Tracking the legend of Chandra

Chandra: A biography of S. Chandrasekhar. Kameshwar C. Wali. Chicago University Press. 1990. $29.95. Published in India by Viking (Penguin India), 1991, Rs 250

Chandra is a legend in his own times, he is one of the colossal figures of twentieth-century science. Few can match his sustained productivity for over sixty years. His achievements have a permanence in their character, and in his intense scholarship he has been compared with Lord Rayleigh and Henri Poincaré. As a mathematical physicist he has been acclaimed as one of the greatest of all times.

The scientific community has eagerly looked forward to this biography of Subrahmanyan Chandrasekhar, and they will not find it wanting in any respect. This is not intended to be a scientific biography of Chandra. The depth and range of Chandra's contributions are so staggering that the only person who can write a scientific biography about him is Chandra himself! And, in a sense, he has, by selecting from his own research papers a collection for a six-volume series recently published by the University of Chicago. Instead, Wali has attempted to track the legend of Chandra. He traces Chandra's family background, his encounter with Sommerfeld and Heisenberg when he was still a student in Presidency College, Madras, his friendship with K. S. Krishnan, his voyage to Cambridge, the year spent at Niels Bohr's institute in Copenhagen, the great controversy with Eddington, his decision to settle in America, and his triumphs and disappointments. It is indeed a moving story, most eloquently narrated. To supplement and enrich this remarkable story, Wali has included excerpts from his extensive conversations with Chandra—indeed, in many ways, this epilogue is the climax of the book! Chandra is a rare scientist, even among the great ones. It is therefore a privilege, and a sobering experience, to listen to the master himself about his attitude to science.

It is customary, while reviewing a book, to paraphrase its contents. But I shall not attempt to do this. Instead, given the diverse interests of the readership of this journal, I propose to highlight the extraordinary characteristics of Chandra that Wali has so successfully brought out in this deeply sensitive, insightful and magnificently written biography—his attitude and values in science, his quest for beauty, his interaction with young scientists, and his motivation for dedicating his entire life to science.

The quest for perspectives

There is a secret society whose activities transcend all limits in space and time, and Dr Chandrasekhar is one of its members. It is the ideal community of geniuses who weave and compose the fabric of our culture.

– Jost

The most distinctive characteristic of Chandra's scientific work is his attitude towards science in general. 'There have been seven periods in my life', says Chandra. 'They are, briefly: (i) Stellar structure, including the theory of white dwarfs (1929–39); (ii) Stellar dynamics, including the theory of Brownian motion (1939–43); (iii) The theory of radiative transfer, the theory of illumination and the polarization of the sunlit sky, the theories of planetary and stellar atmospheres, and the quantum theory of the negative ion of hydrogen (1943–50); (iv) Hydrodynamic and hydromagnetic stability (1952–61); (v) The equilibrium and the stability of ellipsoidal figures of equilibrium (1961–68); (vi) The general theory of relativity and relativistic astrophysics (1962–71); and (vii) The mathematical theory of black holes (1971–83).' In each of these phases, in addition to publishing a series of papers in which major problems are solved, he has written monumental treatises in which each subject is presented from a unified perspective, which is his own. About this attitude of striving to understand things in his own way, within his own framework, Chandra has written:

After the early preparatory years my work has followed a certain pattern motivated, principally, by quest after perspectives. In practice, this quest has consisted of my choosing (after trials and tribulations) a certain area which appears amenable to cultivation and compatible with my taste, abilities, and temperament. And when after some years of study I feel that I have accumulated sufficient body of knowledge and achieved a view of my own, I have the urge to present my point of view *ab initio* in a coherent account with order, form and structure.

A couple of examples may illustrate this attitude. After completing his classic book *Introduction to the Study of Stellar Structure* (with which he concluded the stellar-structure phase of his research), he turned his attention to the motion of stars in the galaxy. Unlike other astronomers who were worrying about specific problems, Chandra approached stellar dynamics as a discipline in itself bringing forth and trying to solve its own theoretical problems. Thus he was able to formulate 'certain abstract problems which appear to have an interest for general dynamical theory even apart from the practical context in which they arise.' This style of approaching the subject as a whole has always had the effect of unifying the field and making transparent connection between the problem under study and other seemingly unconnected areas in physics. After the publication of *Principles of Stellar Dynamics* he devoted the next four or five years to the problem of specifying the radiation field in an atmosphere. Although this problem originated in Lord Rayleigh's investigations in 1871, the formulation of the fundamental equations and their solutions had to wait till Chandra turned his attention to it in the early forties. Approaching the problem of radiative transfer as a branch of mathematical physics he developed novel techniques to generalize and exploit certain principles of invariance that had been formulated by the Armenian astrophysicist Ambartsumian. Recently a new branch of mathematics known as 'Invariant Embedding' has blossomed, inspired largely by Chandra's book on *Radiative Transfer*. During the sixties he turned to the classical problem of the stability of rotating liquid masses, and this phase culminated in a monumental book entitled *Ellipsoidal Figures of Equilibrium*. He begins this book with a historical introduction of the problem, which had attracted the attention of past masters like Riemann, Dedekind, Jacobi, Maclaurin and others. In the epilogue of the book he writes: 'But the

