Achievements in Retrospect

Chandra. A Biography of S. Chandrasekhar. KAMESHWAR C. WALI. University of Chicago Press, Chicago, 1991. x, 342 pp. + plates. $29.95.

This life of the great astrophysicist Subramanyan Chandrasekhar is worth reading for the light it throws both on Chandra personally and on the development of theoretical astrophysics in our time. Not all scientists—even great ones—have the privilege of being the subject of a biography during their lifetimes. Chandra has this privilege because his countryman K. C. Wali, a physicist at Syracuse University, has written this compact and lively book.

Chandra was born in Lahore, India, in 1910. As a Brahman, the grandson of a dedicated scholar, and the nephew of the Nobel Prize–winning physicist C. V. Raman, Chandra had a head start in becoming a scientist. He was educated at home up to age 11 and entered college at age 15, already obviously highly accomplished in mathematics. At that time, education in India was sought as a means to enter government service, a route to a secure life in an otherwise economically deprived country. Chandra's father looked at education in these terms and throughout his life urged Chandra to accept a government job teaching in India. This proved to be a source of friction when Chandra later committed himself to life as a research scientist, since for Chandra this meant working in the West.

In 1930 Chandra won a scholarship to Cambridge University to study with the physicist Ralph Fowler. Having earlier met the great Arnold Sommerfeld in India and having read about Fermi-Dirac statistics and their application to white dwarf stars, he ended up working with Edward Milne of Oxford University, who, like him, was interested in stellar structure. In addition, he attended lectures by Eddington and Dirac. Recognized as an exceptionally able mathematician, he was also interested in theoretical physics. On the advice of Dirac, he spent six months in Copenhagen at Bohr's institute in 1932–33, working on a problem in quantum statistics suggested by Dirac. Chandra was very happy in Copenhagen, but he ultimately left theoretical physics to return to astrophysical problems.

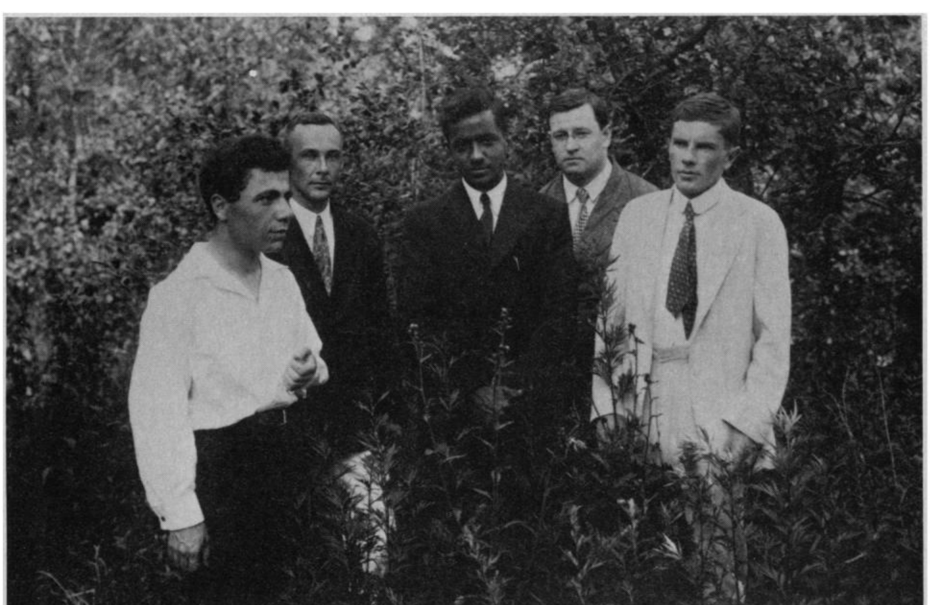
During his first voyage to England in 1930 Chandra had made the discovery that led to his Nobel Prize 53 years later. Earlier he had worked out models of white dwarf stars using the recently discovered electron degeneracy pressure predicted by Fermi-Dirac statistics. On the ship he realized that for large stellar masses the electrons in the core of a star would be relativistic, so that the pressure would be calculably less than that of nonrelativistic electrons of the same density. Because of this there could not be any equilibrium configurations whatever for stars whose masses are greater than a value now known as the Chandrasekhar limit (about 1.4 solar masses for stars of standard composition).

