



# Meghnad Saha, F.R.S.: the multiple facets of a teacher

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## Abstract

Meghnad Saha, the famous scientist, researcher, organiser and institution builder became a D.Sc. at the age of 25 and the 5th Indian Fellow of the Royal Society (F.R.S.) at 34. Having primary education in village schools, he rose to be one of the top scientists India ever produced, establishing two of the foremost science academies of the country. He has been nominated six times for the nobel prize. These are discussed elsewhere elaborately, as also his political career. However, Meghnad was primarily a teacher, starting his initial teaching career during 1916–1923 at Calcutta University; moved to Allahabad University from 1923 to 1938 and again returning back to Calcutta University in 1938. He retired from Calcutta University in 1953. Meghnad Saha's teaching and in particular, his text books had a global impact. The *Text Book on Heat* (1931), *Treatise on Heat* (1931), *Treatise on Modern Physics* (1934) and *Six Lectures on Atomic Physics* (1931) were all voluminous books, co-authored by his students (excepting the last one). The revised editions of these books were brought out at regular intervals. This article deals with Saha's teaching and his text books, which withstood the ravages of time.

**Keywords** Allahabad University · Calcutta University · Joseph Larmor · Meghnad Saha · Thermodynamics texts · R.H. Fowler · Treatise on heat

## 1 Introduction: education

Meghnad Saha's researchs, organisational abilities, institution building capacities and progressive political outlook—has all been portrayed in detail in the existing biographies and books on him (Chattopadhyay & Chattopadhyay, 1994; Mukhopadhyay, 2012). However, Meghnad (1893–1956) was first and foremost a teacher. This article tries to deal with that aspect only. In Calcutta University, he joined as a lecturer in Applied Mathematics during 1916, just after his M.Sc. (1915) from the same University. Then he was shifted to the Physics Department (where C.V. Raman was the Head). He retired from Calcutta University in 1953, few years before his untimely death in 1956 in Delhi. In between, he spent 15 years at Allahabad University (of Central Province, as it was known then) as a Professor and Head of the Physics Department from 1923 to 1938. And then from 1938 to 1953, he was a Professor at Calcutta University. He built-up

institutions galore; but he taught classes and built-up an excellent band of students of research, particularly in Allahabad and most importantly wrote three excellent textbooks (co-authored by students) which were lauded by experts world wide, as revealed in reviews of the books published in *Nature* and such other journals. In fact, the present article also explores the origin of the Zeroeth Law of Thermodynamics (as is taught in all text book on Thermodynamics) which was first hypothesized by R.H. Fowler, Professor of Cambridge in one of the book reviews in 1936.

Born and taught in village schools, M.N. Saha did his Intermediate and B.Sc. in Applied Maths (1913) from Presidency College, M.Sc. (1915) from Calcutta University in Applied (*Mixed*) Math and was almost immediately inducted by the then visionary Vice-Chancellor, Sir Ashutosh Mookerjee, into teaching. **M.N. Saha joined as a Lecturer when C.V. Raman was the Palit Professor in Physics.** His compatriot during all these years were Satyendra Nath Bose (1894–1974). Meghnad was proficient in German and he had the keen desire to go through journals in the library.

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### Both M.N. Saha and S.N. Bose were requested to teach Physics as Dr. D.M. Bose was away in Germany.

In 1920, he and S.N. Bose jointly made the first English translations of Einstein's papers, which was published as a book format by the Calcutta University. The foreword of the book was written by Prasanta Chandra Mahalanobis (1893–1972). It seems that this was the only time, the trio of Bengal renaissance worked together. Prasanta Chandra Mahalanobis and Meghnad Saha combinedly wrote the footnotes of the book (Saha & Bose, 1920).

## 2 The teacher: Calcutta University and Allahabad University

What did Meghnad Saha teach? As Devorkin writes (Kar-Mahapatro, 1993): “His broad research interests may well have been a result of his teaching responsibilities. Saha's course lectures cut a wide path through physics. He lectured on hydrostatics, geodesy and the figure of the earth, as well as spectroscopy and thermodynamics. He was also in charge of the Heat Laboratory.” This was in Calcutta University.

