit.

As for the lunch, I was wondering whether it would be a South Indian meal. Lalitha had once told me, while a beaming Chandra listened, how good he was at making dosais. He ought to be, I had remarked, being an expert on rotating fluids. After all, a dosai is an extreme example of a spheroid. Chandra sat down with an immense stack of bread slices and a toaster. 'I shall toast as many slices as you like,' he promised 'and you can have all the tea you want'. 'We have a treat today', chimed in Lalitha, 'fig jam. Chandra's favourite'. She served the main course. Tossed green salad with cottage cheese! I remembered Cornell with nostalgia. Not that they did not enjoy a good, normal meal. Kameshwar Wali lists pongal as one of the favourite dishes from Madras liked by Chandra in his Cambridge days. An affinity shared with Ramanujan. According to the reminiscence of Smt. Janaki Ammal, wife of Ramanujan, 'He (Ramanujan) did not know cooking while he was in India. As he had to eat in England by cooking himself, he started cooking. His favourite item in cooking was pongal

(boiled green gram and rice). Mr. Kas-turi Ranga Iyengar of *The Hindu* who had been once to England told me that he on one occasion and an English lady on another occasion found his pongal tasty'. I do not know about pongal. But, I have watched Chandra enjoy a full meal of several courses, all vegetarian of course. On one occasion, he had a second helping of rasagullas for dessert. Probably they reminded him of white dwarfs.

Coming back to the chronological order of events, I joined New York University in 1969 to work with Engelbert Schucking, the eminent relativist and cosmologist. One of the memorable events that occurred during my tenure at the New York University was Chandra's visit to the physics department. Chandra gave a beautiful talk on rotating fluids. It was a consummately orchestrated presentation of historical background followed by his own contributions.

We discussed the work I had done on scattering of gravitational radiation by black holes, in particular what came to be known as the quasinormal modes. In the evening Engelbert gave a party. At that time Engelbert lived in the East Village, which was known for its Bohemian life style as well as for a non-negligible crime rate. As the party was getting underway, the bell rang and Engelbert opened the door. In rushed an excited young couple. Behind them stood two burly gentlemen. Engelbert invited them in, waving his arms expansively in a gesture of welcome. To Engelbert's great disappointment, instead of accepting his invitation, the two men took to their heels. These two gentlemen happened to be muggers who had been chasing the young couple! Engelbert's apartment was predominantly furnished with crates retrieved from supermarkets and topped with cushions to sit on. Normally I occupied orange crates, leaving the apple crates to senior people. Chandra, dressed in a crisp grey suit as always, did not sit down and left early so as not to miss his customary bedtime. The party went on till the early hours in the morning.

Around five or so, Engelbert was awakened from his deep, tired slumber

by the ringing of the telephone. It was Chandra calling. There was no hot water in his hotel and he could not shave. The pipes had frozen and it would be at least a couple of hours before he could have running hot water. This delay in shaving would throw Chandra's schedule into unthinkable confusion, hamper his calculations and ruin his day. So Engelbert had to arrange with Larry Spruch, another professor who lived close to Chandra's hotel, to have hot water fetched to Chandra so that he could shave in time.

After New York, I spent four more years in the United States, two each at Boston University and the University of Pittsburgh. During this period I met Chandra thrice: when he visited Boston to lecture at Harvard, when I visited Chicago to participate in the symposium in celebration of Chandra's sixty-fifth birthday and finally when he visited Pittsburgh. Our discussions, when we met or on the phone, focussed on two topics, black hole perturbations and Indian science.

Chandra was well into black hole physics by now concentrating on the perturbations of the non-rotating Schwarzschild black hole. The rotating Kerr black hole was to follow later. He had started to give talks on his work in this area as he did at Pittsburgh. One day I got an unexpected telephone call from a rather excited Chandra. He wanted to discuss the scattering of waves from black holes. There are two types of gravitational waves of odd and even parity or axial and polar as Chandra called them. Their behaviour is governed by a Schroedinger-like equation with potentials that look quite different. This is even more pronounced in the case of neutrinos of opposite helicities. Now, Chandra asked me whether I had noticed anything peculiar about the scattering by these non-similar potentials. Yes, I said, in both cases – gravitational waves and neutrinos, scattering was identical for the two potentials. Did I know the reason for this? No, I did not. 'I have discovered the reason!' announced Chandra triumphantly. He asked me to send him my results and in return he sent me his calculations which very clearly ex-

plained this intriguing phenomenon. It was typical of Chandra to be quite excited whenever he discovered something new.

