Asoke Nath Mitra (1929–2022)

Professor Asoke Nath Mitra, a distinguished theoretical physicist, passed away on 26 November 2022 in Delhi, aged 93. He was a survivor of the group of heroic figures who shaped theoretical physics in India after independence. He spent almost his entire life associated with the Department of Physics and Astrophysics at Delhi University. He was a Professor Emeritus there for the last several years.

Mitra was born on 15 April 1929 in Rajshahi, India (now Bangladesh). His father, Jatindra Nath Mitra, taught mathematics at Delhi University's Ramjas College. Mitra also attended Ramjas College to study mathematics, graduating with a bachelor's degree in 1947 and an MA in 1949. He then joined the Physics Department of Delhi University to do a PhD under R. C. Majumdar in 1949. There were several other students who had passed M.Sc. from Physics Department in 1949. B. P. Nigam, S. P. Pandya and M. K. Sundaresan from this group went to the US to do their Ph.D. L. S. Kothari went abroad later. They all studied theoretical physics. Subramanian Lokanathan, who left a year later, was the only one who worked in experimental physics with Jack Steinberger (Nobel Prize, 1988) at Columbia University, USA. (I joined as a student of the Department of Physics in 1949 in B.Sc. (Hons) course, and Mitra took our mathematical physics course in 1950–51.) Mitra was probably the first to finish his Ph.D. in 1952. He got the Central States Scholarship in 1952 and went to Cornell University in the USA. At Cornell, he worked with two great luminaries, Hans Bethe (Nobel Prize, 1967) and F. J. Dyson, and obtained a second Ph.D. in Physics in 1955.

During the world war in the US and Europe, all the technical personnel, including the scientists, were busy with war work. During the war, radar was a field where scientific work helped in anti-aircraft operations. There were innumerable other scientific and technological advances. When the war ended, scientists returned to universities and other civilian institutions. The technical progress, during the war, helped them in their work. Willis Lamb looked at the spectrum of hydrogen atoms more closely and discovered that two energy levels of H atoms did not have the same energy value as calculated by Dirac and Schrödinger independently in the late 1920s. This shift in one of the levels was called the Lamb Shift. Such a shift was expected, as radiative corrections to the energy level would change their values. But calculations of such corrections led to diverging or infinite values. What was needed was a way of handling the infinities to get a finite difference of value. Bethe, within a short time, did a 'back of the envelope' calculation that gave a nearly correct value of Lamb shift. (D. S. Kothari had taught us this method in 1953 in the M.Sc. final class.) Tomonaga in Japan and Schwinger

and Feynman in the US had independent schemes of their own for calculations. But there was little understanding or agreement in general. After 1949, in about five years, Dyson brought a lot of clarity into the field and the diagrammatic method of Feynman (Nobel Prize, 1965) was put into a form capable of calculations. One of the new features of the Feynman diagrams was the treatment of a positron as an electron going back in time. The post-war generation, including in India, had to learn these new methods. In the early 1950s, Bethe, Hoffman and others wrote the first textbook on the subject.

Learning and using these new methods in India, Mitra calculated the radiative corrections for Compton scattering and Bremsstrahlung in Delhi. It was published in *Nature* in 1952. The details were published in the Japanese journal *Progress in Theoretical Physics*, in October 1952. The third paper by Mitra, from the US, also published in 1952, was with his supervisor at Cornell, F. J. Dyson, on 'Evidence of a direct meson–meson force' in *Physical Review*, 1952, **90**, 372. In those days, the publication of a paper easily took more than a year. (The IT revolution, beginning in the late 1990s has shortened this time drastically. It is now almost a level playing field, whether one is in India or the West, for the time taken to publish. The attitude towards papers from India is changing, but slowly).

Mitra returned to India in 1955 and joined Aligarh University as a reader. He continued his research work with students along with teaching. In 1960, he moved to Delhi as a reader. He was a visiting professor at Indiana University in Bloomington in 1962–63. He was appointed professor at Delhi University in 1963 at the relatively young age of 34. His work at Delhi as a reader marked a distinct shift in his interests, creating and exploring a new field of research rather than joining the 'bandwagon' as many other particle physicists did.