Such was Meghnad Saha's brilliance that as early as 1917, he published his research paper in *Physical Review*, the most prestigious journal, in physical sciences.

In 1918, he did original research work on the pressure of light by fabricating a set up in the physics laboratory of the university. He published the results in a paper, ‘on the pressure of light’ in the *Journal of Asiatic Society*, Volume No. XIV, pp. 425–432, 1918. This was his first paper (Sen Sarma, 2004). Ultimately, expanding this as a thesis, he submitted it for D.Sc. degree of the Calcutta University. The three foreign examiners of this thesis were W. Richardson, Dr Porter and Dr N.R. Campbell (Mukhopadhyay, 2012). On their unanimous recommendation, Meghnad was awarded the D.Sc. degree in 1919. In the literature review part, he writes ‘Bartoli (*Nuovo Cimento*, 15, 1883, p. 195) showed in 1877 that the pressure could also be deduced by means of thermodynamic reasoning involving only the two laws of thermodynamics...’. Such absorbed he was in the subject thermodynamics. Calcutta University awarded the first D.Sc. in 1916 and Meghnad Saha was one of the earliest recipients. The degree definitely added to his stature as a teacher. For his other publications on Stellar Spectra, on which he started working in 1919, he was awarded the Premchand-Roychand stipend and Griffith Scholarship. In this period, he used to teach Thermodynamics to M.Sc. students. One of the books he followed was Max Planck's *Treatise on Thermodynamics* whose English translation was just published.

Meghnad Saha spent about two years in England and in Germany and came in touch with Alfred Fowler, Walther Nernst, Arnold Sommerfeld and others. His relationship with Sommerfeld continued for lifetime. He was called

back to India in the end of 1921 to join Calcutta University as Khaira Professor of Physics by Sir Asutosh. But during 1921–1923, though he tried to build-up a research laboratory and a research group—he failed, one of the main reasons being fund crunch. So he decided to leave Calcutta in 1923 to join as Professor and Head of Physics at the Allahabad University. He spent 15 years in Allahabad and that was a very fruitful period of his life. He became F.R.S. in 1927 and in 1930, he established the Allahabad Science Academy and amongst all these activities he carried on research, teaching and above all, writing text books for students.

How Prof Meghnad Saha could devote time to teaching despite all his busy schedule including research and administration. We also have to remember that he was only the 5th Indian at the age of 34 years to become a Fellow of the Royal Society (FRS) against stiff internal opposition at the society for his aggressive nationalist views. A D.Sc. and F.R.S. Prof Saha used to take classes from undergraduate first year to post graduate final year on subjects ranging from kinetic theory to statistical thermodynamics to spectroscopy (Sen, 1954). He did supervise laboratory classes and tutorial classes too. Prof Saha read extensively the existing texts particularly that of Max Planck and Nernst both of whom were Nobel laureates (Singh, 2016). And he did read journals and articles regularly to remain updated in his subjects. During classes, he used to write on the blackboard part of his lecture, used slides and in particular did small experiments designed for the particular class. These novel methods increased his reputation as a teacher. Parallely, he also motivated his research students to write research papers independently. Amongst the famous students he had, were D.S. Kothari (later to become advisor to Government of India), Brahma Narayan Srivastava (Dr. B.N. Srivastava who co-authored and revised books for him), R.K. Sur, N.K. Saha, G.R. Toshniwal, L.S. Mathur, B.D. Nagchaudhuri etc. Most of the students rose very high in life and kept in touch with their teacher as long as possible (Chattopadhyay & Chattopadhyay, 1994; Gupta, 1994; Sen, 1954).

Prof Saha counseled and mentored students and maintained life long relation with most of his students. It must be remembered that in an age, when mobile phones and e-mails were not even heard of or imagined—this was a tough task but a pleasure for a true teacher, as Prof Saha was. His house at Allahabad was always open and accessible to students, as many memoirs of his students mention (Chattopadhyay & Chattopadhyay, 1994).