At this time I was seriously considering the possibility of returning to India for good. Chandra supported such a move strongly. We discussed research pursued and the environment at different places in India. Chandra offered to write to those places that would be conducive to my work, which he did. All this in the end paved the way for my return to my homeland.

During the years between 1976 and 1993, I met Chandra several times whenever he visited India, whenever I visited the United States or when we met at general relativity conferences. On these occasions, we discussed a variety of topics including science in all its aspects – science in relation to other disciplines, science administration, Indian science, science popularization and, of course, our research.

Chandra kept himself informed of what was happening in Indian science and was surprisingly well aware of the political scene – science politics that is. Although he was totally uninvolved in all this, he was ready to deal with administrators in order to help the deserving. Cases such as that of Smt. Janaki Ammal, wife of Ramanujan, may be well known. But there are many other obscure cases in which Chandra went out of his way to meet heads of institutions to make his recommendations. His efforts were not always rewarded nor were they universally appreciated. At least in one instance when he tried to recommend a scientist for promotion that was long overdue, he was told in no unequivocal terms that as a foreigner, he had no idea of how the Indian science machinery worked and was asked not to interfere. This hurt Chandra deeply. All the same, he did not stop helping others.

Chandra was a theoretician of the highest order whose world centered around research. I had imagined that in his estimation only research counted most. It was exhilarating to discover that this was not at all true. During an informal discussion, one of our colleagues remarked that he failed to understand how Homi Bhabha could have given up research in order to

build up institutions. Surprisingly enough, Chandra reacted very sharply to this. Science, he said, could be served in many ways. All of them are important and one should choose the path best suited to one's ability and according to what is most needed. He gave the example of Hermann Bondi. Bondi, who had made outstanding contributions to relativity and cosmology, relinquished active research to become the scientific advisor to the British government. When asked how he could do such a thing, apparently he had replied, 'Ah, nobody understands. You see, if I work ten times harder, I could do something like what Roger Penrose does. But why should I? Roger does it so easily. But, Roger is incapable of bringing a single pound to science, whereas I can bring millions. Roger should do research and I should bring money'. Later on, I asked Bondi about this and he said, 'Yes, yes, yes. Nobody understood'. Chandra gave another example, that of James Jeans who devoted much of his time to science popularization after a distinguished career in research. Chandra was quite emphatic in his view that scientists must convey to the public the work they did. It was their duty to do so especially if they had the gift of communication. As a matter of fact he was very encouraging to the journal some of us ran called *The Bulletin of Sciences* that was devoted to science and society. He read the articles with interest. It was not at all surprising, then, that Chandra was quite happy to spend a morning at the newly established Jawaharlal Nehru Planetarium in Bangalore.

A proud possession of the Planetarium is its visitors' book signed by many distinguished visitors who have paid very handsome compliments. The first entry is by Chandra dated December 11, 1989 with the remark 'A happy experience'. It is followed by Lalitha's comment, 'Very striking program'. Undoubtedly Chandra was happy about his visit, which started off in a rather strange manner. We wanted some good photographs to commemorate the occasion. Uday Jadugar, who was going to take the photographs had made some elaborate arrangements. Chandra was quite obliging. But, when

he was asked to strike a thinking pose, he said with a wooden expression, inclining his head by a millimeter, 'This is how I think'. Again, when he was asked to smile, his expression became even more serious as he replied, 'I never smile'. Jadugar, who is also a professional magician, would not give up. He took out a coin, made it disappear at Lalitha's left ear and made it reappear at Chandra's right ear. I looked on helplessly preparing myself for the impending explosion. But Chandra was unperturbed. I think he was enjoying this novel experience. Only at the end of this bizarre photographic session, did he permit himself a smile and thank the photographer who promptly materialized a rose from thin air and presented it to Chandra.

