

# The Legacy of S Chandrasekhar

Remembering a Giant of Our Times

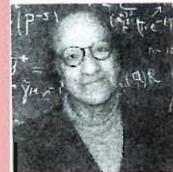
*Kameshwar C Wali*

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

Res Jost

The twentieth century has witnessed many outstanding scientists who have revolutionized our understanding of Nature. Chandra is certainly one of the foremost among them. With his prolific contributions to wide ranging fields in physics, astrophysics and applied mathematics, he became and continues to be a legendary figure. He has undoubtedly left behind a rich legacy of scientific accomplishments. While there have been scientists whose discoveries have had greater impact and names that have become more illustrious, Chandra stands alone in a broader perspective of a life devoted to science. It is from this broader perspective that I want to reflect upon Chandra's life in this article. What makes him so special when it comes to his style of research, is his attitude to and single-minded pursuit of science. I will not speak about Chandra's science that extends over such a wide and varied landscape that is almost impossible to describe in a short article like this one. I refer the reader to the six volumes (and one more to come) of *Selected Papers*, published by the University of Chicago.

Any account about Chandra brings to mind the celebrated discovery of the *Chandrasekhar Limit*, the limit on the mass of a star that could become a white dwarf. In 1930, Chandra was only nineteen years old when he made this discovery on his maiden voyage to England to pursue his graduate studies in Cambridge.



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In those days white dwarf stage was considered to be the only terminal stage for stars in the course of their evolution. Chandra's discovery raised fundamental questions: What is the fate of more massive stars whose masses were greater than the limiting mass ( $\sim 1.44$  solar mass)? Are there other terminal stages? "Great progress in the analysis of stellar structure," Chandra wrote, "is not possible before we can answer the following fundamental question: Given an enclosure containing electrons and atomic nuclei (total charge zero), what happens if we go on compressing the material indefinitely?" After years of hard work and establishing his preliminary finding of 1930 on a rigorous basis, when Chandra presented his results at the January 1935 meeting of the Royal Astronomical Society, he encountered a totally unexpected confrontation with his senior and mentor, Sir Arthur Stanley Eddington. Eddington made it look like Chandra had gotten it all wrong. A conceptual error! The manner in which Eddington cavalierly dismissed the whole idea of a limiting mass amounted to public humiliation. Eddington's prestige and authority prevailed and it took over two decades before *Chandrasekhar limit* entered the standard lexicon of astronomy and astrophysics. It pioneered the way to the discovery of other terminal stages, namely, neutron stars and black holes.

I have described in some detail the irony, the drama and its aftermath of this historical event in my biography of Chandra (*Chandra: A Biography of S Chandrasekhar*, University of Chicago Press, Chicago 1991). What is remarkable is how Chandra handled the situation. Instead of confronting, Chandra withdrew himself from further work related to white dwarf studies. He wrapped up his findings in a monograph, his first book titled, *An Introduction to the Study of Stellar Structure* (1939), and went on to work in another area. "After all I was in my middle twenties at that time," Chandra reflected in my conversations with him. "I foresaw for myself some thirty to forty years of scientific work, and I simply did not think it was productive to constantly harp on something which was done. It was much better for me to change the field of interest and go into



something else. If I was right, then it would be known as right. For myself, I was positive that a fact of such clear significance for evolution of the stars would in time be established or disproved. I didn't see that I had the need to stay there, so I just left it." After a few years of work in stellar dynamics and radiative transfer, he wrote the book *Principles of Stellar Dynamics* in 1943 and published the monograph *Radiative Transfer* in 1950.

Thus began Chandra's distinctive style of research and the pattern continued throughout his life. It is to his credit that instead of being destroyed by the traumatic event, he became inward bound, seeking mastery of a certain area and a personal perspective. This is best described in his own words, in the autobiographical account published along with his Nobel lecture in 1983:

After the early preparatory years, my scientific work has followed a certain pattern motivated, principally, by a quest after perspectives. In practice, this quest has consisted in my choosing (after some 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 a 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 quest for perspectives and a striving for as complete an understanding of a subject as humanly possible became Chandra's dominating motives. The relative importance or unimportance of the subject, how others perceived it, whether it was likely to strike a breakthrough and bring fame and recognition, were never the guiding factors in his research endeavours. A particular area would occupy him for a five to ten year period in which, as Marvin Goldberger once said, "he

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would produce an infinite series of papers followed by an infinitely thick book on the subject.” Once he was satisfied with the perspective gained in a particular area, he would leave it entirely, and was even reluctant to maintain a passing interest in it. He passed on from one area to another with a complete sense of detachment and absence of emotion. To leave behind the hard work and the single-minded intensity invested in a particular area for a number of years did not trouble him in the least, since he was ready to start fresh in another new area. If necessary, he would attend classes, go to conferences and take notes like a student.