## 3 Text books by M.N. Saha

Text books must have problems for students. It is also important that eminent professors write text books with lucidity and nationally relevant examples. This makes the students



more comfortable as we still use the English language for our teaching at tertiary education. Prof M.N. Saha was so much of a teacher that he wrote three text books, two on ‘heat and thermodynamics’ and one on ‘modern physics’—all arising out of his class lectures at both Calcutta University and Allahabad University. The thermodynamics books were written, one for B.Sc. students and the ‘Treatise Book’ for M.Sc. & Research students (Saha and Srivastava, 1958).

Also, he delivered a series of lectures at the Patna University on Atomic Physics which was published by the Patna University as a book titled ‘*Six Lectures in Atomic Physics*’ in 1931. The records indicate that the books were written between 1931 to 1934. The reviews of all the books were published in *Nature* between 1932 to 1952, as also in the *Quarterly Journal of the Royal Meteorological Society*, *Science and Culture* and *Current Science*. Very few of Indian text books written at that time were so widely reviewed and lauded, as the following discussions will highlight.

As mentioned above, there were two versions of the book *Text Book of Heat* (including Kinetic Theory of Matter, Thermodynamics, Statistical Mechanics and Theories of Thermal Ionisation). Both were published from the Indian Press Ltd., Allahabad in 1931. The co-author B.N. Srivastava (Born: 1905) was only 26 years old then. The foreword for the *Text Book of Heat* was written by C.V. Raman (July, 1931), where he states ‘...readers both in and outside of India—who, it is confidently hoped, will study this book and appreciate its merits’. C.V. Raman was by that time a Nobel Laureate, however, the differences of opinions (if any) with Prof Saha was not reflected in this foreword (Anderson, 2010).

The review of this book by N.M.B. was published in the November 26, 1932 issue of *Nature*. Two lines only will be quoted here: “The need for a good digest of modern heat theory must have been acutely felt by the majority of advanced students and the publication of this text book ...is all the more welcome at the present time...a comprehensive survey, conceived and carried out on broad and generous lines which could only otherwise be obtained by labourious references to a large number of special treatises and original papers. ...The volume as a whole is undoubtedly one of the best advanced text books of heat and much attendant physical chemistry, at the present time ...’. The printing was criticised by the reviewer.

The second and revised edition of the book titled *A Treatise on Heat*, was a 815 page voluminous book published in 1935 from the Indian Press Limited, Allahabad and Calcutta. It was priced 27 shilling, meaning an edition for international sale was also there. This book was reviewed by R.H.F. (R.H. Fowler) who was an eminent physicist from Cambridge University. It was a 3 page review

published in *Nature*, April 4, 1936, and was titled ‘Heat a Mode of Motion: A Modern Version’. The words/phrases ‘grand manner’, ‘pleasing’, ‘as a whole high level of the earlier part of the book’ were scattered in the review. Also, this was where R.H. Fowler first coined the term ‘Zeroth Law’ of thermodynamics. He writes: “There exists a variable called the *empirical temperature*, which may be used in defining the state of any system having the property that it has the same value of all parts of a system in thermal equilibrium”. R.H. Fowler also argues/comments that thermodynamic functions should be defined following Carathéodory’s approach. The statistical thermodynamics part was criticised as also some symbolism. But ironically, then he comments ... “I have already expressed my admiration for the style of the book, and this in no way is diminished by a number of sentences incorrectly constructed. Such mistakes...add a pleasant favour to the style rather than detract from it...”! He also criticises the printing and the layout of the pages. R.H.F. concludes by writing “...the general standard of the treatise is so high that criticism of the points with which one disagrees seems worthwhile. ...It will be widely read and run rapidly through many editions”.

Interestingly, a rejoinder of this review by the eminent Scottish physicist Prof Joseph Larmor, F.R.S., was published in the May 9, 1936 issue of *Nature*. In a short but firm note, he wrote “Especially would I firmly support the Indian authors in passing over the preliminary abstractions of Prof Carathéodory of Munich and his school. I remember, when Prof Planck, in a new edition of his book on Thermodynamics attracted attention by ultimately blessing them”.