I have no doubt that Chandra enjoyed the sky theatre programme. He seemed to be quite moved by the passages from the Upanishads as well as by the one that depicts the loneliness of a man in a

A rose from nowhere



vast universe. He paid me one of the best compliments I have received. 'It is beautiful,' he said, 'I cannot understand how someone whose occupation is to compute Riemann tensor can also produce something like this'. He liked the music too. 'There is no question that one of the strongest of our memories of India was its music,' Lalitha has written. I think that Chandra liked music in every form not just a concert by a celebrity. When I introduced to him my late brother C. V. Nagaraj, an accomplished violinist, Chandra asked him to play some music and listened with pleasure. The two most wonderful photographs of Chandra I have seen are those with children that have been reproduced in his biography. Maybe he was a Lewis Carroll at heart – shy and reserved with adults, but comfortable with children. Agnes Herzberg describes what a hit he was with the children at the Yerkes observatory and how, dressed in black on Halloween nights, he used to chase the 'observatory brats'. Our daughters Smitha and Namitha, aged eleven and six respectively, sent Chandra a card made specially for his seventy-fifth birthday. It shows in cartoon form the red giant, the white dwarf and the black hole. Lalitha told us that this was the best birthday card Chandra had received. Chandra enjoyed humour and liked cartoons. He used to ask me to



Red Giant, White Dwarf and Black Hole



Limits of Science



Music, one of the strongest memories of India



Among children

show him the ones I had drawn. Gujjar, who has caricatured several scientists, drew one of Chandra for the Inter-University Centre for Astronomy and Astrophysics, Pune.

Chandra might have been playful with children. But, on the other hand, if a child wanted to discuss science he would be dead serious treating the child like any other adult. When Chandra asked our daughter Smitha, fifteen years old at the time, what she was doing at school, she started describing her science project. It was based on the book *Limits of Science* by Peter Medawar. It is a scholarly book that examines complex ideas such as self-limitation, cognitive and logical limits, and so on, ultimately touching upon the concept of God. Chandra started the discussion with the preliminary remark, 'These are big people with big words. I am a small man. Maybe my ideas are small. But, let me tell them anyway. One thing though.

Let us keep God out of it'. Then he went on to enumerate different types of limits encountered by science. Limit due to lack of information at any given moment in time. Newton could have arrived at the periodic table, had he been in possession of the information that was available to Mendelyeev. On the other hand, nature may impose limitations on the availability of information as in the case of horizons or as in the case of uncertainty principle. What about limits to human intelligence? If Newton had all the information Einstein possessed, would he have arrived at the general theory of relativity? And finally, how about the possible absolute limit inherent to the human intellect? Is it possible that the mind can never go beyond a certain point? God only knows, I would have interjected. But He had been outlawed. In his later years, Chandra had openly admitted to being an atheist which also meant that he subscribed to no religion in the customary sense of the word. Perhaps his religion was that of Christopher Marlowe who wrote,

I count religion but a childish toy,
And hold there is no sin but
ignorance.

Let us move back to the year nineteen eighty-three, the nineteenth of October in particular. I had gone out for a haircut in the evening. A haircut is a profound existential symbol. To quote Samuel Hoffenstein, perhaps with some negligible approximation,

Newborn babes have no hair
Old men's heads are just as bare
Between the cradle and the grave
Life is a haircut and a shave.

On my return, I was greeted with the glorious news that Chandra had been awarded the Nobel Prize. Soon I received a call from a representative of the Press Trust of India. He wanted to know my reaction to this event. I asked him why me? Because I was one of those who knew Chandrasekhar well. Fair enough. I told him how overjoyed I was like all my colleagues. Especially so since Chandrasekhar had been working on black holes which happened to be a subject of particular in-

terest to me. Then came the final question. 'Sir, how are you related to him?' I was taken aback to say the least. The logic underlying this inference must have run as follows. My initials were C.V., the same as those of C. V. Raman. And I worked at the Raman Research Institute. Therefore I must be related to Raman. Chandra was Raman's nephew. *Ipsa facto*, I was related to Chandra. I said, 'Look, we are relativists, not relatives'. 'But, Sir,' he protested, 'our head office told me that you two are related'. I told him politely that I should know better than his head office whether I was related to Chandrasekhar or not. If they wanted my reaction as his relative he could forget the whole conversation. 'No, Sir,' he answered me, 'we are very much interested in your remarks'. They were taking no chances. Next day, on the front pages of newspapers appeared a boxed item recording the reactions of two chosen ones: Prime Minister Indira Gandhi felt proud and C. V. Vishveshwara was happy! Chandra had a big laugh when I recounted this episode to him. This was a comic relief to what he thought was a sombre affair. As is well known, he had his own reservations regarding the award made in recognition of his work of fifty years earlier.

