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Sun’s sunny side is outside

The sun seems warmer at the surface than deeper within, says S. Ananthanarayanan.

A peculiar thing about the sun is that its halo or corona (crown) emits more ultra-violet light than the visible mass of the sun. Thus, during a total solar eclipse, when the sun’s disc is covered, people tend to stare at the fantastic sight and often lose the capacity ever to see again. This is because, while the bright disc, which we can hardly see for an instant, is covered, the halo is not and it is invisible. But it emits in the deadly ultra violet and can sear the unprotected retina in seconds.


Total solar eclipse

Mystery

This emission of higher frequencies from the sun’s corona, than from within, was long a mystery of solar science. If the sun was heated because of thermonuclear or whatever reaction in its high pressure core, how could the surface be hotter than inner regions, to emit radiation at higher frequencies?

The Indian scientist, **Meghnad Saha** has the honour of settling the question. His background was in the study of chemical systems and also the theoretical study of gasses of charged particles. Following a few leads of others who had worked in the field, **Saha** was able to work out how the atoms of the different elements would be distributed in the intensely hot gas that makes up the body of the sun. The rapid movements and energetic collisions would strip the atoms of the electrons and the melée would be of singly, doubly or even more numerously charged atoms, speeding and swerving within intense electric and magnetic fields.

Saha was able to work out that there was selective presence of atoms of heavier elements in the ionized, or stripped of electrons, state in the outer layers of the sun and the radiation from them would be at higher frequencies, which is characteristic of ionized atoms. This was exactly what was seen, that at higher altitudes, heavier elements radiated at frequencies they generally emitted in ‘sparking’, which is more energetic, than in ‘arcing’, which only throws out light from excitations of atoms that are yet to lose an electron.

Saha's ***ionization formula***, which describes how the ions are distributed with increasing distance from the sun's interior, accurately explains the radiation that is observed and has become the cornerstone of research in the field

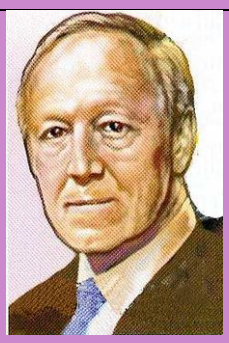
Meghnad Saha was interested in the development of his country and the development of Indian science as much as in science itself. He was in exalted company, as J C Bose and P C Ray were his teachers and S.N Bose was his classmate. He became part of a group that translated the world's leading scientific papers into English for Indian students to read.

Among these were the first English translations of the papers on the Special Theory of Relativity, by Albert Einstein and H Minkowski. When Arthur Edington first confirmed relativistic bending of light by gravity, Meghnad Saha wrote a piece, "Time and Space – the new scientific theory' in The Statesman, Kolkata of November 13 and 15, 1919.

