

## Creating the measure of Chandrasekhar's life

**In his review** of my book *Empire of the Stars: Obsession, Friendship, and Betrayal in the Quest for Black Holes* (PHYSICS TODAY, February 2006, page 53), Kameshwar Wali refers to his own biography of Subrahmanyan Chandrasekhar,<sup>1</sup> “based on more than a decade of extensive conversations with him,” and asserts that “Miller’s account is totally different from Chandra’s.”

Quite so! As historians of science worth their salt are well aware, there is a vast difference between what a subject tells you in an interview and what is to be found in the archives. It is the historian’s job to probe beyond the subject’s own assertions. Wali had very limited access to Chandra’s letters, manuscripts, and other papers, and he elected to believe to the word Chandra’s account of events that had occurred 40 years before. His book is now outdated.

My book was based on the huge Chandrasekhar archive in the Joseph Regenstein Library at the University of Chicago, together with other extensive primary and secondary materials. Such resources are absent from Wali’s book, and nowhere in his review does he support his allegations with historical evidence. Instead, yet again, he tells us to believe what Chandra told him.

What I discovered through my research was a complex man, as we would expect of someone of Chandra’s brilliance, who never recovered from his 1935 encounter with Arthur Stanley Eddington at the Royal Astronomical Society. In public Chandra pretended that the Eddington episode was behind him—as it should have been. But, as I learned from diary entries, letters, and interviews with his friends, he could not shake it off.

Wali dismisses my suggestion that Eddington was homosexual. My argu-

Letters and opinions are encouraged and should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842 or by e-mail to [ptletter@aip.org](mailto:ptletter@aip.org) (using your surname as “Subject”). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit submissions.

ment is complex and based on historical evidence. Many people have made the same suggestion, and indeed homosexuality was not unusual among Oxbridge dons in the 1930s. Living “a life of concealment” at a time when draconian laws prohibited homosexuality meant that Eddington’s psychological well-being was fragile. His life’s work was his fundamental theory—which would be threatened if Chandra’s theory of white dwarf stars was right. Wali is the only person who has publicly questioned my interpretation of Eddington’s personal life.

Wali claims that Chandra’s theory of white dwarf stars “was not the theory of black holes.” But that was not what I said. What Chandra’s theory did was to show, for the first time, that after burning up their fuel, stars could begin an eternal collapse to an infinitely tiny point of infinite density. The dramatic collapse contained the seeds of the concept of black holes. General relativity was not necessary to come up with the insight. But no one believed it, not even Eddington, who had speculated on just that in his 1926 book, *The Internal Constitution of the Stars* (Cambridge U. Press), using general relativity—albeit tongue in cheek.

Wali says that Chandra “did not have to fight for recognition” of his theory of white dwarf stars and asserts that Ralph Howard Fowler, for one, supported him. To the contrary, I have documented this at great length and Wali seems to have forgotten that he, too, made this same point in his biography of Chandra. After quoting from a footnote in Fowler’s 1936 book on statistical mechanics<sup>2</sup> in which Fowler points out Eddington’s disagreement with Chandra’s theory of white dwarf stars, Wali states that Fowler did “not come out to say that he” disagreed with Eddington.<sup>3</sup>

Certainly, Eddington took Chandra to a tennis match and on bicycle rides. But that does not contradict the evidence of the heated exchanges they had over the years. Wali writes in his review that Eddington’s later letters to Chandra were “full of warmth, humor, and affection.” In fact, there was very little warmth between the two, and they

certainly avoided discussing the death of stars.

Wali questions my comments on racism in 1930s Britain. Chandra was the first Indian to lecture on astrophysics, but no one offered him a position, even though positions were available. Chandra wrote to his father in 1936 that there was “some prejudice giving Indians a definite appointment” at Cambridge University.

Indeed, Chandra must have been delighted when Wali appeared at his door in 1977. He could finally put on record through a biographer that he had set the Eddington episode behind him. Perhaps Chandra forgot that two years earlier he had made the following diary entry:

I recall that during my first year in Cambridge (in 1930–31), I saw Eddington, going by on the other side of the street, smoking his pipe as usual, looking so confident and serene. And I thought to myself: how wonderful it must be to be secure in one’s accomplishments with the recognitions of one’s fellow scientist. And I thought of being [a fellow of the Royal Society], a Gold medallist of the Royal Astronomical Society, and being famous. I suppose that I have all the tangible recognitions that Eddington had at that time received. But in my heart I have none of the serenity that I thought I saw in Eddington’s face, 45 years ago.