Chandrasekhar in his twenties

Chandrasekhar in his forties

subject, nevertheless, had been left in an incomplete state with many gaps and omissions and some plain errors and misconceptions. It seemed a pity that it should be allowed to remain in that destitute state. Whether the effort expended in its rehabilitation was worth the time the author cannot presume to judge'. As Wali has eloquently put it: 'Chandra's works have an architectural quality to them—he is simply not putting a nail here, a window there. Others may have contributed a great deal to its shape and dimension but the whole structure is put together in an uncannily durable and inspired way, which is his own'. Those who have made great discoveries and experienced a moment of glorious insight into some of nature's secrets often want to experience it again and again. To hack away at something less important, less fundamental than the previous discovery, appears demeaning to them. As Wali says, for Chandra there is no such deliberate homage to past glorious moments and momentous discoveries. Attaining complete understanding of an area, grasping and internalizing it is the essence of Chandra's scientific life. 'If one's motivations are not galvanized to pursue science for its own sake', then, according to Chandra, 'one's scientific life has not matured properly.' In his memorial address given in Westminster Abbey, J. J. Thomson said of Lord Rayleigh: 'There are some great men of science whose charm consists in having said the first word on a subject, in having introduced some new ideas which have proved fruitful; there are others whose charm consists, perhaps, in having said the last word on the subject and who have reduced the subject to logical consistency and clearness'. Like Rayleigh, Chandra belongs to the second group.

Chandra's writings have become legendary not only for their thoroughness, lucidity and scholarship but also because they have a distinctive style. Commenting on Maxwell's papers on the dynamic theory of gases Boltzmann writes, 'Even as a musician can recognize his Mozart, Beethoven or Schubert after hearing the first few bars, so can a mathematician recognize his Cauchy, Gauss, Jacobi, Helmholtz or Kirchhoff after the first few pages...' Similarly a paper by Chandra is instantly recognizable through its distinctive style. John Sykes once mimicked the style of Chandra's papers in an amusing parody **S. Candlestickmaker, On the Imperturbability of elevator operators, LVII** (see pages 56 and 57). This spoof is reproduced in the anthology compiled by R. Weber, entitled *A Random Walk in Science.*

Elegance and love for and attention to language play as important a role as scientific facts and weaving them into mathematical formulae. 'He has an incomparable style' says Weisskopf. 'Good English style is a lost art in physics but he has it and this wonderful feeling for the essential and a feeling for beauty.' In the same vein, Lyman Spitzer says: 'It is a rewarding aesthetic experience to listen to Chandra's lectures and study the development of theoretical structures at his hands. The pleasure I get is the same as I get when I go to an art gallery and admire paintings.' Chandra practises style in a very deliberate way: 'I acquired my style from not only just reading, for instance, the essays of T. S. Eliot, Virginia Woolf and Henry James but also paying attention to how they write – how they construct sentences and divide them into paragraphs, do they make them short or long? For example, the idea of just using one sentence for a paragraph, or a concluding sentence without subject or object, just a few words...so it is....'

His deep interest in literature and classical music comes through in a transparent manner in his lectures and writings. To quote Weisskopf again: 'Right from the beginning, but even more later on, he became sort of the most pure example of the ideal scholar in physics...nothing of vanity, nothing of pushiness, nothing of job seeking, publicity seeking, or even recognition seeking.... His deep education, his humanistic kind of approach to these problems, his knowledge of world literature, and in particular English literature, are outstanding. I mean you'd hardly find another physicist or astronomer who is so deeply civilized.' He cultivates his interest in literature and music with the same discipline and intensity as in science—he dislikes a 'frivolous' attitude to anything! For example, about five or six years ago, Chandra and wife Lalitha decided to spend a month in Europe and 'do something serious'; they had managed to get tickets to see the entire *Ring Cycle* of Richard Wagner in Bayreuth. Characteristically, to prepare themselves for this 'event', they studied several biographies of Wagner, and systematically listened to as many recordings of the operas as possible!

