Book Review

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Empire of the stars: Obsession, friendship, and betrayal in the quest for black holes

Arthur I. Miller, 2005, 274 pages, two appendices, notes, bibliography, biographical sketches, glossary, and index, ISBN 0-618-34151-x, Houghton Mifflin, Boston and New York.

On January 11, 1935, an event that was, in the words of author Arthur Miller, "singular in the annals of modern science," took place at a meeting of the Royal Astronomical Society (RAS) at Burlington House, Piccadilly Square, London. In an elegant presentation lasting only fifteen minutes, a very young Indian astrophysicist, Subrahmanyan Chandrasekhar (now known universally as simply Chandra) presented his startling theory about the fate of stars which have consumed their basic fuel. Chandra believed his theory, which predicted that stars not much larger than the sun would collapse into compact objects now known as either neutron stars or black holes, would solve a critical problem posed by the doyen of British astrophysics, Sir Arthur Stanley Eddington. In a vitriolic response that immediately followed, however, Eddington demolished Chandra's paper. Eddington's rhetorical flurry of denial that such objects could possibly exist was to have lasting consequences for both individuals. Those consequences form the basis for the remainder of this very readable and interesting book.

Born into a Brahmin family of high intellectual achievement (his uncle C. V. Raman was the first Indian to receive a Nobel Prize in Physics), Chandra exhibited prodigious mathematical talent as a child. His ability was widely recognized and led to a scholarship for graduate studies at Cambridge University, where he chose astrophysics as an emerging field of science rather than pure mathematics. While in transit to Britain from India, Chandra made the discovery that would plague him for the remainder of his life, as he calculated the maximum mass of a star that could remain stable as a white dwarf, recognizing in the process that any larger star would collapse under the influence of its own gravity. The mathematical details of the whole process were only worked out by Chandra after his arrival in Cambridge. During that working out of the details, Chandra was pleased that Eddington would visit him in his office on a frequent basis to learn about the progress of Chandra's work; he felt certain, on that basis, that Eddington would support his paper when it was presented to the RAS. Thus, Eddington's vehement attack on the paper was a stunning surprise to all present in the RAS audience, but most of all to Chandra. Almost as disappointing to Chandra was the failure of others like A. E. Milne who had befriended Chandra, James Jeans who opposed Eddington on nearly everything, and others who seemed sympathetic to Chandra's scientific conclusions to publicly challenge Eddington. In effect, the British astrophysical community was completely cowed by its acknowledged *éminence grise*.

Unfortunately for Chandra, in two subsequent opportunities when he presented his theory in international forums, the outcome was the same—Eddington's vehement denial of the possibility of the collapse of a white dwarf into any smaller body accompanied by surprising condescension to Eddington's position by senior astrophysicists. At the last of these occasions, an International Astronomical Union meeting in Paris, the reluctance of those assembled to challenge Eddington was all the more surprising in that in that same meeting Gerard Kuiper had already presented observational evidence that tended to support Chandra's theoretical proposition.

Several decades passed, during which Chandra relocated to the University of Chicago, first at Yerkes Observatory and eventually to the main campus in Chicago. His work also moved on to demonstrate his theoretical prowess in a succession of book length theoretical explorations, first of stellar structure, then radiative transfer, hydrodynamics, and finally a series of papers exploring the application of general relativity to astrophysical problems, culminating in a book on the mathematical theory of black holes.

Progress on Chandra's original problem, the collapse of white dwarfs of more than 1.4 solar masses (now known as the *Chandrasekhar Limit*) was slow, and came from a surprising quarter. Work on supernovae proceeded observationally from the 1930s and on with little understanding of the theoretical mechanisms involved. It remained for physicists who were interested in high temperature nuclear reactions to sort out the mechanisms involved. They worked under the urgent pressure to understand the physics of thermonuclear explosions necessary for nuclear weapons development. Supernovae and superbombs thus developed apace in both the United States and in the Soviet Union under the pressure of cold-war geopolitics. The story abounds with the names and personalities of well known figures from this period like Oppenheimer, Teller, Bethe, and Fermi. Astrophysicists also made their own contributions; thus Baade, Zwicky, Gamow, Hoyle, Gold, and Wheeler enter the story at appropriate points. Miller also adds interesting glimpses into the personalities and workings of astrophysics and nuclear physics in the Soviet Union, including biographical information on Russian scientists like Landau and Zel'dovich.