### References

1. K. C. Wali, *Chandra: A Biography of S. Chandrasekhar*, U. Chicago Press, Chicago (1991).
2. R. H. Fowler, *Statistical Mechanics*, 2nd ed., Cambridge U. Press, Cambridge, UK (1936), p. 652.
3. Ref. 1, p. 145.

**Arthur I. Miller**  
([a.miller@ucl.ac.uk](mailto:a.miller@ucl.ac.uk))  
University College London  
London, UK

**Kameshwar Wali’s review** of *Empire of the Stars: Obsession, Friendship, and Betrayal in the Quest for Black Holes* exposes

author Arthur I. Miller's flawed socio-historical analysis of the Eddington–Chandrasekhar controversy and of its impact on the development of stellar astrophysics.

Subrahmanyan Chandrasekhar's own perceptions of his life and times in Cambridge, UK, are quite different from what Miller would have us believe. I quote from two of Chandra's letters to the Indian physicist Kariamanikkam Krishnan, who was the co-discoverer of the Raman effect and a close friend of Chandra's. The first letter, dated 11 August 1934, was written a few days after Chandra received news of the unpleasant episode in which Chandrasekhara Raman and Krishnan were removed from their positions on the management committee of the Indian Association for the Cultivation of Science and a new management structure sans Raman was put in place. Raman had to resign from the membership of the institution with which he had been associated for more than a quarter century and where he had done his best work. In this letter Chandra says,

Oh! How I wish that you had come to Cambridge. The atmosphere here is so pure, so encouraging and so wholesome—and so free of personal animosities and jealousies. The sincere collaboration of the best minds, sacrificing personalities for the progress of science—it seems so impossible now that in India we would build a similar school—where the same spirit would prevail, even if a Rutherford, Eddington, Fowler or Dirac do not exist. You can never know how much I owe to the inspiration of your friendship, and even in Cambridge I miss you so much, and to me it is ever so intense a sorrow that one whom I respect and admire so much should now be in the whirl of such bitter winds.

A second letter was written on 20 March 1935, barely two months after what Miller has called Chandra's "fatal collision" with Eddington. Chandra was spending some time in Niels Bohr's institute in Copenhagen. He genuinely wanted Krishnan to come to Cambridge and savor the Cambridge atmosphere. Chandra writes:

Is there any possibility of your coming to Europe sometime before the summer of 1936. I hope myself to return to India by about that time and imagine our travel-

ling back together! Somehow I think that you will enjoy a small tour in Europe if you cannot afford the time to spend a longer time. As for me I am continuing in the same way more or less. I sent you last week my recent work on Stellar Structure. I should be glad to know what you think about it.

In Cambridge I get the utmost sympathy and encouragement for my work. Fowler, Eddington and Dirac are all extremely kind and encouraging and even spend quite considerable time to clear up some difficulties that I may come across. When I first came to Cambridge, I used to look forward to returning home, but now after nearly five years in Cambridge I feel so very unhappy that I should soon return.

Last term in Cambridge, I gave a course of about 20 lectures on "Special Problems in Astrophysics" and these and some of my later work all kept me so busy that I am glad to have come now to Copenhagen again. I came here on Sunday and expect to stay on till the middle of April when I will return to Cambridge.

A proper scientific understanding of the full implication of Chandra's discovering the mass limit, and the consequent acceptance of the possibility that black holes existed, had to wait for many related things, among them the implications of supernova explosions, the theoretical studies of J. Robert Oppenheimer and his students, the discovery and observation of mass loss in stars, the advent of x-ray astronomy, and the discovery of pulsars and their identification as rotating neutron stars. All these developments took time. Eddington did not delay anything by asserting that "there should be a law of Nature to prevent a star from behaving in this absurd way."