He found that his constant contact with younger scientists was enormously exhilarating. It allowed him to constantly rejuvenate himself and escape the most common fate of many great scientists who become victims of their own success and depart from the path of creativity by succumbing to positions of power, leadership in national and international committees and so on or their desire to relive the past. Those who were fortunate to have made great discoveries and experience the moment of glorious insight into some of nature’s secrets often want to experience it again and again. They find it demeaning to engage in something less important, less fundamental than their previous discovery. For Chandra, there was no such homage to past achievements. For him, the essence of scientific creativity consisted in constant, sustained effort. No holy grail, but a personal vision, perspective, and a complete mastery of a certain area were the only satisfactory motivating factors. He was at his happiest moments when problems took on their own momentum and one problem generated another. He felt compelled, as though obligated to solve them. In this respect he was like an artist with an irresistible, internal urge to express himself.

Chandra’s books and monographs have all become classics that evoke a feeling of respect and wonder. They leave an indelible impression of their enduring value in spite of the continual progress in fields he has touched upon and numerous later texts



and monographs. They teach the innate values of science, the continuity, the interdependence, and the necessity of combining original research with scholarship. Furthermore, in addition to their thoroughness, lucidity, and accuracy, Chandra's books and monographs have a highly personal, distinctive style he deliberately cultivated. "I practice style in a deliberate way," Chandra said. "I acquired my style from not only just reading, for instance, the essays of T S Eliot, Virginia Woolf, and Henry James, but also by 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 of a concluding sentence without subject or object, just a few words ... 'so it is' ... or some small phrase like that. I deliberately follow such devices. In fact there is one technique I started following when I was writing my book *Radiative Transfer*, and I have followed it since; that is, as you know, in music you repeat periodically the same phrase in exactly the same form. Very often in my books, when I have a key idea, and I have to restate it at a later stage, I don't leave it to chance. I go back and copy exactly what I had written before.' It is extremely rare in scientific literature to find such care for elegance and love for literary style.

Thus Chandra, with his extraordinary success in his scientific endeavours, combined an equally extraordinary personality characterized by an intensity and fervor for completeness, elegance, and above all, gaining a personal, aesthetic perspective in his scientific work. For him, science was not only a way of making discoveries, but a way of life. Just as his theories and his equations demanded a strong adherence to the description of Nature, his life demanded discipline, integrity, perseverance, and objectivity. He practiced all these to near perfection. It would be wrong to think of him as purely a scientist. He was intensely humane with deep and abiding interests in music, arts and literature. His Ryerson lecture, *Shakespeare, Newton and Beethoven* and his book, *Truth and Beauty* are well-known

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## Suggested Reading

- ◆ Kameshwar C Wali. *Chandra – A Biography of S Chandrasekhar*. The University of Chicago Press, USA, 1991.
- ◆ G Venkataraman. *Chandrasekhar and his Limit*. Universities Press Limited, 1992.
- ◆ R Nityananda. Subrahmanyam Chandrasekhar. *Curr. Sci.* Vol.69. No.6. pp554-556. September, 1995. (An obituary notice)
- ◆ G Srinivasan. *Curr. Sci.* Vol.70. No.1. pp.95-101. January, 1996. (A profile of Chandrasekhar)
- ◆ G Srinivasan. Subrahmanyam Chandrasekhar. *J. Astrophys. Astron.* Vol. 17. Nos. 3 & 4. pp. i-vii. December 1996. (A special issue in which S Chandrasekhar's contributions and later developments are covered by experts.)

examples of the bridge he built between what C P Snow calls the Two Cultures, the cultures of sciences and humanities. Furthermore, he did not spare himself from service to the community when required. During the second world war, he joined the war effort and became a part of an outstanding group of scientists that included John von Neumann, Ronald Gurney, Joseph Myer, L H Thomas, Martin Schwarzschild, Edwin Hubble, Robert G Sachs, and many others. And as the sole editor of the *Astrophysical Journal* for nearly twenty years, he was chiefly responsible for making it the foremost journal of its kind in the world.

Although Chandra lived most of his life abroad, India was always on his mind. He concerned himself deeply with India's problems. In recent years he had strong association with institutions and many young scientists in India. He had a life-long interest in Ramanujan, his ideal and a role model for a life dedicated to science. Chandra was instrumental in many ways in perpetuating the memory of the tormented genius that Ramanujan was. He helped in founding the Ramanujan Institute of Mathematics in Madras in the late 1940s, and when it faced imminent death due to financial difficulty, Chandra, with the help of Jawaharlal Nehru, made sure of its survival. Along with Andre Weil, he served as advisor to the Madras Government for the management of the Institute. He also helped to secure an increased pension for Ramanujan's widow who was living in poverty till then. Finally, Chandra and his wife Lalitha, with the help of Richard Askey, brought into being the busts of Ramanujan cast by Paul Granlund. These busts now occupy prominent places in India, England and America. To end this brief article, I consider myself extremely fortunate to have had the opportunity to get to know Chandra and Lalitha as well as I did and write about his extraordinary life. The years I spent with him were certainly the most enjoyable years in my life. He left behind a rich legacy of warmth and affection, and a fountain of inspiration for striving and living the life of the mind.

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