Chandra had this persistent, nagging feeling that people were predominantly interested in his earlier work and not so much in what he was doing at the moment. Once he had finished with one area, that was it. He moved on to another. He did not keep in touch with the subjects that had interested him in the past. He was scheduled to deliver a public lecture which involved explaining how the stars shine. A couple of hours before the talk his aversion to speaking about his work in the past hit him with depressing intensity. Like a rebellious child he started remonstrating, 'Why should I give this talk? I am not interested in why stars shine. I am interested in black holes. They don't shine, do they? Give me one good reason why I should give this talk'. Quietly I answered, 'I shall give you two hundred reasons'. Chandra seemed confused. 'There will be two hundred students in that lecture hall,' I continued 'who

else, but you, should tell them why the stars shine?' He gave me a brooding, pensive look and said 'You are right'. The talk, needless to add, was fabulous.

In some ways, Chandra's work on black holes formed the epitome of his scientific career. A career that was an arduous but enlightening journey through fertile fields, mountains and vales. I can only describe this relentless venture by borrowing from different poets. Chandra's quest finds expression in the words of Christopher Marlowe:

Still climbing after knowledge
infinite,
And always moving as the restless
spheres,
Wills us to wear ourselves and
never
rest.

It seems Chandra once said, according to Robert Sachs, that his motivation for research 'has always been systematization based on scholarship'. His exploration of black holes perfectly fulfilled such a motivation. A great deal of scholarship was needed in mastering a new field considered to be quite difficult involving concepts, techniques and approaches alien to other branches of physics. It was an active field with many younger researchers who had produced important results and were still continuing to do so. While systematizing all this and gaining insights into partially explored grey areas, Chandra seemed depressed whenever he felt that some people did not attach enough importance to his work. But he continued, in all probability, with the conviction of finally attaining the desired goal of consummate understanding of this magnificent edifice. But the passage, for the moment at least, must have been difficult. To quote T. S. Eliot,

To arrive where you are, to get from
where you are not,
You must go by a way wherein there
is no ecstasy.

As I have already mentioned, there had been a great deal of information gathered on black holes and more be-

ing derived when Chandra entered the field. To systematize all this required enormous effort. It is said that if all the equations Chandra had derived in his lifetime were to be written end to end, they would reach the moon. One wonders what would have happened had he been named after the sun rather than the moon. Chandra revelled in deriving equations, manipulating and analysing them, squeezing out in the process every drop of the underlying physics. But all this he had to do on his own, preferably in his own way. There were no short cuts. As Antonio Machado wrote in Spanish,

*Caminante, no hay camino
Se hace Camino al andar*

Traveller, there is no path,
Paths are made by walking.

By taking his own path, Chandra picked up what others, following their own courses, might have missed. And as he walked his lonely way and reached his own goal, he looked upon the gorgeous valley below and the lofty summit above, perhaps as others had seen as well, but from a different angle, from a different view point.

Once upon a time, when Chandra had arrived at the startling but inevitable conclusion that there was a limit to the mass of white dwarfs, he had written,

'A star of large mass cannot pass into the white dwarf stage and one is left speculating on other possibilities.'

The long speculation was over. A star of large mass ended its lifecycle as a black hole, the simplest, and therefore the most beautiful, entity in nature. The culmination of the long journey had revealed the significance of the starting point. Again, to quote Eliot,

We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first
time.

In 1989 I had the rare opportunity to interview Chandra at the invitation from the Indian Institute of Astrophysics. We covered a variety of topics many of which we had discussed

over the years. Profundity of general relativity, the structural unity of black holes and colliding waves, *Principia*, significance of new theories and so on. All through the interview, Chandra seemed to be in a distant world of contemplation. One dominant theme was what he had pursued with passion, the quest for beauty. He said 'What man perceives as beautiful in his mind, he finds it in nature'. He was lost virtually in a reverie oblivious of his surroundings as he kept repeating to himself, 'It is a miracle. It is a miracle'.

