

Lyman Spitzer and Martin Schwarzschild

Rajaram Nityananda

Two giants of astrophysics, both from Princeton and comrades-in-arms for fifty years, passed away within the same fortnight, Lyman Spitzer died on 31 March and Martin Schwarzschild on 10 April 1997.

Spitzer was born in 1914 in the United States. He is known not only as a pioneer in the study of stellar dynamics and the interstellar medium, but also as the originator of the plasma physics programme at Princeton, and one of the first to make (in 1946!) the case for a space telescope. His early efforts drew in more support and ultimately resulted in the Hubble Space Telescope which is revolutionizing many branches of astronomy even as you read this article. The titles of his books, *Physics of Fully Ionised Gases*, *Dynamics of Globular Clusters*, *Diffuse Matter in Space*, *Physical Processes in the Interstellar Medium* and the more popular *Searching between the Stars* tell the story of his scientific interests. In the



thirties, he realized (with Ambartsumian) that the 'evaporation' of high-velocity stars from clusters would drive them to denser and more tightly-bound states. This theme was explored with literally generations of graduate students and is the basis of our understanding of globular star clusters. Interestingly, the same inverse-square law scattering which gives rise to these processes occurs in plasmas as well and his analysis resulted in the now canonical formula for 'Spitzer resistivity'. His insight into the heating and cooling processes in the gaseous medium

between the stars in our galaxy led him to predict the existence of a much hotter component which had not been observed at that time (1956). He conceived of 'Copernicus', an ultraviolet telescope in space, which opened up a new realm of the spectrum to observation and confirmed his prediction. It is now part of the Spitzer legend that his calculations days before the launch led to a correction of the telescope focus (the effect of gravity and temperature gradients in the lab test had been forgotten) which proved vital for the functioning of the satellite. The Hubble space telescope was not as fortunate and functioned myopically for two years till corrective optics could be installed in a second shuttle flight! Spitzer

succeeded H. N. Russell as the Head of the Astrophysics Department at Princeton University and led it to the unique niche it occupies today. It is a relatively small and mainly theoretical department which nevertheless stays close to the most exciting current observations and produces students who go out to staff some of the best observatories and departments worldwide.

Martin Schwarzschild was born in Germany in 1912, the son of Karl Schwarzschild, the great astrophysicist who died in the first world war. He came to the US in 1937. His early work was on the giant phase of stellar evolution, and during the war he served in the US Army, starting as a private! He was one of the

Spitzer and plasma physics

With the death of Lyman Spitzer, the plasma physics, astrophysics and space physics community has lost a great soldier. Lyman Spitzer was born in Toledo, Ohio in 1914 in the family of a businessman. While studying at Yale University Spitzer developed interest in physics and went to Cambridge University for further studies in astrophysics. After his return, he worked as a post-doctoral fellow at Harvard University during 1938-39. He established in Princeton a unique centre of Astrophysics. He was also the Director of the astrophysical observatory until 1979. He held position of Professorship until 1982 and was active in research subsequently. On the day of his death he worked a full day in his beloved Peyton Hall, talking enthusiastically to his colleagues and working on the finalization of a research paper. This shows the sense of his commitment, devotion and dedication to development of scientific research. He taught his students and younger colleagues by exemplary execution of his own plans, completion of his research problems and publication of his own scientific results in addition to various co-authored papers.

During his early thirties, Spitzer came up as one of the leading space scientists. He postulated as early as in 1940 that stars are formed from clouds of gas and dust in interstellar space. In 1946, he proposed the development of a large space telescope through a report called 'Astronomical Advantages of an Extra-terrestrial Observatory'. The first version of this telescope, which was called the 'Hubble Space Telescope', took a long time to complete and was eventually launched in 1990. Another important contribution of Spitzer was to the US Atomic Energy Commission during 1951. On a ski slope, Spitzer conceived of a reactor known as the 'Stellarator' and directed this program until 1967. This program provided an impetus towards the goal of controlled thermonuclear fusion. He conceived of an ultraviolet telescope in the orbit which could measure the spectra of atoms and molecules in interstellar space. This telescope was launched as the 'Copernicus satellite' in 1972.

I was myself lucky to have heard him lecture in Cornell University in 1963. I had already gone through his book on the *Physics of Fully Ionized Gases*. This book was where learning plasma physics used to start in those days. One of his important contributions to the Physics of fully ionized plasma is popularly known as 'Spitzer Conductivity'. He himself confessed, 'I love to work on big problems'. One might well add that he solved most of the problems he tackled.

