# Meghnad Saha and his equation

**Jayant Narlikar and Thanu Padmanabhan**

Tomorrow is the 116th birth anniversary of a pioneering Indian astrophysicist, Meghnad Saha, who was born on October 6, 1893 in Sheoratali, a village near Dhaka, now in Bangladesh. He joined the Presidency College in Kolkata in 1911 and published a key paper on the plasma atmosphere in the Sun in 1920. (Incidentally, the period 1920 to 1930 was the golden era of physics in India with four important discoveries being made — the Bose Statistics by SN Bose, the Raman Effect by CV Raman, the Chandrasekhar Limit by S Chandrasekhar and the contribution by Meghnad Saha.) Saha's paper caught the attention of the experts and he was sent abroad to collaborate with Alexander Fowler and Walter Nerst. Coming back two years later, he joined the University of Calcutta as a professor of physics.



Saha in Berlin

His key contribution to astrophysics — which is now standard textbook material — is an equation named after him. To understand its significance, we need to recall a few facts related to the fourth state of matter, called plasma, which occurs at higher temperatures than the more familiar three phases (solid, liquid and gas). If the hydrogen gas, for example, is heated to sufficiently high temperatures, then the electrons in the hydrogen atom will acquire sufficient thermal energy to break free from the protons. At such high temperatures, say in the range of 3000 - 3500 Celsius, the gas will have three constituents. There will be some atoms in which the electrons are still bound to the protons while the remaining atoms would have dissociated as protons and electrons so that we will have electrons, protons and neutral atoms coexisting in the material. As the temperature increases, more number of atoms will get dissociated so that the fraction of neutral atoms will come down. But at any finite temperature, there will be some fraction which will continue to remain neutral.

Saha's equation gives the fraction of atoms which are ionised as a function of temperature and density of the gas. In the outer regions of a star like the Sun, the temperature is sufficiently high for the material to exist in the plasma state. When we study the spectrum of electromagnetic radiation emitted by a star, it is important to take into account this effect in order to accurately estimate the physical parameters. Because of this reason, Saha's equation is extensively used in astrophysics.




DNA special

Saha has contributed significantly to the growth of scientific societies in India like the National Academy of Science and the Indian Association for the Cultivation of Science. Interestingly enough, he was also the chief architect behind river planning in India and was involved in the original plan for the Damodar Valley project. The Damodar river had a history of producing seasonal flooding and a set of dams built on it continue to control this flooding to a significant extent as well as generate hydroelectric power.

**Next week: Subrahmanyan Chandrasekhar and White Dwarfs**

*Astrophysicist Jayant Narlikar and theoretical physicist Thanu Padmanabhan will contribute to DNA's special series through 2009, designated the International Year of Astronomy.*