*I acknowledge with gratitude the permission granted by Vijay R. Thiruwady, grandson of K. S. Krishnan, to quote from his grandfather's correspondence with Chandrasekhar.*

**D. C. V. Mallik**  
(dcmilk@iiap.res.in)

*Indian Institute of Astrophysics  
Bangalore, India*

**Wali replies:** Arthur Miller's assertion that I had "very limited access" to Chandra's letters, manuscripts, and other primary and secondary sources when I wrote my biography of him,<sup>1</sup>

and that I elected to believe Chandra's word is totally false. I have had full access to the Chandrasekhar archive since its inception in the late 1970s. Besides extensive conversations with Chandra, I interviewed more than 50 people, including his friends and relatives in India; his former students and associates at Yerkes Observatory and the University of Chicago; his Cambridge University contemporaries David Shoenberg, William Macrea, and Paul Dirac; and US physicists and astrophysicists Margaret Burbidge, Freeman Dyson, Martin Schwarzschild, Kip Thorne, and Victor Weisskopf. Audio-tape copies and transcripts of these interviews are in the Chandrasekhar archive.

Miller asserts that Chandra publicly "pretended" the Eddington episode was behind him, but that he could not shake it off. As Miller writes in his book:

His [Chandra's] life was tinged with tragedy. . . . Chandra never really regained his confidence. . . . I wondered what other great discoveries he might have made, had his early life not been blighted by disappointment.

Those statements are a travesty of Chandra's vast, almost unparalleled legacy of theoretical and mathematical physics. As Thorne has noted, for instance, "Nobody has done more than S. Chandrasekhar to bring general relativity to its 'natural home,' astronomy."<sup>2</sup>

Miller's "complex" interpretation of Eddington's sexual preferences leading to a "fragile psychological well-being" as an explanation for his behavior in scientific controversies is too simplistic, purely suppositional, and without evidentiary basis.

About the theory of white dwarf stars and the theory of black holes, Miller says a great deal more in his book than he presents in his letter.

Chandra's mathematical verification of black holes and his four decade wait until the scientific community accepted it. . . . Chandra's great discovery concerned nothing less than the ultimate fate of the universe. Like Einstein, he had lifted a corner of a great veil, revealing a majestic yet terrifying picture of the fate of stars and of humanity.

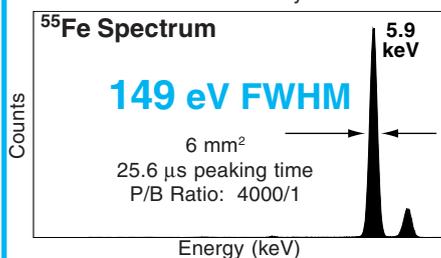
I find it, as I said in my review, an overblown and inaccurate account of Chandra's discovery.

Chandra did not have to fight for recognition of the fact that his physics was right and Eddington's was wrong.

# X-Ray and Gamma Ray Detectors

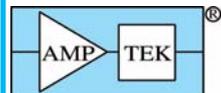
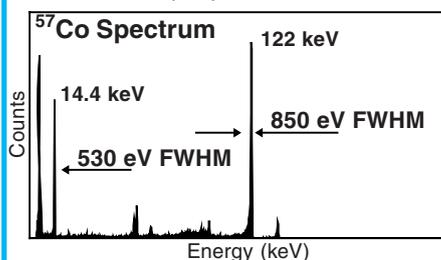
## XR-100CR

With Si-PIN for X-Ray Detection



## XR-100T-CdTe

With Cadmium Telluride (CdTe) for  $\gamma$ -Ray Detection



**AMPTEK INC.**

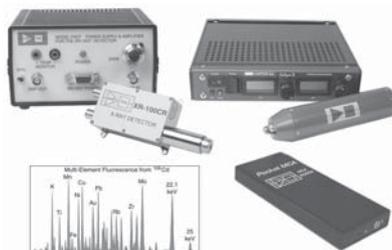
Tel: +1 781 275-2242

**Solid State Design**

**No Liquid Nitrogen!!**

**Easy to Use**

**Low Cost**



## Complete XRF System

XR-100CR X-Ray Detector System  
ECLIPSE-III Portable X-Ray Tube System  
MCA Multichannel Analyzer  
XRF-FP Quantitative Analysis Software

**Visit Us Now**

[www.amptek.com](http://www.amptek.com)

14 DeAngelo Drive, Bedford, MA 01730-2204 U.S.A.  
Fax: +1 781 275-3470 e-mail: sales@amptek.com

## NEW!!! Complete X-Ray Spectrometer

**INCLUDES**

- 1 X-Ray Detector and Preamplifier
- 2 Digital Pulse Processor
- 3 Power Supply



2.7 x 3.9 x 1 in. (7 x 10 x 2.5 cm)

The X-123 is a complete X-Ray Detector System in one small box that fits in your hand.

