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A centenary tribute to Meghnad Saha

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Meghnad Saha was born in an obscure village Sheoratali near Dacca now in Bangladesh, on October 6, 1893. He was born to poor parents, belonging to the weakest section of society, who could not afford his education at any level. It, therefore, became necessary for young Saha to win a merit scholarship at every stage to continue his education. He joined B.Sc. I year at Presidency College, Calcutta in 1911. He was the classmate of one other famous Physicist, Satyendranath Bose, a name associated with Bose-Einstein statistics. In 1919, the degree of D.Sc. was conferred on Saha by the Calcutta University.

In 1920, at the age of 27, Saha published the paper "Origin of lines in stellar spectra" in the Proceedings of Royal Society, a work which gave him lasting fame. In the scientific world, Saha's fame mainly rests on the theory of thermal ionization and its application to the interpretation of stellar spectra in terms of the physical conditions prevailing in the stellar atmosphere. Apart from this, he and his students published papers in such diverse disciplines as Propagation and reflection of electric waves in upper atmosphere, Magnetic monopoles, Statistical mechanics, Nuclear Physics etc, but none of them rank as high as the series of papers on thermal ionization in gases. Apart from stellar phenomena, his theory found numerous applications in the study of ionosphere, conductivity of flames, electric arcs, phenomenon of explosion etc. His theory of thermal ionization gained immediate recognition. In the words of Rosseland, "the impetus given to Astrophysics by Saha can scarcely be overestimated, as nearly all later progress in this field has been influenced by it and much of the subsequent work has been refinement to Saha's theory".

Another outstanding Astrophysicist Sir Arthur Eddington, in the fourteenth edition of Encyclopaedia Britannica, has hailed the theory of thermal ionization as one of the twelve fundamental landmarks in Astrophysics, since the discovery of the first variable star in 1596. At the age of 34, Saha was elected a Fellow of the Royal Society.

Because of its great importance in Astrophysics, a brief account of the theory of thermal ionization might be in order. The subject may be introduced as follows : The effect of heat on a substance is to loosen its components. At low temperatures a substance exists in the solid state. With the addition of adequate heat it passes on to the liquid state, a process called fusion. At still higher temperatures the liquid normally goes into vapour state. This is the stage of vapourisation. When the vapour is further heated, the molecules break up into atoms. Now the question arises, what happens when we heat a gaseous mass consisting of

atoms to very high temperatures? At very high temperatures atoms would undergo violent collisions with one another, leading to excitation of valence electrons to higher quantum states or even ionization.

The reverse processes are also conceivable. When an ionized atom and electron come closer, the ion may capture the electron and become a normal atom or an atom in an excited state. This is the analogue of reversible chemical reaction. Saha applied the laws of chemical reactions in equilibria in terms of partition functions to the problem of thermal ionization and deduced an equation which bears his name. It shows that the fraction that is ionized depends on three factors : Temperature, Pressure of the ions and electrons, and the Heat of Dissociation.

Use of this formula shows that Calcium begins to get appreciably ionized at temperatures around 4000°K, and that ionization is promoted by the reduction in pressure.

The said equation and its more exact form and the other variations for non-equilibrium cases have been applied to a variety of problems in Physics and Chemistry, among which the important ones are :

1. Astrophysics, which includes Physics of the Sun, the stars and nebulae.
2. Electrical conductivity of flames.
3. Formation of electrical arc.
4. Formation of ionosphere. This is a non-equilibrium case.
5. Determination of the electron affinity of halogens.