The quest for beauty

The simple is the seal of the true. And beauty is the splendour of truth.

An important aspect of Chandra's science is his quest for beauty in science. One may ask as to what extent the quest for beauty is an aim in the pursuit of science. Chandra very seldom explicitly states his own answers to such questions, but one may infer his views through his illustrations and examples of what other great scientists have responded to as 'beautiful'. For example, in a memorable lecture devoted to this question, he quotes G. N. Watson's reactions to one of Ramanujan's incredible identities, '...such a formula gives me a thrill which is indistinguishable from the thrill which I feel when I enter the Sagrestia Nuova of Capelle Medicee and see before me the austere beauty of

'Day', 'Night', 'Evening' and 'Dawn' which Michelangelo has set over the tombs of Giuliano de Medici and Lorenzo de Medici.'

He once asked me what I thought was the most profound discovery from antiquity till today. Not being satisfied (disappointed?) with my answer he told me what Heisenberg thought was one of the truly momentous discoveries in the history of mankind: this was the discovery by Pythagoras that vibrating strings, under equal tension, sound together harmoniously if their lengths are in simple numerical ratios; in this discovery, for the first time, profound connection between the intelligible and the beautiful was made.

Those who have studied his papers, and heard his lectures, will know that his concept of beauty in science is based on the following two criteria:

> *There is no excellent beauty that hath not some strangeness in the proportion!*
> *– Francis Bacon*

> *Beauty is the proper conformity of the parts to one another and to the whole.*
> *– Heisenberg*

Chandra has remarked that the experience of beauty in science is not limited to the context of great ideas by great minds.

> This is no more true than the joys of creativity are restricted to a fortunate few. They are, indeed, accessible to each one of us provided we are attuned to the perspective of strangeness in the proportion and the conformity of the parts to one another and to the whole. And there is satisfaction also to be gained from harmoniously organizing the domain of science with order, pattern and coherence...

In Kip Thorne's words: 'Chandra's research mode is... trying to make the mathematics fit into patterns... mathematics in the sense of symmetry properties of the equations he is working with, algebraic relations between various terms in these equations, and where the equations had come from.... you get the feeling that he knows he has the answer when the ultimate mathematical formula is simple, when everything has fallen into place in a nice, simple, coherent mathematical fold.' When he achieves this, his joy comes through in his writings. For example, after a long and extremely complicated analysis of the Kerr black hole, he writes, ... the analysis has led us into a realm of the rococo: splendorous, joyful, and immensely ornate.'

© SRINIVASAN

Chandrasekhar with Murray Gell-Mann and Valentine Telegdi

Chandra and his students

Along with research, teaching is an integral part of Chandra's life. In 1937 he left Cambridge and joined the University of Chicago, where he has been ever since. (Why he chose to stay there when there were offers from numerous other places is chronicled by Wali.) Soon after that he set up a series of 18 courses for graduate students and taught most of them himself! He prepares his classroom lectures with the same thoroughness, and they are delivered in a masterful way; every step and every argument will be written on the board in his beautiful handwriting. He does not, however, tolerate simple or trivial questions because he expects the students to have studied the material thoroughly. In 1965 I was one of the students attending his course on statistical mechanics and on the first day someone asked a question to which Chandra gave the answer, 'Please read some elementary books before the next lecture.' He is a stickler for time and would finish a lecture after precisely 60 minutes. He seldom gave examinations, but expected the students to attend all his lectures.

The following story may be of interest in this context: In 1967 there was a severe blizzard in Chicago and the whole city came to a grinding halt for five days; the University of Chicago had also declared holidays. On the first day, I was walking around on the campus taking photographs when I accidentally ran into Chandra wading through waist-deep snow towards Ryerson Hall. He suddenly asked me, 'Aren't you coming to my lecture?' (He was teaching an advanced course on general relativity.) I had no option but to say, 'Yes, of course.' Although there were only three of us in the class that day (instead of the usual 40 or 50) he proceeded to give the lecture. A few days later I asked him why he did not cancel his lecture; after all, the university was closed. In reply, he narrated the following episode: In the mid-forties he was teaching a course on statistical mechanics and he used to drive 75 miles from Yerkes Observatory to the university campus to deliver the lectures. One day there was a severe blizzard and he could not drive. This meant a complicated procedure of taking several trains, and walking the last two kilometres in deep snow. He was very proud that despite all these obstacles he arrived five minutes before the scheduled time. And there were only two students in the class! Then he looked at me with a twinkle in his eyes and said, 'Do you know, my entire class got the Nobel prize?!' He then went on to admonish me: The great composer Handel was visiting Germany from England and was giving a recital in the neighbourhood where Johann Sebastian Bach lived. Bach came to know of this and walked more than ten miles to attend this recital. But he was too late; by the time he reached the venue Handel had left. Chandra then said to me: 'I am not Handel, but you are not Bach either! Why are you complaining?'