## Features of the X-123:

- Simple to Operate
- Low Power (1.2 Watts)
- Small Size
- USB and RS232 Communication
- Accommodates all Types of Amptek Detectors

See [www.pt.ims.ca/9468-8](http://www.pt.ims.ca/9468-8)

Chandra's work was vindicated fairly promptly—first, through acceptance by all serious theorists working in the field, and second, through observations that empirically established the range of masses of white dwarf stars.

The footnote in Fowler's book that Miller refers to was in the general context of authority and prestige held by Eddington, which prevented people from coming out and openly saying he was wrong.

As for the Chandra–Eddington relationship subsequent to the incident, anyone who reads the letters in the archive will disagree with Miller that they lack warmth and affection. I recount one of Chandra's own recollections as an example of their continued friendship in spite of the controversy:

When Chandra returned from India after getting married [in 1936], Eddington invited the couple for tea. When he learned that they were leaving for America soon, he asked Chandra to his rooms one morning. "Let us not talk science," Chandra recalls him saying. "That is what we have done all along." Eddington

then talked about his early years, the poor circumstances he grew up under, his living alone, and the loneliness of an intellectual life. He then brought out a map of England on which he had pinned all the places to which he had bicycled and marked the routes he had taken. "You are the first person to see this map," he said to Chandra. Chandra was obviously moved. "I sort of felt," says Chandra, "that Eddington was trying to add to our professional relationship a personal dimension. The enormous respect I had for him made me feel grateful, grateful that I had such an opportunity to know him."<sup>3</sup>

Chandra did not seek a position in Cambridge, and to the best of my knowledge none were available. Through consultations with Eddington, Chandra decided to join Yerkes rather than Harvard University.

Miller's last comment is most insulting to Chandra and to me. Miller implies that Chandra's sole purpose in allowing me to write his biography was to put on record that he had finally set

the Eddington episode behind him, and that I did just that.

Chandra had not forgotten what he had written in his diary two years earlier. He repeated it to me verbatim; that led to our intense discussion. His not finding the peace that could be expected after such enormous success had little or nothing to do with Eddington, but with the larger, more complex reality of how an individual creates the measure of his or her life.

## References

1. K. C. Wali, *Chandra: A Biography of S. Chandrasekhar*, U. Chicago Press, Chicago (1991).
2. K. Thorne, in S. Chandrasekhar, *Selected Papers, Vol. 5: Relativistic Astrophysics*, U. Chicago Press, Chicago (1990), p. x. For more information about Chandra's extensive contributions, see R. M. Wald, ed., *Black Holes and Relativistic Stars*, U. Chicago Press, Chicago (1998), and K. C. Wali, ed., *S. Chandrasekhar: The Man Behind the Legend*, Imperial College Press, London (1997).
3. Ref. 1, p. 139.

**Kameshwar Wali**  
(wali@physics.syr.edu)  
Syracuse University  
Syracuse, New York

## Distance learning a losing tactic for advanced physics

I was very dismayed to learn that some US universities are putting such a low priority on fundamental science that they are pooling students into “distance learning” for upper-level physics coursework. Now is the time to put resources into undergraduate physics programs, not to withdraw them. This country is at an all-time low for US citizens earning PhDs from its own graduate programs in physics and engineering.

Physics is the most difficult academic subject to study, and few students have both the skills and the willingness to work hard enough to succeed in it. Getting through freshman-level physics, although challenging, is a walk in the park compared with passing upper-level physics, let alone doing well in it.

Those students who make it into upper-level coursework have earned the right to a solid program. According to “Small Programs Survive by Pooling Students” (PHYSICS TODAY, September 2005, page 31), it is at this point when the most basic resources, such as professors to speak with in person and lectures to attend in person, are being cast off. The apparent reason for the pooling of students, from the bean-counters’ perspective, is to save money, since some states will not fund courses whose enrollment drops below a certain threshold.

Distance learning is a prescription for the death of high-level science and technology, for the following reasons: Students need the physical presence of professors; professors need to observe students directly in order to judge their needs and their understanding of the material; and faculty need to keep their teaching skills honed through regular opportunities to teach upper-level physics courses. If upper-level courses are shared among institutions, professors will be teaching their specialties only once every four or more years; without practice, professors will see the deterioration of their skills and their effectiveness as teachers.

