

and will be reassured of the legitimacy of their rationalist conception of science.

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## Empire of the Stars: Obsession, Friendship, and Betrayal in the Quest for Black Holes

Arthur I. Miller  
*Houghton Mifflin, New York,*  
*2005. \$26.00 (364 pp.).*  
*ISBN 0-618-34151-X*

The quest to understand stellar evolution—how stars are born, live, and die—is a fascinating subject. Arthur I. Miller's *Empire of the Stars: Obsession, Friendship, and Betrayal in the Quest for Black Holes* traces the history of this intellectual adventure, intertwining it with the stories of the pioneering astrophysicists and theoretical physicists who have contributed to its success. Miller also examines the connections among the astrophysical processes, the making of the hydrogen bomb, and the role of general relativity in firmly establishing the existence of black holes in the astronomical universe.

The book, which is absorbing and scientifically well researched, is intended for general audiences but goes beyond the rational scrutiny of the history of science. It offers tidbits of personal lives of some key players and ventures into highly speculative sociocultural and psychological explorations that I find disturbing and unwarranted. For example, Miller writes that Arthur Stanley Eddington's only intimate, other than his sister, was Charles Trimble, a mathematics tutor. He speculates that the intimacy could have been more than just friendship: It could have been homosexual, and because homosexuality was illegal, it made Eddington "lead a life of concealment, a life on the edge with fragile psychological balance."

Aside from many such explorations, the real focus of Miller's book is Subrahmanyan Chandrasekhar (popularly known as Chandra), Eddington, and the controversy between the two concerning the theory of white dwarfs. On his long voyage from India to England in 1930, Chandra discovered, as a consequence of combining special relativity and quantum mechanics, the celebrated upper limit on

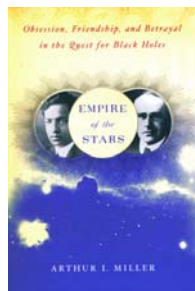
the mass of a star that could become a white dwarf. For stars more massive than the Chandrasekhar limit of 1.44 solar masses, the electron degeneracy pressure is not adequate enough to withstand gravity. The star continues to collapse. During a meeting of the Royal Astronomical Society in January 1935, Chandra presented a rigorous proof of that startling result based on the exact relativistic equation of state for degenerate matter. In the dramatic sequel, Eddington, speaking after Chandra, ridiculed the whole idea of relativistic degeneracy. He claimed the underlying idea was wrong and had no validity.

Eddington's rebuttal came as a total surprise to Chandra. Eddington had known about Chandra's work and had followed it carefully in the months preceding the meeting but had given no warning that he disagreed. Being publicly refuted by Eddington, a towering figure with great international prestige, was traumatic to young Chandra.

I first learned about the eventful encounter in an article Chandra wrote in the *American Journal of Physics*, volume 37, page 577, 1969. The article led me to get to know Chandra well, and write *Chandra: A Biography of S. Chandrasekhar* (U. of Chicago Press, 1991), based on more than a decade of extensive conversations with him. Miller's account is totally different from Chandra's. For instance, the author gives an overblown, inaccurate description of Chandra's discovery. He describes it as "a great discovery concerning nothing less than the ultimate fate of humanity," and "like Einstein, [Chandra] had lifted a corner of a great veil, revealing a majestic yet terrifying picture of the fate of stars and of humanity." And further, according to Miller, Chandra's discovery had provided mathematical verification of black holes.

Chandra's theory of white dwarfs was certainly one of the most important discoveries of the 20th century, but it was not the theory of black holes. It did not incorporate general relativity—the basis of our current understanding of black holes—which was done by J. Robert Oppenheimer and Harland Snyder in the late 1930s.

Miller also writes that Chandra's story is "of one man's fight with the scientific establishment for recognition of



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his idea—an episode that sheds light on what science is, how it works, and where it can go wrong.” Yet Chandra did not have to fight for recognition. The morning after the meeting, when Chandra saw Ralph Howard Fowler and told him what Eddington had said, Fowler said not to worry; Eddington was wrong. Leon Rosenfeld, Niels Bohr, Paul Dirac, and Wolfgang Pauli all agreed that Eddington’s criticism had no substance. It was the empirically bound nature of astronomy and astrophysics of the 1930s, not the shortsightedness of the physics establishment, that impeded the acceptance of new theoretical ideas.

Miller is equally fanciful when he writes about the effects of the controversy on Chandra’s personal life and accomplishments. According to the author, Chandra’s life became tinged with tragedy and he never regained his confidence. Eddington had convinced Chandra that “success in the world of science was not simply a matter of the brilliance of one’s ideas; even more important, it seemed, was playing the game and scheming along with every one else.”