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early users of the first computers for scientific purposes. His 1958 text on the 'Structure and evolution of the stars' became a classic reference, superseded since then on many points of detail but not yet for clarity in exposition of the basic principles. His work led to the concept of shell flashes and other instabilities which have since become crucial to our understanding of stellar evolution. He also worked on theoretical aspects of the plasma physics programme initiated by Spitzer, and took the initiative in the effort to beat the limits to resolution set by the earth's atmosphere by launching optical telescopes to stratospheric heights in balloons. The Stratoscope programme did not last long, but the pictures it produced of the convection on the sun's surface, and the nucleus of the Andromeda galaxy, were not bettered for decades. In 1979, around the time of his formal retirement, he launched with vigour into a new field, the dynamics of triaxial galaxies. Most earlier work rested on the simplification which comes from having a gravitational potential which is spherically or axially symmetric, but it had become increasingly clear that some galaxies did not fall into this class. His strategy was a clever mix of physical insight and numerical integration of orbits, and formed the basis for the current picture of how the stars and gas move in these galaxies. In some sense, he did for triaxial galaxies what Hartree and Fock did for atoms by providing a self-consistent potential and orbits in numerical form.

This much about Spitzer and Schwarzschild is public knowledge. To this it

Schwarzschild and the stars

The following incident illustrates both an interesting point of astrophysics and gives a feel for the character of Martin Schwarzschild. It was the day on which the award of the Nobel Prize to S. Chandrasekhar had been announced. A gathering over mid-morning coffee at Peyton hall was discussing the great man and his work. Schwarzschild, a good friend of Chandrasekhar, recalled how the work on polarized radiative transfer gave him the greatest pleasure. Someone asked whether Chandrasekhar had ever made a mistake. 'Well, he "proved" the Vogt-Russell theorem'. All eyes turned to Bohdan Paczynski who explained that in the book, *Stellar Structure*, Chandra had presented a proof that there is a unique stellar configuration for a given mass and chemical composition. However, this 'theorem' is in fact not true in general. Mathematically, although the differential equations are first order, it is a two-point nonlinear boundary value problem for which there is no uniqueness theorem. Physically, one could take the sun as it is today, and get another solution, namely a white dwarf with the same mass, in a thought experiment which extracted all the entropy. Now it was the turn of the one of the students. 'Martin, what did you say about the Vogt-Russell theorem in your book?'. Of course, he did not remember. The student went and brought his copy and began reading out the relevant passage. It was clear that Schwarzschild too had followed the same fallacious reasoning as his illustrious predecessor. As a newcomer, I wondered what was going to happen next, but I need not have worried. The great peal of laughter for which Martin Schwarzschild was famous boomed out. On other occasions, he recalled how he missed the convective character of protostellar configurations (discovered by Hayashi) or a family of orbits in his galaxy model (found by de Zeeuw). Here was a man who was generous in his appreciation of what was new and interesting in the work of others, and cheerfully acknowledged the (very few) mistakes he had made.

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is worth adding some personal glimpses, obtained during a few months' stay in Peyton Hall (the building housing the Astrophysical Sciences Department of Princeton) in the early eighties. Both were nominally in retirement. But the glass wall of Spitzer's office showed passers-by that the hours he spent working at his desk were as long as those of most research students. In fact, Schwarzschild used to joke that his own next move would be to the basement which houses the students. Apparently he still wrote many of his own programs in FORTRAN, without using a single subroutine since he learnt the trade when these new-fangled things were not in vogue! The students, not unduly conscious of being with living legends, would go mountaineering with 'Lyman' or keep joking with 'Martin'. Lunch was one occasion when one could get Spitzer to comment on something, always briefly and clearly though in a deceptively mild manner. Any newcomer to the Princeton circle would actually be

sought out by Martin Schwarzschild who would introduce himself first with true Continental courtesy. This was no posture as he and his wife went out of their way to make visitors feel welcome. Perhaps he never forgot the fact that he was a newcomer once! It would be hard to find anywhere examples of academic retirement so filled with grace and purposeful activity and the respect which it engenders. The Indian tradition describes the ideal of a 'sanyasi' – an older person who sheds all desires, living in the middle of the world but apart from it, carrying out his duties and sharing his wisdom with younger people in a spirit of detachment. In faraway Princeton, I was fortunate to see two people who exemplified this spirit.

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The University of Chicago held a symposium in honour of S. Chandrasekhar in December 1996. The programme reproduced on the next page is testimony to Chandrasekhar's enormous influence on 20th century physics. We reproduce below the text of the after-dinner remarks made by Kameshwar Wali on that occasion.