Administrators must understand that many fewer students have the ability to learn physics compared with those who do well in the humanities. If we want to retain the few students who can—and choose to—study physics, then we must provide them with at least the minimum resources, including professors in the flesh, real instead of virtual lectures, and all the help they need to succeed.

Since the US has a great need to bolster science, we should be putting every-

thing we can into making programs better, not worse. It is my opinion and that of the colleagues I’ve spoken to that upper-level distance learning courses will end up destroying our programs in physics, not saving them. If our nation wants to improve science academics, universities have to bite the bullet, hire the best faculty, and see the lean times through. Otherwise, the world will see no new science and technology coming from the US during this century.

**Cecilia Barnbaum**  
(cbarnbau@valdosta.edu)  
Valdosta State University  
Valdosta, Georgia

## Phillips’s death marks the end of an era

With the passing of Melba Newell Phillips in November 2004, an era of three great women in physics came to an end. They are Lise Meitner, Maria Goeppert Mayer, and Phillips.

These three physicists contributed immensely to research and education in physics, yet they faced a tremendous amount of discrimination and difficulty in securing decent university positions. As a result, they were not able to guide graduate students toward their PhDs and stay active in their respective fields.

I strongly feel that the younger generation of our physics community, in particular women physicists, must be made aware of the achievements of these three physicists.

**Y. V. Rao**  
(yrao@bhcc.mass.edu)  
Bunker Hill Community College  
Boston, Massachusetts

*Editor’s note: See the obituaries in PHYSICS TODAY for these three women: Lise Meitner in December 1968, page 101; Maria Goeppert Mayer in May 1972, page 77; and Melba Phillips in July 2005, page 80. All three obituaries are available online with this letter at <http://www.physicstoday.org>.*

## Memories of Philip Morrison

I was saddened to read in the March 2006 issue of PHYSICS TODAY (page 83) of the death of Philip Morrison. As a graduate student in chemistry at Cornell University (1950–54) with minors in math and physics, I was fortunate that Morrison was the teacher of my first graduate physics class, Theoretical Mechanics. What a teacher he was! At the end of a class, his face often running with sweat from his exertions, he would beam at the

class with a smile I remember vividly still.

I was also fortunate that Morrison agreed to represent the physics department on my doctoral committee, and at my oral qualifying exam, he demonstrated both his sense of humor and his quickness of mind. I arrived for my oral at Baker Laboratory to find that a final doctoral exam for an organic chemist had also been scheduled for the same room and time. The organic chemist had been working with an obscure and complex organic compound, a molecular model of which was lying on the lecture-room table. While my major professor, Frank Long, and the other professor were discussing which exam would be moved, Morrison entered.

He stopped by the table, gazed at the complicated molecular model, and then remarked, “Ah, I see you have been studying \_\_\_” and gave the correct chemical name of the compound. A profound silence followed as the assembled chemists marveled at the chemical erudition of this physics professor. I did not know then, nor do I remember now, what the compound was, and I suspect that Long, a physical chemist, was equally unsure.

As department chairman, Long won the argument as to which group would leave. After the organic chemistry student and his committee had departed, Long turned to Morrison and asked how in the world he had recognized that obscure chemical compound. Morrison flashed his charming smile and explained that as he had walked over to the lab, the organic chemistry student had passed by, carrying his thesis, and Morrison had glimpsed the thesis title in which the compound was named. He deduced that the molecular model on the table most probably represented the compound named in the thesis title and was thus able to astound the assembled chemists.

It was a great privilege to have known Philip Morrison.

**E. B. Bagley**  
(ebbagley@aol.com)  
Morton, Illinois

The obituary for Philip Morrison, written by Leo Sartori and Kosta Tsipis, is lovely. Readers may be interested to know of an online memorial site dedicated to Philip and Phylis Morrison: <http://www.memoriesofmorrison.org>. The site contains many personal memories of Phil and Phylis, and readers may send contributions they wish to share to [stories@memoriesofmorrison.org](mailto:stories@memoriesofmorrison.org).

**Herbert Lin**  
(hlin@nas.edu)  
National Research Council  
Washington, DC