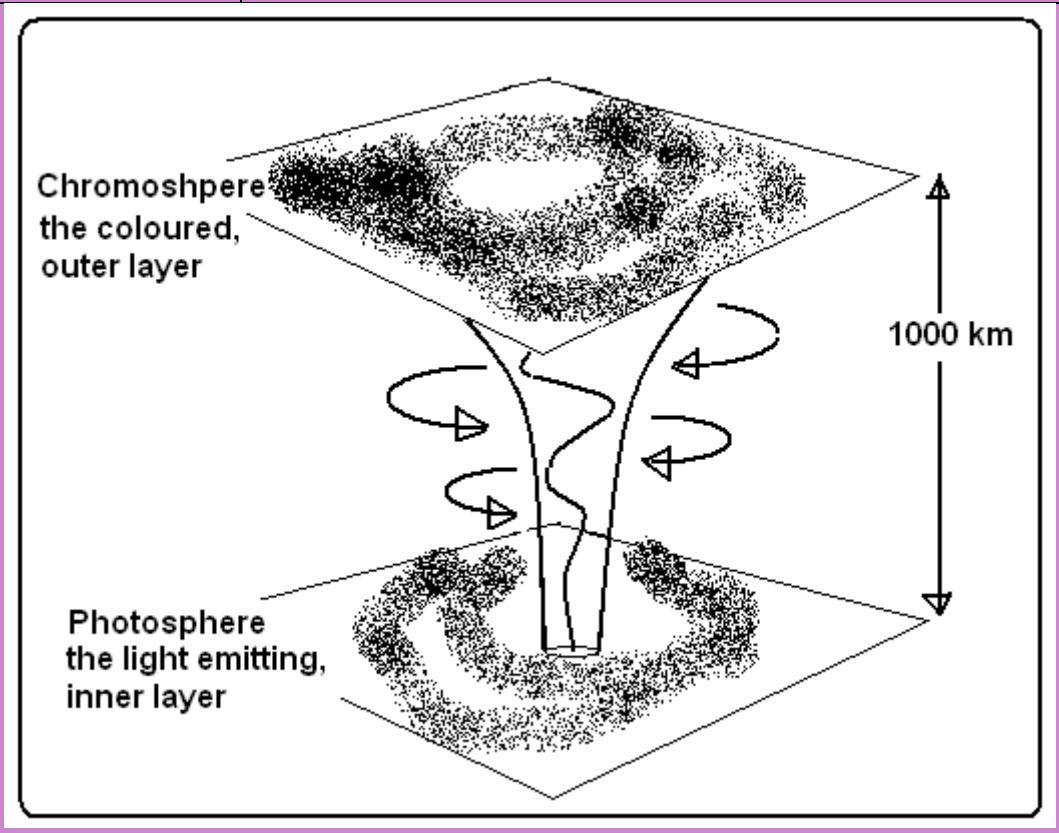
Traffic within the sun

Although Saha's formula and work did provide a start into understanding the sun, the details of how energy gets transported to the periphery has been another mystery. In an atmosphere like we have on earth, there is simple convection and the theory is of cool and warm air, evaporation and condensation, pressure and winds and the spin of the earth. But on the sun, it is quite a different thing, with electric charges, magnetic fields and relativistic speeds.

Important work was done in the field by ***Hannes Olaf Gösta Alfvén***, a Swedish electrical engineer turned plasma physicist. Plasma is a gas where some or all the particles are not electrically neutral, like in a normal gas, but are ionized, or charged. This creates electrical forces between particles and also electric currents and magnetic fields when the particles move, which they do incessantly. The theory of the plasma is then a complex study involving electromagnetism, relativity, thermodynamics and statistical physics, all in one



Alfvén's work was in the theory of Polar auroras, of the Van Allen Belt, the collection of cosmic ray particles that envelop the earth and the behaviour of plasma found in the Milky Way and he got the Nobel Prize for Physics in 1970. An important contribution was the ***Alfvén wave***, an oscillation of ions, or charged atoms, along a magnetic field, something like the vibration of a violin string. This kind of wave would carry energy along its direction of propagation and could form the ***transmission line*** for transfer of energy over space or within the sun!



Waves detected

David B Jess, of Queen's University, Belfast and his colleagues have reported experimental work that detects Alfvén waves within the sun to show that this may be the mechanism of energy transport to the corona.

The group measured solar activity with the Swedish Solar Telescope, which is the second largest glass lens telescope in the world. The telescope is managed by the Swedish Academy of Science and is located at La Palma in the Canary Islands. The telescope is evacuated, or has a vacuum within, to avoid distortion that heating of air can cause.

With the help of an arrangement to analyse the electric and magnetic orientations, or the ***polarization,*** of the light collected from a narrow area on the sun, and special optics to eliminate distortions, the group could identify variations in the emissions of specific spectral lines and

make out that there was a clear periodic movement within the body of the sun – characteristic of Alfvén waves. And the energy stream the waves carried was sufficient to heat the corona to the temperatures that have been observed.