Mitra chose to shift to the study of the three-body problem. In classical mechanics, the two-body problem is easy to solve. One separates the centre of mass motion and solves the dynamics in relative coordinates. There is, however, no simple way to proceed with a three-body problem. In quantum mechanics, the difficulties are even greater. Mitra was able to reduce exactly the three-body problem to a two-body problem using a potential separable in momentum space (a potential of zero range in space is one such; this is a very good approximation to very short-range potentials present in many areas of physics). The solution leads to a better understanding of the ground and excited states, unlike in a variational approximation. In 1961–62, he published about five papers, ending with a paper in the *Nuclear Physics*. This generated a lot of interest in the context of Faddeev's theory of the three-body system and got a number of citations. Initially, the three-nucleon problem was taken up. In 1964, Gell-Mann (Nobel Prize, 1969) and Schweig proposed a model for the nucleon with three quarks. Mitra could, thus, study the nucleon also by his method. R. H. Dalitz also took up the quark model seriously, and it caught on rapidly. As a capstone of his nearly decade-long work, Mitra published a long review on 'The nuclear three body problem' in the *Advances in Physics* in 1969.

Mitra's principal contributions are (i) the exact solution of the nuclear 3-body problem with separable potentials, which offered a new insight into the structure of the 3-body wave function, leading to 'few nucleon studies' as a new branch of physics, (ii) a node in the proton e-m. form factor unless fermion quarks have an extra degree of freedom; a forerunner for the discovery of 'colour' and (iii) 'the quark recoil effect' (in association with Marc Ross) for the understanding of enhanced heavy meson modes of decay. The study of 2-body and

3-body systems at successively deeper levels of compositeness, from nuclear to sub-hadronic, attempted to bridge the traditional gap between theoretical sophistication and empirical fit to data. His initial work was non-relativistic, but to deal with light quarks with relativistic velocities, he used the Bethe Salpeter equation in later stages in the 1980s. One of Mitra's finest hours was when he hosted successfully the VII International Conference on 'Few-Body Problems' at Delhi University in December 1975 and then edited the proceedings published in 1976. In the 1980s, he lectured on these ideas at Caltech in the USA and got the appreciative attention of Feynman. Mitra became Senior Professor at Delhi University in 1969 and continued untill 1994. He was the Albert Einstein Research Professor at INSA from 1989 to 1994.

Mitra was a fellow of the three science academies in India, INSA, IASc and NASI, as well as the Third World Academy of Sciences (TWAS) in Trieste. He won several awards, beginning with the S. S. Bhatnagar Award in 1969, the Meghnad Saha Award (1975), the S. N. Bose Medal of INSA (1986), and others.

Mitra became the Head of the Department of Physics at the University of Delhi in 1973, when F. C. Auluck retired. The university had amended the rules to make it a three-year term instead of a lifelong one. Almost the first thing he had to deal with was the procedure for inviting visiting speakers from foreign countries. Like most good institutions, many lecturers spoke in the Department of Physics. Almost all foreign invitees to the Indian Science Congress and other big meetings passed through Delhi and gave lectures. In 1972, a well-known particle physicist was invited to stay in the guest house and give some lectures in the department. Unfortunately, the invitee was also a member of a committee advising the US Government on science related to warfare. Some leftist organizations at the university became aware of this and organized a protest to prevent the lecture. After some scuffles and disturbances in the lecture hall, they succeeded. Besides media coverage, there was also political fallout. Questions were asked in parliament. Mitra, who became head soon after the event, had to answer a large number of queries and give clarifications to higher bodies like Parliament, the Ministry of Education, the University Grants Commission, and others. I had occasion to see the bulky file later. Mitra's plea for academic autonomy was evident in every letter he wrote. What amazed me was the fact that Mitra never mentioned or took credit for all his efforts in minimizing the constraints. Probably, it was the most natural thing for an academic to do, and that was that, as far as he was concerned.