This conclusion did not sit well with Eddington. In a talk at a 1935 meeting of the Royal Astronomical Society at which Chandra was present, Eddington, who had previously encouraged Chandra in his work, without warning attacked Chandra's conclusion, declaring that the underlying physics was incorrect because it would lead to unacceptable astronomical results. Although no others found any flaw in Chandra's reasoning, Eddington persisted in this view until his death, never losing an opportunity to discredit Chandra's result. Perhaps because of this opposition by one of the world's best-known astrophysicists, the correctness and importance of Chandra's discovery were not publicly recognized until 1974, when he was awarded the Heineman Prize for it.

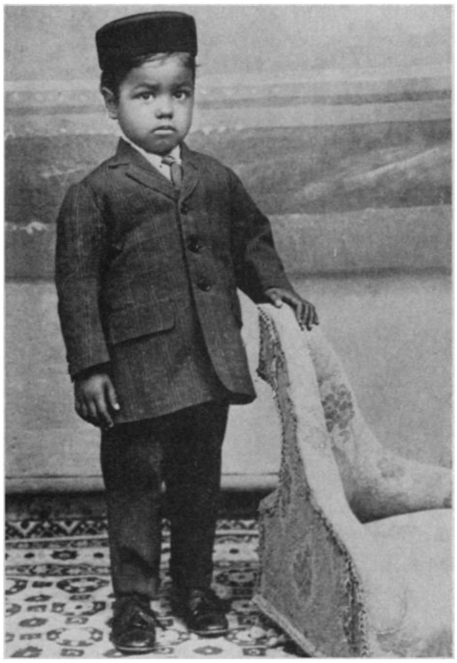
Eddington's hostility toward the Chandrasekhar limit may have impeded the development of our understanding of stellar evolution. Had Eddington instead accepted Chandra's result and thought about its implications, he might have been the one, rather than Oppenheimer and his collaborators, to realize that black holes are the end points of evolution for massive stars, and Chandra might have taken up the theory of black holes far earlier than he did. Relativistic astrophysics as we now know it might have become an important subfield long before the 1960s.

Chandra pursued research overseas for three years after obtaining the doctorate, incurring the wrath of his father for not returning to India. In 1936 he married "for love," contrary to the tradition of taking as a wife someone chosen by the family. His wife, Lalitha, like Chandra, came from a well-educated family and was studying physics. Her aunt, Sister Subbalakshmi Iyer, was famous for the school that she had founded for young widows like herself, who had traditionally been ostracized by Indian society.

In 1937 Chandra came to the University of Chicago, where he has been ever since. There he had a transforming effect on the astronomy department and more generally



From a meeting at the Pulkovo Observatory in Leningrad, 1934. Left to right: Viktor A. Ambartsumian, Nikolai Kozyrev, Chandrasekhar, Evgenii Ya. Perepelkin, and Dmitri I. Eropkin. [From *Chandra: A Biography of S. Chandrasekhar*]



S. Chandrasekhar at age six, 1916. [From *Chandra: A Biography of S. Chandrasekhar*]

on astrophysics in America. His scientific energy was prodigious. With Gerard Kuiper he set up 18 courses for the graduate students and proceeded to teach most of them himself. He took up one field of mathematical astrophysics after another, solving outstanding problems in a series of papers and in due course summarizing the field in one of seven authoritative monographs. An elegant lecturer himself, he presided over 1000 colloquia. He served as editor of the *Astrophysical Journal* from 1952 until 1971, maintaining conspicuously high standards. In the meantime he found time to supervise the Ph.D. research of over 50 students, many of whom have gone on to illustrious careers. Few if any of his peers have equaled his contribution to science.

The book closes with a section entitled Conversations with Chandra. After reading the facts of his life, it is most interesting to read Chandra's own views of it. Most surprising are those toward the end, where he says, "I have a feeling of disappointment because the hope for contentment and a peaceful outlook on life as a result of pursuing a goal has remained unfulfilled." He goes on to speak of the distortion and one-sidedness of his life, his loneliness, and his inability to escape from it all. He wonders whether he was justified in imposing that type of life on his wife. Generalizing from his own experience, he says, "It does not seem to me that the pursuit of science results in the feeling of contentment or peace after years of pursuit."

