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Prof. Meghnad Saha (1893-1956)

A. K. DAS

Astrophysical Observatory, Kodaikanal

Prof. Meghnad Saha, the eminent scientist, passed away at New Delhi on 16 February 1956 at the age of 62 years. In his death India has lost one of her illustrious sons, the world a brilliant scientist and modern astrophysics one of its most distinguished founders who by virtue of his fundamental contributions ranked with Eddington, Russell, Jeans, Hale and a few others.

1. Early life

Meghnad Saha was born on 6 October 1893 in the small village of Seoratali in the district of Dacca in East Bengal, now in East Pakistan, as the fifth child in a Hindu middle class family whose livelihood was a small shopkeeping business. After his early education in the local primary school and in a middle school at Simulia at a distance of 7 miles from his home, he came to Dacca in 1905 and was admitted to the Secondary School attached to the Dacca College. This was the time when Lord Curzon, then the British Viceroy of India, announced the partition of Bengal which gave rise to the great national movement under the leadership of Aurobindo Ghosh. Like many other brilliant boys young Meghnad also reacted to the political ferment of the day and forfeited the scholarship and free studentship which he had won through sheer merit. This was a great set-back, for Meghnad did not come from a rich family. But as was to be demonstrated again and again in his life Meghnad was not daunted by such difficulties. He carried on with his studies, sometimes paying his way by what he could earn through giving private tuition to younger boys. He was always a brilliant student and in 1911 joined the B.Sc. class of the Presidency College of Calcutta, which then as in later days had the distinction of having on its rolls the very best students of the University. That was a period when two of India's most distinguished scientists of the older generation, Prof. Jagadish Chandra Bose and Prof. Prafulla Chandra Ray, were on the staff of the Presidency College and young Meghnad drew his inspiration for scientific research from the examples of these two great men. As was to be expected he got a first class M.Sc. degree in Applied Mathematics which he took in 1915. After this Saha wanted to compete for the Indian Finance Service, but his nationalistic tendencies and his independence of

spirit were known to the authorities who could not approve of the admission of such a man in the Indian Services of those days. Thus, the Government of the day, saved Meghnad Saha for science.

2. Beginning of his scientific work

Soon after Meghnad Saha obtained his M.Sc. degree, the University College of Science and Technology of Calcutta was founded through the munificence of the lawyers Tarak Nath Palit and Rash Behari Ghosh, two outstanding donors to the cause of scientific research and education in Bengal. Saha joined the college as a Research Scholar in Mathematical Physics, a subject to which, as a student of Applied Mathematics, he was naturally attracted. Thus began one of the most successful careers in the history of science in India. Soon thereafter Saha was invited by Ashutosh Mookherjee, the eminent Vice-Chancellor of the University of Calcutta at that time, to serve on the staff of the Department of Mathematics. He agreed and was appointed as Lecturer in Physics and Applied Mathematics. In those days there was hardly anyone in India, other than Prof. D. N. Mallik of the Presidency College of Calcutta, who did any original research in mathematical physics. Meghnad Saha's efforts in this field were therefore almost entirely self-initiated and all the more remarkable for that reason. One of his first original contributions to theoretical physics was his mathematical derivation of the law of attraction between two moving electrons. This was of course an old problem first studied mathematically by Gauss in 1835. But Saha determined the law with the aid of the New Electrodynamics, *i.e.*, the classical Maxwellian electrodynamics modified by Lorentz, Einstein and Minkowski according to the Principles of Relativity.

3. His contributions to Astrophysics— Thermal Ionisation Theory and its verification

Then followed a series of remarkable papers dealing with an entirely novel manner of interpreting the spectra of the sun and the stars which were regarded by many astronomers to be so revolutionary that some of the conservative astronomical journals refused to accept them for publication. However, this was not the first time that unimaginative conservatism had hampered the progress of scientific thought. Eventually, the earlier papers dealing with Prof. Saha's new theory of astronomical spectra appeared in 1920-21 in the *Philosophical Magazine* of England and at once attracted the notice of some of the most famous contemporary astronomers, notably Henry Norris Russell of the U.S.A. who hailed the Saha theory as a discovery of the highest importance to the then very young Science of Astrophysics. The central idea of this new theory, which is now universally known as the Saha Theory of Thermal Ionisation, is that gases can be ionised by heat alone and that in the outer layers of the sun and the stars the details of the observed spectra of the constituent atoms can be quantitatively explained from a knowledge of the degree of ionisation of the concerned atoms under the prevailing thermodynamic conditions of temperature and pressure. Saha's theory was the first application of thermodynamics to the outer layers of a star, although, as Prof. Saha himself wrote in 1920 in his first published paper on the subject, Eggert of Germany had applied thermodynamics already a year earlier to the question of dissociation in the inside of fixed stars and had shown that many of the assumptions made by Eddington in his beautiful theory of the internal constitution of stars could be substantiated by the use of the Nernst formula of "Reaction-Isobar". However, what Saha did was not merely an application of