Miller's approach to this story is methodical, with a clear exposition of the technical stakes as well as the personal styles that entered into the eventual resolution of the problem. Through it all, Chandra contributed in his own inimitable way. Eventually, the prescience of Chandra's 1935 paper was confirmed with the award of the 1983 Nobel Prize in Physics (there is no Nobel prize for astronomy). Along the way, he was honored with nearly every other honor that astronomy confers on both the European and North American continents. As Miller points out, however, the long delay took its psychological toll and "Chandra's lifelong quest for personal peace could never be fulfilled," even with the award of the Nobel Prize.

The first half of this book is basically a biography of Chandra, with a chapter about Eddington and sufficient additional detail to make clear the extent to which both were affected by the exchange they had on 11 January 1935. In neither case is the biography exhaustive; for more thorough biographical treatments of each individual see Wali,

Kameshwar C., *Chandra: A biography of S. Chandrasekhar* (U. Chicago P., 1990) and Douglas, Allie Vibert, *The life of Arthur Stanley Eddington*. London (Nelson, 1956).

Incomplete as they are, Miller's biographical sketches, when coupled with the powerful drama of the confrontation between these two individuals, would make the book worth reading. But the real strength of the book is found in the second half in which the events in the decades that followed Eddington's last denial of Chandra's theory were played out in astrophysics and in other related areas. Confirmation and acceptance of Chandra's 1935 assertions about the limits to the mass of a white dwarf and the collapse of stars that exceed that mass into neutron stars and black holes eventually emerged in physics, not in astrophysics. The yarn that unwinds in the second half of the book is a marvelous exposition of the interaction between physicists and astrophysicists, between pure and applied science, between science and weapons development, and between strong personalities who entered the arena in some or all of these areas to impact our current understanding of supernovae as fundamental events in stellar evolution. Both the first and second halves of the book are peppered with short but colorful biographical sketches of many of the key players in astrophysics; these sub-stories contribute greatly to the readability of the text in human terms.

Empire of the Stars could have been more carefully edited. This is true in both a stylistic and in a factual sense. Readers with a scientific background, for example, are likely to find themselves irritated with Miller's reliance on words to characterize large numbers, and to fix on miles as a standard unit of measure for astronomical distances. Some historians will notice small details in error, for example the fact that in 1917 Dutch astronomer Willem de Sitter sent a copy of Einstein's latest paper on relativity to the RAS rather than directly to Eddington as Miller alleges. In doing so, Miller missed an opportunity to reinforce the idea that Eddington, as the foreign secretary of the RAS who received de Sitter's paper in that role, exercised considerable power within the organization. Miller also confuses the state of variable star astronomy in 1908 by claiming that over 1,700 Cepheid variable stars were known at that time, whereas the extant catalogues of variable stars from the period contain fewer stars of all types of variation, and consisted mainly of long period variables.

In summary then, and in spite of the few problems cited above, *Empire of the Stars* is a well written book that should be read by anyone who has more than a passing interest in the history of astrophysics in the twentieth century. As an introduction to the character of its primary actors—primarily Chandra but clearly also Eddington—Miller's book makes an important contribution to biography with its careful articulation of the key issues from both scientific and personal perspectives. Moreover, it will be of significant value to those whose interest is located in the history and philosophy of science, and those who ponder about how science is done in the nitty-gritty sense. More broadly, anyone who has an interest in the psychology of intellectual activity, including the emotional cost of relentless competition in the academic arena, will find this a fascinating tour through that landscape.

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