On becoming the head, Mitra started by consulting teachers, both senior and junior, and tried to bring about much-needed changes in the courses offered and in administration. He succeeded to some extent, but soon found it difficult to persuade others to go along. Midway through the term of three years, he gave up the headship. This also happened with the two other young professors appointed at the same time as Mitra. Both L. S. Kothari and S. N. Biswas resigned halfway through their terms.

Mitra, unlike some other scientists, kept himself up to date with current events and trends in the country and in the world, in science as well as in politics. But his first love was research in science. George Sudarshan, in his Nehru memorial lectures in the 1970s, said that scientists are the modern rishis (sages) for whom research is tapasya or worship. Looking at some of the eminent teachers in Delhi University and the country, this may be easy to believe. According to D. S. Kothari, this was true even in the West. Rutherford and Dirac did not pursue money. The commitment and devotion of these teachers to the study and teaching of science are so intense that they forego many other interests and economic advantages in life. While spending time at the International Centre of Theoretical Physics (ICTP) in Trieste, Italy, Mitra would often stay overnight at the Centre, even sleeping on a couch in the library. This drew comments from Abdus Salam (Nobel Prize 1979), the founder and director of ICTP. He knew Mitra well and had high regard for him. Salam used to advise visitors not to underestimate themselves or their personal needs. Yet, commitment above physical needs does lead to admiration.

Mitra has constantly tried to identify, propose and support possible candidates for election to the science academies in India. He succeeded in some cases. In one particular case, bright scientist failed because of disunity among the teachers of the department and their supporters in the Academy. Senior professors often disagree. Sometimes they discuss among themselves and agree on a common approach. This is what happened in Delhi when D. S. Kothari and R. C. Majumdar were senior professors. With professors who came later, this process did not quite work out. This caused difficulty running the department from time to time.

After retirement, Mitra did quite a bit of writing and editing. His descriptive English writing has always been a source of admiration. He brings out the nuances and subtleties in the themes, and the intellectual level of his articles is high. In 2000, he edited a book on *Quantum Field Theory, A 20th Century Profile*. During 2005–2010, he took up the editing of a book about physics in India after independence, titled *India in the World of Physics: Then and Now* for the Centre for Study of Civilisations at the request and recommendation of Raja Ramanna. It was a mammoth task; it took, even Mitra, all of five years. The time taken indicates the difficulties associated with such a task. His stature persuaded eminent and not-so-eminent scientists to find time to write. The reviews in the book are lucidly written by well-known experts and edited knowledgeably. Reading the book, one feels that a lot of very impressive Physics research activity is going on in India. But work of the caliber of Raman, Bose or Saha is very rare. Maybe bold and imaginative thinking is needed. The change in emphasis of IITs to outreach and study of problems of direct impact in daily life may also help. There should also be easy access to the internet for such reviews and books.

Mitra had a way of underplaying himself and not taking centre stage, which sometimes leads to amusing situations, as the following anecdote describes. N. Mukunda was once giving a lecture in Delhi when Mitra came in a little late and tried to sneak in quietly and take a back seat. Mukunda paused and asked him to come forward. Mitra said apologetically 'I am only an observer, please ignore me'. Mukunda said, 'When the observer comes, the wave function collapses. We cannot ignore you.' (In quantum mechanics, the wave function of a superposition of two mutually exclusive states, on measurement by the observer, collapses to one of the states in an irreversible process.)

In 2013, *Current Science* launched a series on Living Legends of Indian Science. I wrote a celebratory piece on A. N. Mitra, which was published in Vol. 106, no. 1, on 10 January 2014.

Asoke Mitra married Anjali Ghosh in 1956. They had two daughters, Bani and Gargi. Anjali passed away a year ago, while Bani, who lived abroad, expired two years ago. Gargi lives overseas but visits India frequently.

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