As a person who counts Chandra one of his heroes, I am disquieted that he has not found peace of mind, and I find myself wondering why. Could it have been the humiliation by Eddington early on his career? the reproaches of his father? or, more generally, his decision not to return to India? We may never know, but I admire Chandra for raising the question whether complete dedication to science leads to happiness.

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Cosmologists Queried

Origins. The Lives and Worlds of Modern Cosmologists. Alan Lightman and Roberta Brawer. Harvard University Press, Cambridge, MA, 1990. xii, 564 pp., illus. $29.95.

Origins is a collection of 27 lightly edited transcripts of 90-minute interviews with scientists who have made notable contributions to the study of galaxies and cosmology, together with a 49-page introduction to modern cosmology. The scientists were asked to talk about their childhood experiences and education and about the influences that helped shape their research interests and "attitudes about cosmology." Each scientist was also asked a fixed set of questions intended to elicit his or her "reactions to recent developments in cosmology." Finally, each scientist was asked two "philosophical" questions: "If you could have designed the universe any way that you wanted to, how would you have done it?" "Have you ever thought about whether the universe has a point or not?"

The project was intended to throw light on a number of metascientific questions, among them: "How do scientists choose the problems they work on and the questions they ask?" "What decides whether a question is scientific or not, worth worrying about or not?" "Why do some questions gain legitimacy only after their solution?" "How do scientists respond to new empirical results that challenge their previous thinking?" "Do questions about the initial conditions of the universe lie within the domain of science?"

Surprisingly, Lightman and Brawer never return to these questions. They don't analyze or discuss their findings, preferring to "let the interviews speak for themselves." *Origins*, therefore, is more an archive than a study. Still, readers who are curious about how temperamental and sociological factors affect the making of science and of scientists will find much to interest them in the nontechnical parts of the interviews.

I doubt, though, whether nonspecialists will be able to make much of the technical parts. The introduction was intended to be helpful in this respect. It gives a clear but oversimplified description of two or three strands teased from the tangled web of contemporary cosmological research. The scientists, however, break out of the mold that has been prepared for them. They speak freely about the portions of the web that interest them most, often in ways that take issue with the scientific presuppositions of the questions they have been asked and usually in ways that assume a lot of specialized knowledge on the part of the listener. The text cries out for explanatory notes. More vigorous editing of the transcripts could easily have made room for them with no loss of substantive content.

The scientific questions relating to theoretical cosmology focus on the "horizon problem" and the "flatness problem," which are introduced in the following way:

> In the last 15 years, a revolution has occurred in cosmology—associated in part with the application of subatomic physics to theories of the beginning of the universe. . . . One product of the union of subatomic physics and cosmology has been a major modification of the big bang model called the inflationary universe model, proposed in 1980. . . . The attraction of the inflationary universe model comes in large part from its resolution of two outstanding difficulties with the standard big bang model: the so-called horizon and flatness problems. The horizon problem asks why the universe appears to be homogeneous over a much larger region than could reasonably be expected—unless it began that way. The flatness problem raises the question of why the universe began with its gravitational energy and its kinetic energy of expansion so closely balanced [pp. vii–ix].

In fact, particle physicists began to take a professional interest in cosmology immediately after the discovery of the cosmic radio background by Arno Penzias and Robert Wilson in 1965. Andrei Sakharov in 1967 sketched a scenario in which baryon-nonconserving processes might account for the emergence of baryon-antibaryon asymmetry, and hence predict the present temperature of the cosmic radio background, in a universe with initially equal numbers of particles and antiparticles. Baryon-nonconserving processes are allowed by grand unified theories, which also permit neutrinos to have finite rest mass. Since it was becoming clear that primordial nucleogenesis in a hot universe would overproduce helium unless most of the gravitating mass was nonbaryonic, cosmologists and particle physicists looked forward with great excitement to the emergence of a grand unified theory that would in one stroke explain the background radiation and account for the bulk of the gravitating mass in the universe.