So it can be seen that the Thermodynamics book by Saha and Srivastava reached a world audience by 1936.

In India, the review of the 2nd edition of the *Treatise on Heat* was written by S.N.B. (Satyendra Nath Bose) in the *Science and Culture*, Vol. II, No. 9, (1937) (12). We find that the review of the book (a short one) came out much later than in *Nature*, which of course is published from England. And again, those were the days of surface mail! Satyendra Nath Bose (S.N.B.) ends the review by saying, “This systematic and up-to-date treatise removes a long felt want in the academic circle. May it prove a vital and fruitful stimulus to all the young aspirants of knowledge and induce fresh work and deeper investigation into the mysteries of nature”. Without irreverence, one can say that it was a ‘surprising review’! compared to that in *Nature*.

The 3rd edition of the book was retitled, *A Treatise on Heat including Kinetic Theory of Gases, Thermodynamics and Recent Advances in Statistical Thermodynamics*. Published in 1950, it was thoroughly revised and priced 32 rupees. The review in *Nature* was published in the January



26, 1950 issue, done by J.F. Allen. Allen writes ‘it is therefore refreshing to read the new edition of this well-known text book, especially the latter half, which contains much new material and has been extensively revised. ...The book is suitable for all levels of university teaching, from first year to graduate study. ...The rest of the book is excellent. In particular, the chapters dealing with statistical mechanics, kinetic theory and vapour pressure and radiation are to be recommended...’.

These portions were highly criticised in the 2nd edition review by R.H. Fowler. So, extensive revision must have been made by the authors.

The review made by G.D.R. in the *Royal Meteorological Society's Quarterly Journal*, Vol.78, issue 338, p.653, October 1952 makes this important point: “There are numerous references to the original work of American Asiatic and European Physicists...”. He writes, “The Treatise can be strongly recommended both as a source book and a text book for the honours students”.

The book, *A Treatise on Modern Physics: Atoms, Molecular and Nuclei* by Prof M.N. Saha, Vol. I was published by the Indian Press Limited, Allahabad and Kolkata in 1934. Priced 30 shilling, it was a 856 page book. The review was made by E.N. da. CA. In his 2½ page review, he concludes by saying that “we all rejoice in the rapid strides Indian Science is making and I wish I could greet this new evidence of activity with more encouraging words. The learned authors have perhaps wished to undertake too much.” The overall review was critical and discouraging. This book did not get a good response and so, no further editions came out.

In 1931, Prof Saha was invited by the Patna University—where he delivered six lectures on ‘Atomic physics and subatomic thermodynamics’. These lectures were compiled later and published by the Patna University in 1931 in a book titled *Six lectures in Atomic Physics* (Chatterjee, 1982).

Prof Saha returned to India from Germany as Khaira Professor of Physics in 1921. Then he left Calcutta to Allahabad in 1923 and returned back again at Calcutta University as Palit Professor of Physics (as C.V. Raman left Calcutta by that time) in 1937. After 1934–1935, his book writing activities stopped as he got involved with travels abroad and other activities like establishment of science academies in India and publication of the journal *Science and Culture*. Finally, he went on to become an elected member of the Indian Parliament, which he was till the last day of his life i.e. 16th February, 1956. Prof Saha joined IACS (Indian Association for the Cultivation

of Science) as Director in 1953 and remained in that post till his demise in 1956.

## 4 Conclusion

In Colonial India, Meghnad Saha was an out and out aggressive nationalist—working for an independent and prosperous India. He left his mark in the progress of pre-independent and independent India in almost all sectors: Power Planning, River Control Planning, Education, Science Academies, Atomic Energy, Science Popularisation etc. However, he was also committed to his students and he wrote excellent text books to inspire a new generation of scientists to take India further ahead. He was successful in his endeavour as a ‘great teacher’.

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