More than 50 students have worked with Chandra for the PhD degree. He considers his collaboration with young scientists an essential part of his scientific style, and much more important than his collaboration with giants like Enrico Fermi and John von Neumann. Needless to say, he expected his students to be as dedicated and to work as hard as himself. Not surprisingly, this led to a process of 'natural selection'. His students found it stimulating to work with Chandra. As one of his distinguished students Nutku says: 'Chandra would transmit an enthusiasm, an enthusiasm not in the ordinary sense that we will go and solve this or that difficult problem but regarding how, in the end, after painstaking and lengthy calculations things would fall into place. Miraculous cancellations would occur and simple results would emerge.'

It is equally true that Chandra found it very inspiring to work with young people. This was particularly true after he got into general relativity. He once said:

I consider myself very fortunate in having made up my mind to do relativity. Among other things, for the first time, certainly after the early forties, I felt I was working in an area in which many others were far more equipped than I was. I thought I had a chance of having a close scientific proximity with people of the highest calibre. Certainly, to have known well and consider among my friends people like Roger Penrose, Stephen Hawking and Brandon Carter, Kip Thorne, James Bardeen—it is a marvellous experience, it is a kind of intellectual stimulation which I had not had before. Of course, I worked with Fermi. Fermi was a very great physicist, but here I am now in a community of young brilliant men. Even though in age I am very much older than these people it has always been a satisfaction to me that these people treat me as their equal.

When Lord Rayleigh was 67 years old his son asked him to comment on the remark 'a man of science past sixty does more harm than good' by Huxley. Rayleigh's response was, 'That may be, if he undertakes to criticize the work of younger men, but I do not see why it need be so if he sticks to the things he is conversant with.' Chandra was nearly 60 years old when he entered relativity. As mentioned above he chose to do that so that he could be in the company of brilliant young men. He felt 'once more rejuvenated, once again with young people tremendously bright, tremendously exciting'. Within a few years, as one has come to expect of him, he had made a number of fundamental contributions to the field, particularly in the mathematical theory of black holes. Chandra has said that this was the hardest project he has worked on, and the one that gave him the greatest satisfaction. His book on this subject, published in 1983, became an instant classic. Reviewing this book Penrose (who, according to Chandra, is at the 'pinnacle') said: 'There is no doubt in my mind that this book is a masterpiece. It is... clearly intended to last a long time. It will.'

Nobel prize in physics

The announcement of the 1983 Nobel prize in physics for Chandra was greeted with great joy and appreciation throughout the scientific world. Astonishingly this award came 50 years after his fundamental discovery of the limiting mass of white dwarfs. But, instead of being overjoyed, Chandra was uneasy about the award, not only because of the public attention that a Nobel prize attracts, but also because he finds it 'a distortion of my life!' This seemingly strange reaction is not difficult to understand for those who have known Chandra well. It is not that he has always disliked prizes and awards. For example, in his early years, he aspired for election to the Royal Society and for the Royal Astronomical Society gold medal. But after that there was no scientific recognition that he 'wanted or wished or thought about'. When the Nobel prize finally came in 1983 Chandra was happy that this most prestigious prize came after all the other prizes and awards. Otherwise, he says: 'My story would have been like that of a certain general in the army who attended a dinner with rows and rows of pins and medals on his well-starched uniform. When a lady at the table asked him, in awe and admiration, what all those honours stood for, the general pointed to the top medal and said: "Dear lady, this one, this top one, was awarded to me by mistake. The others followed as a domino effect."' As an illustration of this he once told me the following story: In 1962 he was awarded the Srinivasa Ramanujan medal by the Indian National Science Academy. Whereas the citation listed all the medals he had won till then, there was no mention of why he was being awarded the Ramanujan medal! Needless to say, Chandra was deeply disappointed. In a more serious vein, Chandra's attitude to receiving the Nobel prize in 1983 is succinctly expressed in the following quotation from a speech given in April 1984:

While an occasion such as this one is personally very gratifying, I must confess to some misgivings as to the appropriateness of selecting for special honour those who have received recognition of a particular kind by their contemporaries. I am perhaps oversensitive to this issue, since I have always remembered what a close friend of earlier years, Prof. Edward Arthur Milne, once said: On an occasion, now more than 50 years ago, Milne reminded me that posterity, in time, will give us all our true measure and assign to each of us our due and humble place; and in the end it is the judgement of posterity that really matters. And he further added: He really succeeds who perseveres according to his lights, unaffected by fortune, good or bad. And it is well to remember that there is in general no correlation between the judgement of posterity and the judgement of contemporaries.

I hope you will forgive me if I allow myself a personal reflection. During the seventies, I experienced two major heart episodes. Suppose that one of them had proved fatal, as it well might have. Then there would have been no cause for celebration. But I hope that the judgement by posterity of my efforts in science would not have been diminished on that account. Conversely, I hope that it would not be enhanced on account of a doctor's skills.

A lonely wanderer in the byways of science

Why did Chandra choose this style of functioning? Many have speculated that his controversy with Eddington in the thirties may have been the turning point. In 1930, when he was only 19 years old, Chandra proceeded to work out a complete theory of white dwarfs along the lines suggested by Fowler. During the long voyage to England in July 1930 he realized that in the interior of white dwarfs the densities would be so high that special-relativistic corrections to the degenerate equation of state were essential. He derived such an equation of state, and, using it in conjunction with the theory of polytropic gas spheres, discovered that the model led to a unique value of the mass

Chandrasekhar (79) lecturing at the Raman Research Institute, Bangalore

of the star, unlike in the case of the non-relativistic equation of state where the finite equilibrium configuration existed for all masses. Given the chemical composition of the star, this mass was determined solely by a combination of fundamental constants — a truly remarkable result! During the first couple of years in Cambridge he pursued these investigations and interpreted this unique value of the mass as representing the upper limit of the mass of an ideal white dwarf (now known as the 'Chandrasekhar limit'). In another remarkably prescient paper published in 1932, he showed that degeneracy cannot set in if the radiation pressure is more than 9.2% of the total pressure. Using the highly successful standard model of Eddington he translated this into a critical mass above which degeneracy cannot set in. Such stars, he concluded, cannot end up as white dwarfs, and an appeal to Fermi–Dirac statistics to avoid the central singularity cannot be made. The far-reaching consequence of these conclusions became generally accepted by the astronomical community only several decades later. But Sir Arthur Stanley Eddington, the most distinguished astronomer of that time, instantly realized the full implications of Chandra's fundamental discoveries. However, instead of publicly acclaiming them, he chose to denounce them. Chandra was dumbfounded, shocked and depressed. He sought the opinion of Bohr, Rosenfeld, Pauli, Dirac and other great physicists. Rosenfeld felt that Eddington's arguments were 'the wildest nonsense', Pauli's response was 'Eddington did not understand physics', Dirac assured Chandra that his treatment of the problem was flawless. But Eddington was unmoved by the physicists arguments. Till he died in 1944, Eddington never lost an opportunity to ridicule Chandra's fundamental discoveries. Chandra was faced with a dilemma. Should he continue with his researches on white dwarfs or leave the field altogether? 'To be involved in a major controversy with the most distinguished figure in astronomy and to have his work completely and totally discredited by the astronomical community was a very discouraging experience for young Chandra who was only in his mid-twenties at that time. He decided to leave the field, and never looked back. This little-known episode, which was to change the course of his life, is discussed in great detail by Wali. There is a feeling among many that Eddington's tirade against Chandra was derived from personal motives. But Chandra insists: 'You may attribute it to an elitist, an aristocratic view of science and the whole world. Eddington was so utterly confident of his views that as far as he was concerned he was a Gulliver in a land of Lilliputs.' Eddington had become a victim of his 'cocksureness'. Astonishingly this serious controversy did not affect their close friendship. As Wali says, Chandra retains the highest admiration for Eddington's extraordinary scientific achievements, his charm and wit, and his great influence in many fields of human endeavour. The letters that Chandra wrote to his father during that period bear testimony to this. Chandra was deeply moved when Trinity College requested him to give the Eddington centenary lectures in 1982.