Anyone who knew Chandra personally or through his works would be astounded by Miller’s assessment. Chandra has left behind an almost unparalleled legacy of theoretical and mathematical physics. For Chandra, his arguments with Eddington were based purely on science. Traumatic though they were, Chandra’s relations with Eddington never faltered from great respect and affection. In the summer of 1935, just months after his unexpected rebuttal, Eddington took Chandra to the tennis finals at Wimbledon. They went to cricket matches and took bicycle trips together. In subsequent years, the two corresponded with each other. Eddington’s letters were full of warmth, humor, and affection.

Although Miller is fully aware of all those events and writes about them in his book, he claims they were all façades Eddington created. He believes there were deep reasons for Chandra’s brutal treatment, born out of racism, clash of cultures, and British colonialism. Such an attitude, notes Miller, “would be taboo today, but in those days the Raj still ruled India, and Englishmen still basked in the belief in their innate superiority.”

Chandra never felt he was discriminated against in England. Both Eddington and Edward Arthur Milne, who also had science-related disagreements with Chandra, were responsible for Chandra’s election to the Trinity and Royal Society fellowships.

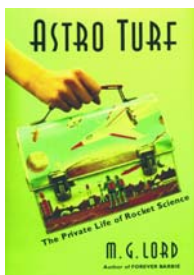
At the height of his dispute with Eddington, Chandra was the first Indian to give lectures on stellar structure at Cambridge University.

Miller’s account of Chandrasekhar and Eddington, made into a story of a young, brilliant student from colonial India stifled and robbed of his discovery by an imperial egotist, gives a distorted view of history and how science works. Other reviews of Miller’s book have taken up this work as evidence of the dark side of science, in which personal rivalry, clash of cultures, and deep-seated prejudices plague scientific minds. As human endeavor, science certainly has human pitfalls that should be brought to light. But *Empire of the Stars* does not do that in a credible way.

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## Astro Turf: The Private Life of Rocket Science

M. G. Lord  
*Walker, New York, 2005. \$24.00*  
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Rocket science is all about perfect physics in frictionless space, about amazing feats of precision in the glare of the public, who ask in awe, “How do they do that?”—not to mention the fantastic fireworks display to get things going. AstroTurf is the perfect engineering solution to having ever-green grass that needs no mowing, sun, or water. But perfection has its downsides, and so the new stadium fields in Houston are real grass. Maybe it was the longing from the fans for dirt on the uniforms and grass stains on the knees.

*Astro Turf: The Private Life of Rocket Science* takes us on an intriguing, well-written walk through the relatively short but spectacular history of the space program at the Jet Propulsion Laboratory in Pasadena, California. Mary Grace Lord, investigative reporter and cultural critic, also offers readers a much more personal look—complete with a little dirt and some grass stains—at those times as experienced by Lord, whose father, Charles Carroll Lord, was of one of those rocket scientists.

Lord recounts the roots of early

space exploration and the personalities and politics that drove it. Going over ground that has been covered before by others, she recounts the contradictions of the dark beginnings and the brilliant successes of Wernher von Braun and his team. She traces the tortured paths of some early leaders of JPL in the McCarthy era—especially the path of Frank Molina, the JPL director on whom the FBI kept an exceptionally thick file on alleged anti-American activities. The history lesson is informative to the reader, and, more important, it informs Lord’s search into the work world of her often distant father.

Charles’s world was one of engineering precision, order, and discipline. Lord observes that at JPL the obsession for clear, logical thought, coupled with singular powers of concentration, was carried to nearly pathological extremes. Nevertheless, those qualities were so valued in scientists and engineers that, if they didn’t have them naturally, they just might want to fake the behaviors for the good of their careers. These same behaviors often had an impact on the personal lives of those involved. Into the engineers’ heady, technical world, Lord weaves her recollections of life growing up with her father, going places and doing things with him—and she ponders the things left undone and unsaid. The common thread of Lord’s story is her discovering new insights about her father—from his making a perfectly knit scarf, just to show that he could, to his dismissive comments about Lord’s ability to concentrate, to his struggles with his own low self-esteem as a second- or third-tier rocket scientist.

Rocket science, although precise and disciplined at the bench level, is fragile, ethereal, and political at the leadership level. Lord builds the story with consummate attention to detail and insight into the complex clashes of personalities of such leaders as Molina and von Braun. For example, the selling of rocket science to politicians and the public caught a wave of excitement with the introduction of Walt Disney to rocket science and the commercial and popular success of Disneyland. Disney raised von Braun to iconic status—every story needs a hero. The whole country was glued to the television set to see spaceflight portrayed in short films such as “Man in Space” and “Man and the Moon” created by the artful Disney cartoonists. Lord leaves us wondering just how much those fanciful previews influenced the decision to go to the moon.

Using more recent history, Lord sets