Eggert's method to the outer layers of the sun and the stars. It was much more than that; it was a most fruitful synthesis of classical thermodynamics and the then new quantum theory of atomic spectra as developed by Niels Bohr. At that time the thermodynamic theory of ionisation was regarded as a bold and uncertain generalisation which could not be tested under terrestrial conditions, although it must be mentioned that in 1921 Prof. Saha himself, in collaboration with a German scientist named Dr. Paul Günther, had performed in Prof. W. Nernst's Physical Chemistry Laboratory at the Berlin University what was probably the first successful experiment establishing the ionisation of gases by heat. A few years later Sir Arthur Eddington wrote, in his "Internal Constitution of Stars", that if the thermodynamical theory of ionisation had received universal recognition it was due to Eggert's application of it to the interior of stars, but more especially because of the methods of testing of the theory in the outer regions of stars as indicated by Saha. As Eddington has written, the theory appears to be logically self-evident from the standpoint of quantum theory, "but it is easier to perceive the inevitability of a conclusion when one is already persuaded by experiment of its truth." Since its publication in 1920 Prof. Meghnad Saha's theory of thermal ionisation has dominated all modern advances in the observation and interpretation of stellar spectra. On the basis of this fundamental work Saha was awarded the D.Sc. degree of the University of Calcutta and the Prem Chand Roy Chand Studentship which helped him to go abroad to England and Germany, where he came into personal contact with Prof. Einstein, Prof. Nernst, Prof. Eddington and Prof. Alfred Fowler. The basic equation of the theory of thermal ionisation, the famous Saha Formula, was developed in its strictest mathematical form a little later by R. H. Fowler and E. A. Milne, but it was to Saha that the world of astrophysics unanimously gave all credit for the new and most fruitful field of research which his theory opened up. It was again Dr. Meghnad Saha, who first drew the attention of the astrophysicists to the possibility of the existence of a *selective* radiation pressure quite distinct from the classical Maxwellian radiation pressure, and showed what important consequences this might have in astrophysical phenomena. This idea became the basis for the theory of chromospheric support later proposed by Prof. E. A. Milne and continued by his associates which finally developed into the theory of line-profiles so fundamental to all quantitative analysis of the structure of stellar atmospheres.

4. Work at Allahabad University

On his return from Europe Dr. Saha was appointed to the Khaira Chair of Physics at the Calcutta University, but he left Calcutta about 2 years afterwards as he found it impossible to secure the kind of facilities he needed for the work he had in view. He accepted the professorship of physics at the University of Allahabad and soon built up an active school of spectroscopy and theoretical physics there, which was noted alike for the high standard of its teaching and of research. Prof. Saha was also responsible for the organisation of an Electronics Laboratory at the Allahabad University and under his leadership a considerable amount of notable research work was done in various branches of physics. While at Allahabad he was elected a Fellow of the Royal Society of England, and soon afterwards he went to Europe for a few months during which he attended the International Congress of Physics held at Como (Italy) on the occasion of the centenary of the great Italian physicist Alessandro Volta. In 1936 the Carnegie Trust offered Prof. Saha an overseas fellowship which enabled him to spend several months in some of the great centres of astrophysical research in the United States. During this period Saha came out once

again with a new theory which purported to show that many features of ionospheric phenomena and of the spectrum of the night sky could be explained only on the basis of the hypothesis that the sun did not radiate as a black body at a temperature of 6000°K . Saha suggested that the normally inaccessible part of the sun's ultra-violet spectrum probably contains emission lines of *H*, *He* etc. whose intensities are of the order of a million times the intensities to be expected from a black radiator at 6000°K . This prediction cannot be said to have been verified fully but the very recent observations made on the nature of the extreme ultraviolet spectrum of the sun with the help of rocket flights at altitudes of 100 kilometres and more suggest that Saha's prediction may yet turn out to be correct.

5. Back at Calcutta

In 1938 Prof. Saha returned to his old University at Calcutta, and this time as the Palit Professor of Physics. His enthusiasm and energy were as great as ever before; and against great financial odds he succeeded in creating an Institute of Nuclear Physics, the premier institute of its kind in the country, of which he was the founder Director. This Institute will forever remain a monument to one of Prof. Meghnad Saha's achievements as a nation-builder. After the creation of the Institute of Nuclear Physics he concentrated most of his attention on researches in nuclear physics and under his leadership much valuable work has been turned out by that institute during the last decade. But he himself could not for long keep away from his favourite subject, for he returned to astrophysics whenever an opportunity arose; and at each such incursion he brought to astrophysics something novel, something worthy of consideration. For instance, in 1941-42 he put forward a new theory of solar corona in which he suggested that the heavily ionised atoms of iron, nickel and calcium could be due only to some kind of nuclear reaction, similar to Uranium Fission, occurring at some depth below the chromosphere. Although this is a bold theory, one cannot deny the originality of the underlying idea. Again in 1946, when after World War II radio-astronomy came to the forefront as an unusually promising tool of astrophysical research, Prof. Saha with his long and mature experience in the theoretical investigation of the propagation of radio-waves through the terrestrial ionosphere showed that the *ordinary* radio-waves of metre wavelength received from the sun could not have their origin either in the reversing layer or the chromosphere; they could originate only in the corona. He also put forward the view that "large sunspots are just the regions whence the *extraordinary* waves of the frequency range 10—200 Mc. can escape." According to this view, radio-waves of both centimetre and metre range from the sun and the stars could be emitted through transitions between energy-levels of the nuclei of atoms in spot regions where the atoms are presumably placed in a strong magnetic field which is crossed at right angles by a much smaller, but rapidly varying field, as in the ingenious absorption experiments by Rabi and his co-workers.