In particular the application of the ionization formula towards a physical explanation of the spectra of stars is outstanding. From the application of laws of radiation it is known that the surface temperatures of stars vary from 3000°K for red stars to over 20,000°K for white stars. A systematic investigation of the spectra of stars was undertaken by the astronomer Sir Norman Lockeyer in the period 1870 to 1900. An important result that emerged from these findings was this : inspite of large numbers, the spectra of most of the stars could be classified in 5 or 6 groups which show tendency of continuous transition from one stage to the other. The work was continued at the Harvard observatory and the earlier results were confirmed. In the words of Prof. H. N. Russell, "The spectra of the stars show remarkably few radical differences in type. More than 99 percent of them fall into one or the other of the six great groups which during the classic work of the Harvard university were recognized as of fundamental importance and received as designations, by the process of the survival of fittest, the rather arbitrary letters, B, A, G, F, K, M. That there should be so few types is noteworthy, but much more remarkable is the fact that they form a continuous series. The peculiarities of the stellar spectra were known only empirically but a physical theory was completely lacking. Saha's theory of thermal ionization provided a sound theory which at once offered detailed explanation of the characteristics of the stellar spectra, the appearance of certain lines of an element at certain stage, the enhancement of its intensity at some other stage and its disappearance at some other stage.

In 1920, Saha proceeded to Europe and worked in the laboratory of A. Fowler in London and with Nernst in Germany. After his return, from 1921 to 1923, Saha was Khaira Professor of Physics in the University College of Science, Calcutta. Then he moved over to Allahabad. Here he obtained a substantial grant from Royal Society to enable his students to carry out various experiments to verify Saha's predictions. High temperature furnaces were constructed to reproduce the conditions on the surface of stars, and Saha's theory of thermal ionization received detailed experimental confirmation.

Although basically a theoretician, Saha was conscious of the importance of experimentation, and devoted as much attention to the development of labs as theory. This approach is found to be lacking in certain scientists of greater reputation. They tend to lean heavily on one side or the other. Thus, for example, Lord Rutherford, the father of Nuclear Physics and one of the great experimentalists, being himself poor at mathematics had scant respect for theoreticians. The only mathematical formula which he had derived to express the results on scattering of alphas and which bears his name, is based on the solution of Kepler's problem which was already known in Astronomy. Rutherford became the foremost scientist in England from 1910 onwards for a quarter of a century and had profound influence on their national planning of Science. The result was that too much emphasis was given to experimental science at the expense of theory. England has not been able to completely recover from this pernicious trend even to date.

During his 15 years stay at Allahabad (1923-38), Saha had built up an important school of both theoretical and experimental Physics which included such scientists as D. S. Kothari, R. C. Majumdar, P. K. Kichlu, G. R. Toshniwal, B. N. Srivastava and A. N. Tandon.

In 1937, Meghnad Saha was appointed as the Palit Professor at the Calcutta University, a post earlier held by C. V. Raman and D. M. Bose.

Up to 1930, Saha was entirely pre-occupied with the problems of teaching and research in Science. He then realized that for effective communication of matters of scientific interest, and exchange of ideas it was necessary to establish several scientific academies. In 1931, on his initiative, the U. P. Academy of Science was founded which later was called National Academy of Science, in order to enlarge its role for the entire country. However, in the mean time, the Indian Academy of Science was founded at Bangalore. Between 1933 and 1935, Saha was responsible for the formation of two other organizations at Calcutta, the Indian Physical Society in 1933 and the Indian Science News Association in 1935. During the years 1935-53, Saha used the journal Science and Culture as a medium for propagating his ideas on the application of Science to national development. In 1938, while serving the Calcutta University as a Palit professor, Saha recognized the importance of the recently discovered fission by Hahn and Strassman, for research in Nuclear Physics and for the utilization of Nuclear Physics for peaceful purposes. He introduced Nuclear Physics as a special subject in M.Sc. and attempted to build up a special laboratory for Nuclear Physics. Later, with the help of atomic energy commission, the Nuclear Physics Institute was founded which is now called Saha's Institute. In the course of time a cyclotron was added as a research facility. Apart from the cyclotron, Nuclear magnetic resonance and Bio-Physics were the other important contributions of Saha to the Calcutta University. Saha had conceived the idea of creating a separate institution for Nuclear Physics as far back as 1936 when he was on a visit to Copenhagen to attend an International conference. But the dream came true only after independence. Here again he built up a strong group of researchers, one of the outstanding students being Nagchoudhry.