Chandra burst into the international scientific scene at the young age of 18. By the time he was 21 he had made two fundamental discoveries. Had Eddington acclaimed his discoveries the Nobel prize may have come fifty years earlier. Wali wonders whether, with such success when so young, with the burden of fame and recognition to bear, Chandra might not have been pressured into a more standard pattern of being in the frontiers of science and striving after flashy discoveries, instead of pursuing his quest for personal perfection and satisfaction, beauty and completeness, in his seemingly hermetic endeavours. He concludes that one might attribute the origin of Chandra's distinctive pattern of work to the early traumatic controversy with Eddington. Whether his conjecture is right or wrong, the world of science has been immensely enriched by this 'lonely wanderer in the byways of science'.

G. SRINIVASAN

Raman Research Institute
Bangalore 560 080

Donna Elbert—The real Canna Helpit

Donna Elbert provides one singular instance of the dedication Chandrasekhar can inspire. Donna's father owned a local barber shop and when she was nine years old she saw Lalitha and Chandra on the streets of William Bay. After school she wanted to find a job and save money to join a dress-design school. And so when Chandra needed a secretarial and computational assistant, she applied for it and got it. Donna mastered Chandra's working methods and the special nuances in his manuscripts. Then with his encouragement she took advanced courses in mathematics and calculus. In fact, Chandra drove her to Madison (about 100 miles away) to register her for a summer course at the University of Wisconsin. Donna was able to assist Chandra in his numerical work; she matched him in patience, strength and tenacity and did some of his most complicated numerical work, completing numerical details which otherwise would have been left alone. 'The fact that she was there and could do such work meant that I could carry on the work until it was aesthetically complete' said Chandra.

Martin Goldberger said '(Chandra) has a woman assistant by the name Donna Elbert, I used to accuse Chandra of chaining her into a closet and making her carry out his horrendous computations. I also accused him of inventing her as a name and that he actually did all the calculations himself'.

The present writer had the previlege to meet Donna Elbert in flesh and blood in 1954 when he visited Candlestickmaker in William Bay.

Lalitha Chandrasekhar

When Prof. Chandrasekhar lectured at the Indian Institute of Science, the Faculty Hall, which normally holds 275 persons, was chockful with almost 550 occupants. The then director of the institute after welcoming Chandrasekhar turned to Lalitha and said, 'A special welcome to you as an alumnus of this institute. You were a student in the physics department working with C. V. Raman. When this astrophysicist like a knight errant came and whisked you away to a far off land some said you forsook physics. No, madam,'you did not. By being with your husband, looking after him and indeed inspiring him, your services to physics are much beyond measure.

At that time it was not known that Chandrasekhar himself had dedicated to Lalitha, his unpublished 'scientific autobiography—1943–1983' in the following words. 'The full measure of my indebtedness cannot be recorded: it is too deep and too all pervasive. Let me then record simply that Lalitha has been my motivating force and strength of my life. Her support has been constant, unwavering, and sustained. It has been my mainstay during times of stress and discouragement. She has shared my life: and selfless devoted, and ever-patient and waiting. And so I dedicate this autobiography which is indeed my life to her'.

Current Science in Wali's biography

In the biography Wali quotes Chandrasekhar: 'In 1971 on my visit to Ahmedabad I found K. R. Ramanathan (an early associate of Raman who was working in Raman's laboratory in 1928 when the effect was discovered*) was in possession of Krishnan's diary. In an article that Ramanathan had prepared for *Current Science* devoted to Raman (Raman had died a few days earlier) he had quoted extensively from Krishnan's dairy. The published version of Ramanathan's article contains none of it. The editor had excised it and I know that to be the case since the editor himself confirmed it I got a copy of the diary made and deposited it in the Royal Society Archives because I thought there should be some record of it'.

When the Golden Jubilee of the Raman Effect was to be celebrated it was suggested that an exhibition related to Raman be put together. The person who was in charge (later to be an editor of *Current Science*) had heard the above story from Chandrasekhar and so he got the full version of K. S. Krishnan's diary and exhibited it for all Indian and foreign delegates to see. It does give the exciting account of the day-to-day happenings during that historic period It also clearly refutes that it was Meghnad Saha who explained the Raman Effect as arising from the Kramers–Heisenberg dispersion theory In fact the entry on 7 February 1928 (three weeks before the formal discovery) says, at 9 p.m. Professor Raman was very much excited and he had come to tell me that what we had observed this morning was the Kramers–Heisenberg effect we had been looking for all these days So we agreed to call the effect 'modified scattering'.

S Ramaseshan
Editor

*K R Ramanathan was not in Calcutta when the Raman Effect was discovered He came there a few months later