I met Chandra again in 1993 at his brother Balakrishnan's house where he was staying on a private visit. We sat in the verandah watching the little garden. It was late afternoon, bright sunlight playing upon the flowers. As the day wore on, light faded and shadows lengthened. Chandra asked me to move closer to him so he could hear better. He looked tired. But, as usual, he asked me in detail about my research. Then he went on to discuss a composite picture of what he had done in recent years. He was satisfied that his work on *Principia* was progressing well. Then came Indian science – research institutions, universities. A short pause. He looked up with a tinge of melancholy and said, 'You know the worst thing one could do to science? Use it for self promotion.... It is sad that people think I cannot see what is happening. For instance...'. His voice trailed off as he closed his eyes. 'Another time, perhaps...' he added in a whisper. Depression seemed to be coming on. It was time to change the subject. I started talking about science education, the need to communicate science in the proper manner, creating opportunities for the young, conveying the excitement of new developments through interaction with practising scientists. Chandra opened his eyes. He was alert now. 'When you were a student, you met Sommerfeld,' I said, 'wasn't that an important occasion?' According to Kameshwar Wali, Chandra described this meeting as 'the

single most important' event in his early life which launched him on a research career. Chandra sat up. His keen, piercing eyes were sparkling now. He said with emphasis, 'Yes, indeed'. He kept nodding as I continued. 'But how many students could have the good fortune of meeting someone like Sommerfeld? And how many would be prepared, as you were, to make use of such an opportunity? Yet, if we create the proper atmosphere and facilities, some motivated children may grow into good scientists, even great ones. Maybe, we will have another Chandra, who knows'. He looked at me wistfully, apparently moved, and asked, 'Are you going to do that?' 'I would like to try,' I replied. 'If you do that,' Chandra said, 'I should like to come and see it'.

It was dusk now. Chandra seemed exhausted. I was reminded of Shelley's lines written to the Moon:

Art thou pale for weariness
Of climbing heaven and gazing on
the
earth,
Wandering companionless
Among the stars of alien birth.

No doubt he had climbed heaven. Not only had he gazed on the earth, often he had to come down to it. He was blessed with the best of companions in his personal life. Yet, in his quest for beauty and truth, he had wandered in loneliness often among those of alien birth who did not understand him.

We stood up and shook hands. There was so much we had not talked about. There was a heaviness of unspoken words, unexpressed thoughts, unshared feelings. Chandra walked me to the gate and stood outside. Before turning the corner at the end of the road, I looked back. He was still there. I waved to him and he waved back. There is so much to talk about, I thought. 'Next time, Chandra, next

time,' I kept repeating to myself. But, there was to be no next time.

Chandra has been described in many ways: a giant among scientists, a hero of science, the supreme aesthete, and a legend in his own lifetime. No doubt he was all these. But to a few of us, more than anything else, he will always be a living presence.

I am deeply indebted to Prof. N. Kumar, President of the Academy, for inviting me to give the public lecture on 13 December 1999.

The following books have been used in writing this article:

W. E. Brittin and W. R. Chapel (eds), *Lectures in Theoretical Physics*, University of Colorado Press, 1964.

K. C. Wali, *Chandra: A Biography*, University of Chicago Press, 1991.

K. C. Wali (ed.), *S. Chandrasekhar – The Man Behind the Legend*, Imperial College Press, 1997.

The following articles in the above book have been referred to:

K. C. Wali, Introduction

Lalitha Chandrasekhar, 'My Everlasting Flame'

Agnes M. Herzberg, 'S. Chandrasekhar, The Friend: Some Reminiscences'

Robert G. Sachs, 'Reminiscences About Chandra'

P. K. Srinivasan (ed.), *Ramanujan – Letters and Reminiscences*, Muthialpet High School, Madras, 1968, vol. 1.

Peter Medawar, *The Limits of Science*, Oxford University Press, 1985.

Christopher Marlowe has been quoted from A. L. Rowse, *William Shakespeare*, Harper and Row, 1963.

T. S. Eliot, *Four Quartets*, Aurora Publishers, 1970.

Antonio Machado has been quoted from Alan Mackay, *The Harvest of a Quiet Eye*, The Institute of Physics, 1977.

It is a pleasure to thank Ms G. K. Rajeshwari, Sri Pramod G. Galgali and Sri H. R. Madhusudan for their valuable help in the preparation of this article.

C. V. Vishveshwara is in the Indian Institute of Astrophysics, Bangalore 560 034, India.

Edited and published by Prof. P. Balaram and Prof. S. Ramaseshan, Current Science Association, Bangalore 560 080.
Typeset by WINTECS Typesetters (Ph: 3327 311), Bangalore 560 021, Printed at Printek Printers, Bangalore (Ph: 3357 763)