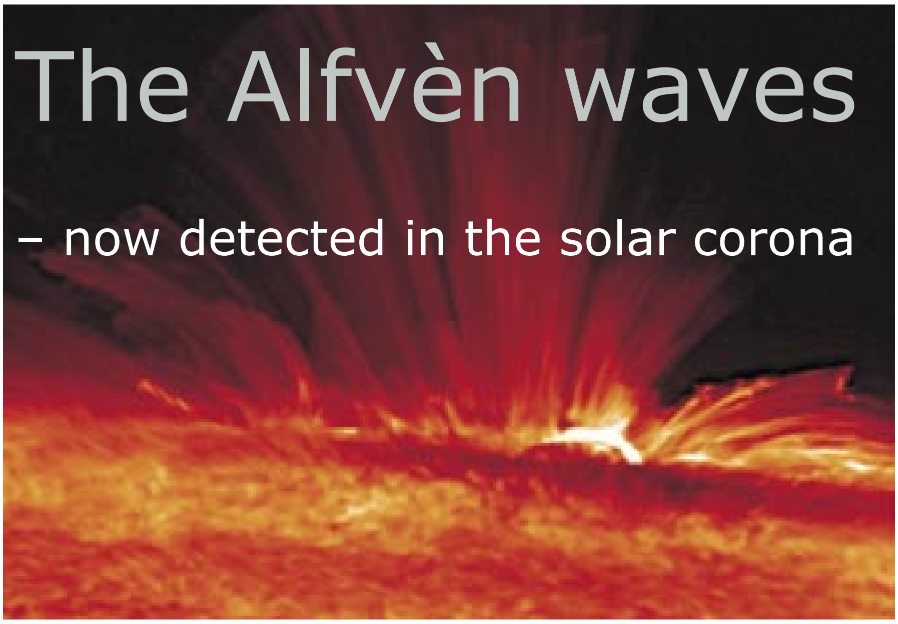
The Alfvèn waves

– now detected in the solar corona



Structures of the Sun's magnetic field. Credits: Hinode JAXA/NASA/PPARC

The surface of the Sun has a temperature at about 10,000 degree Fahrenheit, but the temperature in the corona is rising to millions of degrees. Although scientists have some ideas of what the temperature in the solar corona might be, there is no universal explanation yet. Many mechanisms might contribute to the coronal heating; a few leading contenders are magnetic reconnection sound waves produced in the Sun's churning outer layer, and waves of magnetic energy called the Alfvèn waves.

Alfvèn waves were for a long a long-time considred as the coronal heating mystery, but until now, evidence of their presence in the solar corona was only circumstantial. With the help from the Hinode spacecraft, scientists at Goddard Space Flight Center, the USA, now have irrefutable evidence of Alfvèn waves moving along coronal loops. Coronal loops are fountains of plasma trapped by the Sun's magnetic fields. Coronal loops like giant arches sticking out of the solar surface, and many of them enough to span several Earth radii.

An Alfvèn wave is a vibration of a magnetic field that carries the charged particles in plasma along within. In other words, it is similar to a vibration string with beads. This type of wave was first proposed to exist in 1942 by Hannes Alfven, a Swedish scientist who won the Nobel Prize in Physics in 1970. Alfvèn waves were later found to exist in laboratory experiments with magnetized plasma, and also in space.

Alfvèn waves can be caused by an impact to a magnetic field. In the case of the new Hinode observations, they were caused by an explosion of magnetic energy, called a solar flare, which immediately preceded the observations.

Hinode detected the Alfvèn waves with its Solar Optical Telescope instrument. This is a high-resolution telescope in space that is sensitive to the emission of relatively cold material that can fill coronal loops due to eruptions caused by a flare. A movie made from a sequence of images shoved a clear pattern of periodic motion of coronal loops. The loops vibrated side-to-side, which is typical for an Alfvèn wave. The relation between the periods of the vibrations and the parameters of the loop (its length, density and temperature) further reinforced the conclusions that what one sees is really an Alfvèn wave.

According to the scientists, Alfvèn waves could heat the solar corona by their vibrations. As the magnetic field lines vibrate, they experience friction with the surroundings magnetized material. The friction results in heating of the corona and damping of the wave motions. The next step to understand the Sun's mysteriously hot atmosphere is to discover how much Alfvèn waves contribute to coronal heating, and to see whether it's the dominant force or it the other possible heating mechanisms play major roles.

This research is a part of a series of papers about observations of Alfvèn waves with Hinode.

Source: Goddard View, Volume 3, Issue 17, December 2007.

Hannes Olof Gösta Alfvén was a Swedish plasma physicist and Nobel Prize winner in Physics laureate for his work on the theory of magneto hydro dynamics. He was originally trained as an electrical power engineer and later moved to research and teaching in the fields of plasma physics. Alfvén made many contributions to plasma physics, including theories describing the behaviour of aurora, the Van Allen radiation belts, the effect of magnetic storms on the Earth's magnetic field, the terrestrial magnetosphere, and the dynamics of plasmas in the Milky Way galaxy.

Hannes Alfvén was born in Norrköping, Sweden, in 1908. Hannes Alfvén studied at Uppsala University from 1926, he obtained the degree of Doctor of Philosophy in 1934, in this same year he was appointed lecturer in physics at Uppsala University. In 1937 he became a research physicist at the Nobel Institute for Physics in Stockholm. A post he held to 1940, when he was appointed Professor in the Theory of Electricity at the Royal Institute of Technology in Stockholm, Professor of Electronics in 1945, and Professor of Plasma Physics in 1963. Since 1967 he was a visiting professor of Physics at the University of California at San Diego.