In 1953, Saha took over the stewardship of the prestigious Indian Association for the cultivation of Science and created new facilities and infrastructure for this institution. By early forties, there was hardly any academic body with which Saha was not associated.

Saha was nationalist to the core. Even in his school days he lost his merit scholarship for boycotting the Governor's visit on the issue of the partition of Bengal.

He had outstanding talent for organizational work. By late thirties he had come close to Mr Nehru and Netaji Subash Chandra Bose. He became deeply involved in the National

Planning Committee of the Indian National Congress constituted by Subhas Chandra Bose with Jawaharlal as chairman. The entire correspondence between Saha and Nehru is now available as an appendix to the book "Meghnad Saha in Parliament" edited by S. Chatterjee and J. Gupta. The correspondence reveals the degree of Saha's involvement in national planning, and the regard, warmth and sympathy Nehru showed for Saha. Saha was also deeply concerned with the problems of the uplift of the poor. A man who had seen misery and abject poverty alone could understand the needs of the poor and destitute.

In 1952 Saha made history by storming into the parliament. A common question asked about Saha is "why a scientist of the caliber of Saha had to enter politics?". The answer is given in Saha's own words "I may say here why I chose to offer myself for election. Scientists are often accused of living in the ivory tower and not troubling their mind with realities and apart from my association with political movements in my juvenile years, I had lived in the ivory tower up to 1930. But Science and techniques are very important now a days at least as much as law and order. I have gradually glided into politics because I wanted to be of some use to the country in my humble way, and I may disclose to the public how I did it and how the Hon'ble Dr Katju was the indirect cause of it. For a while Industries Minister in the first congress government in 1938 in the United Provinces Dr Katju was invited in 1938 to open a match factory, somewhere in the United Provinces, where he delivered a very eloquent speech saying that a great step was taken by the opening of the match factory towards large scale industrialisation. The speech gave me a rude shock, for it disclosed that a top-ranking Congress leader, entrusted with the important tasks of reorganising, improving, and initiating industries of his province, had revealed by his speech that he had no idea of what large scale industrialisation was. I found this to be the case with most elderly Congressmen, who were defacto potential ministers and could foresee that when in power, they could be like landsmen who have never seen large sheets of water and still asked to pilot ships in the ocean. It was these considerations which led me to apply my mind to the problem".

Furthermore, Saha alone is not there in this category. There are other outstanding scientists like the nobel laureates P. M. S. Blackett who was elected to the House of Commons and Glen Seaborg who was a U.S. senator.

The idea of entering the parliament was first suggested to Saha by Sarat Chandra Bose who was a member of the first interim cabinet in 1946. It was expected that Saha's presence in the parliament with so much experience in national planning, river valley development and industrialisation would give tremendous advantage to the ruling party. However, Saha's extreme views on khadi and charkha came in his way for securing the nomination from Congress. Saha, therefore, decided to contest the 1952 elections as an independent candidate from north-west city of Calcutta. He won the Loksabha seat by a thumping majority backed up by leftists, and leaving far behind in the trail professional politicians.

Being a straight forward person, frank even to the point of bluntness, a true nationalist, committed to social reforms and national development, his life became more and more difficult in political circles. He was always under bitter attacks from other M.P.'s who had no tolerance for his criticism. He had to face sarcastic remarks like "You must confine yourself to your physical laboratory and not step out on a territory to which you do not belong". But Saha had the will to continue his work with unabated enthusiasm.

Saha who was earlier so close to Panditji, on issues like national planning etc. had now a different role to play in the parliament, sitting in the opposition. Very soon, Saha became

a firebrand speaker in the parliament. Whenever he rose to speak the treasury benches were all on defensive. Nevertheless, Mr Nehru, the then prime minister valued his advise on such matters as U.G.C. bill, and many other things concerned with science and technology.