— Editors

Subrahmanyam Chandrasekhar

Kameshwar C. Wali

Chandra often remembered his close friend of earlier years, Edward Arthur Milne, and quoted him as saying,

Posterity, in time, will give us all our true measure and assign to each of us our due and humble place; and in the end it is the judgment of posterity that really matters. He really succeeds who preserves according to his lights, unaffected by fortune, good or bad. And it is well to remember there is no correlation between the judgment of posterity and the judgment of contemporaries.

A year after death may not be a true measure of posterity. But this two-day symposium in Chandra's honour certainly marks the beginning of that posterity's assignment to bestow him his due place. To further aid the posterity, I have the honour to announce the publication of two books: the first one, titled *S. Chandrasekhar: The Man Behind the Legend* is a memorial volume containing articles by several of Chandra's students, associates and admirers. It includes many members in this distinguished audience. In these articles, the authors write, not so much about Chandra's scientific triumphs, but more about Chandra as a person, more about his rich and multi-faceted personality. This volume, to be published by World Scientific and Imperial College Press is now being copy edited in Singapore. I expect this to come out in two months' time. The second one, for which I have no good title as yet, will contain a set of Chandra's scientific papers selected from the seven plus one volume collection of selected papers. It will also include some of Chandra's unpublished lectures and articles of non-technical nature. It will be a part of the World Scientific series titled as *Twentieth Century Science* that includes the selected works of Julian Schwinger, Abdus Salam, and others.

For me personally, the years I spent

in working with Chandra and writing his biography were the most enjoyable and creative years in my life. After the completion of the book, although my visits with Chandra became less frequent, our friendship continued to grow and develop. During the summer of 1994, Lalitha and Chandra, my wife and I, spent a week together at the Stratford Shakespeare Festival in Canada. 'Get the best seats for the plays,' Chandra had ordered me. When I had called him a few days before our scheduled meeting in Stratford, he said he was rereading *Othello*, *Hamlet* and *Twelfth Night*, the plays we were going to see. Along with Lalitha, he was also listening to the records. Thus he came fully prepared to enjoy his rare vacation, setting aside his preoccupation with Newton at the time. We all had such good time, seeing a new play every day and taking sight-seeing trips surrounding Stratford. I recall on one of these car trips, Chandra surprised me by asking, 'which moves slower, heat or cold?'. While I was racking my brain, thinking about Boltzman and Maxwell's demon and all that, he said with a twinkle in his eye, 'cold, of course, because you can catch it!'

It was great to see Chandra as a full-time tourist, so light-hearted and impulsive in enjoying himself. Without the slightest hesitation, he bought a large-size painting he liked on the side walk and can any one of you imagine Chandra eating a patty burger without silverware in an open-air restaurant called Anna Banana?

I was not bugging him with questions about his life, his childhood, his days in Madras and Cambridge, his encounters with Eddington and Milne, The Yerkes Observatory and The University of Chicago, or the University of Chicago Press with which he was strongly, almost sentimentally, attached as the editor of the *Astrophysical Journal* for nearly

twenty years. Over the years I had made him tell and retell these stories. Without showing the least annoyance, he had obliged. I consider myself indeed fortunate that I had the opportunity to tell his life.

The last time I talked to him on the phone was during the first week of August 1995, when I received a complimentary copy of Newton's *Principia*. It had just come out in June. Still he regretted that I did not get the copy sooner. I thanked him and congratulated him. We both agreed that the Oxford University Press had done a commendable job in producing the book so elegantly. I said, 'Chandra, this work of yours will go down in history as monumental.' He had his doubts, he said. He had seen one or two critical reviews. But, he accepted my compliment and said, he no longer had the energy or stamina to do hard work. He complained about exhaustion and how he had to be helped back home when he was taking a short walk near his apartment. Those were grueling hot days in Chicago. I reminded him of that and said in a rather harsh tone, 'I forbid you to work hard anymore. You must relax and enjoy.' 'Yes, yes, that is exactly what I am going to do,' he replied. 'Just two short papers to be finished with Valeria Ferrari. I am indeed relaxing... I am reading *Les Miserables*.'

Famous last words, I said to myself. I am sure, if he were alive, he would be working on Newton and Michelangelo, and writing about a comparison between the motivations of scientists and artists in their creative quests. That is what he would devote himself to do, after disengaging himself from serious scientific work, he had said once.

Reading Chandra's essay on the series paintings of Claude Monet and the Landscape of General Relativity, one cannot fail to see an analogy. In Monet's series paintings, the same scene is depicted over