6. An active life

Prof. Saha retired a few years ago from the Palit Professorship of Physics at the Calcutta University, but his innate zeal for work not only continued unabated but enabled him to enlarge his sphere of activities. He continued to direct the Institute of Nuclear Physics. In addition, he served the Indian Association for the Cultivation of Science, of which he was a life member, as Secretary, Vice-President and since

1948, as President. When the Association was reorganised and expanded, he became its first Director in 1953.

Mention should be made here of the valuable services rendered by Prof. Saha to the organisation of teaching of Science and Technology as the President of post-graduate teaching of Calcutta University and also as a member of the University Commission appointed by the Government of India in 1948.

National Institute of Sciences—In 1930 Prof Saha founded at Allahabad the Academy of Sciences of which he was founder President; this later became the National Academy of Sciences, India. In 1934 he was elected President of the Indian Science Congress which met at Bombay. In his address he pleaded for the first time for a scientific platform in India for the utilisation of science for the benefit of society and for the formation of a body of scientists like the Royal Society of London. The National Institute of Sciences of India which was founded in 1935 and of which Prof. Saha was the President from 1937—39, was the result.

Science and Culture—Prof. Saha was the founder Editor of the Journal "Science and Culture" in which were published, from time to time, many of his progressive ideas including his vigorous campaign for undertaking river valley schemes and a large scale industrialisation in the country for the last 20 years.

National Planning Committee—It was at Prof. Saha's suggestion that Netaji Subhas Chandra Bose, when elected President of the Indian National Congress in 1938, founded the National Planning Committee which met for two years under the Chairmanship of Mr. Nehru, now the Prime Minister of India. As a member of the main Committee and as Chairman of two Sub-Committees on "Power" and "Education", Prof Saha rendered very valuable services to the Planning Committee.

Astronomy and Calendar Reform—Among Prof. Saha's varied interests special mention should be made of 'astronomy' the study of which was almost a passion with him. Ever since 1946 he had been a member of the Standing Advisory Board for Astronomy set up by the Government of India, and it was indeed due to his initiative and zeal that the Council of Scientific and Industrial Research set up an Indian Calendar Reform Committee with Prof. Saha as Chairman. Just a little before his death this Committee completed its work and has produced a very valuable report with recommendations for a uniform civil calendar for the country and for the preparation of an Indian Ephemeris and Nautical Almanac. No less were Prof. Saha's efforts successful in convincing the Government of the need for establishing a modern well-equipped Central Astronomical Observatory in India so that the country may be able to regain its prestige in astronomical researches for which India was renowned in ancient times.

Scientific Delegations—His interest in scientific work took him several times in his eventful career to U.K., west Europe, the U.S.A. and the U.S.S.R. on a number of official as well as non-official missions. His last mission was to Dublin where in August-September 1955 he attended the 9th General Assembly of the International Astronomical Union.

Parliamentary Work—All these heavy responsibilities in the field of science which Prof. Saha had borne during this period did not seem to exhaust his indefatigable capacity for work. He entered the Indian Parliament as a member of the Lok Sabha in 1951 as an "Independent" from West Bengal after a very keen election

fight. His speeches in the Parliament commanded attention from all sections of the House. It is worthy of mention here that he laid down his life on the very portals of India's Parliament to which he was proceeding to attend a Committee meeting of the Planning Commission.

Social Work—Ever since his early youth Meghnad was devoted to social work and as early as 1914 he took a prominent part in flood relief and other similar work and in 1923 he set up the Bengal Relief Committee. In 1950 as a maturer man he organised the East Bengal Refugee Relief Committee and led several deputations to the Government on behalf of the displaced persons.

Although in his college days he was not known for his prowess as a sportsman, Meghnad Saha was nevertheless regarded by his contemporaries as one of the most active young men of those days. He was known to have a phenomenal memory and a great capacity for hard work, both intellectual and physical. He was greatly influenced by his association with Prof. Prafulla Chandra Ray from whose example he derived his inspiration for the nation-building activities, which along with astrophysics and pure physics continued to be his passion till the last day. He had too versatile a mind to remain circumscribed within the narrow limits of personal scientific research. He devoted a great deal of his restless energy to activities calculated to promote the organisation of science in aid of economic development of India, for he was not only a celebrated scientist, a great thinker, an eminent educationist and an indefatigable organiser of research, but also an ardent patriot.

By his sudden death India has lost a scientist of truly international repute, a true democrat, a fearless opponent of what he considered to be evil and a zealous advocate of large-scale industrialisation, national laboratories and every project likely to contribute to the economic development of the country on scientific lines. His students have lost a great teacher—a "Guru" in the best of old Indian traditions—and a life-long friend and well-wisher.