Saha took an extraordinary interest in the river projects concerned with flood control and irrigation, navigation and water power development. His interest in rivers bordered on obsession, and was closely connected with the background of his childhood which he had spent in his native village, Seoratali in the Brahmaputra delta which remains virtually under water for a period of four or five months every year. In this context, he used to remark that the children in his native place learn swimming even before walking.

His originality and independent thinking became handy in the parliament. He studied every problem thoroughly and critically. His speeches are marked by an uncanny mirth and humour. Thus, in the general discussion for the railway budget, Saha went on to say "There was a British Prime Minister who always travelled third class, and when he was asked why he travelled third class, he said because there was no fourth class. I do not understand why our railway minister has brought a proposal for the abolition of classes. I think it is a prelude to the formation of a classless society to which the planning commission is pledged. But, are we taking a leaf out of Russia here? Then there are many things which we have to imitate. Has the hon'ble minister ascertained whether classes have been abolished in Russia? The word CLASS is taboo there : but when I was there, I was told that people can travel 'SOFT', they can travel 'MEDIUM' and they can travel 'HARD'. In our country when we are being led by fads like this that all classes ought to be abolished, we really ought to study what other countries are doing, because such fads have cost us crores of rupees in former years. I am all for improvement of our third class so that people do not travel like cattle. They should be like English third class. But before that is done, all efforts should be made to improve the standard of third class so that everybody can travel by third class".

Saha was haunted by the fact that he was constantly opposing Nehru in the parliament. On April 23, 1952 Saha wrote a letter to Dr Sarvepalli Radhakrishnan saying : "Fate has ordained that I shall be in opposition, but I hope my friendship with Panditji will stand the strain. I am reminded of a Puranic story where Jay and Vijaya, attendants of Vishnu, were cursed by an angry sage to undergo the pangs of birth, but were told that if they preferred to be as enemies of Vishnu, they would be freed from the curse after three births; but if born as devotees it would require seven births. So naturally, they preferred to be born as enemies. I have the same consolation."

On two occasions Saha came in head-on collision with Nehru, one was in the course of a debate on Appropriation Bill in July 1952 and the other on the motion on Economic situation in December 1954. During the debate on Appropriation Bill of 1952, Saha was infuriated by Government's decision to abolish Standing committees to the ministries. He pointed out that this was a retrograde step to exclude the opposition from getting access to intimate knowledge of the mechanism of administration. In this connection he made a sweeping remark "The present action proves that the party in power is proceeding towards Fascism". Panditji was mortified, and sharply reacted "Prof. Saha does not understand the meaning of the word FASCISM. Prof. Saha had lost touch with Science and degraded Science".

In the course of debate on Economic situation, in December 1954 Prime Minister Nehru was once again infuriated when Prof. Saha concluded his speech by saying "I have no doubt that this Government will go the same way as the Government of Chiang Kai-shek has gone". Panditji reacted violently and resorted to make again a personal attack on Prof. Saha

"He used to be a great scientist but has drifted from the fields of Science and has found no foothold elsewhere yet. Shri Meghnad Saha has, fortunately returned to this house". Saha sharply retorted, avoiding a personal confrontation "I have done very little in Science but my name will be remembered for some hundreds of years while some politicians will go to oblivion in a few years".

In 1956 Saha's health declined and inspite of doctors advise he continued to work. On February 16, 1956 Saha collapsed on his way to parliament.

Saha's assessment about the worth of his own work has come true. There are bound to be many more centenary celebrations to come. His name is assured in the books of Astrophysics and will be mentioned so long as Astrophysics is studied and taught in any quarter of the globe. He will also be remembered as the champion of poor, a reformer, an outstanding organiser, a nation builder, a man of varied interests, outright candid, and above all humble and modest.

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