Hinode "A New Solar Observatory in Space"

Saku TSUNETA
Hinode Science Center, National Astronomical Observatory of Japan

It is a fascinating fact that a solitary star like the Sun emits intense X-rays from its outer atmosphere. Observations with the Japan-US *Yohkoh* satellite showed that all the sporadic heating from X-class flares to ubiquitous tiny bursts in the solar corona is due to magnetic reconnection; a process to efficiently annihilate magnetic fields with opposite direction and generating jets, heats and non-thermal particles. Magnetic fields do dissipate in the solar corona with a time scale 10^{12} faster than that of the classical Ohmic dissipation. Though this leads to an attractive conjecture that the solar corona is heated by nano-bursts as initially proposed by Parker, the precise mechanism for the heating the solar corona and for the solar wind acceleration mechanism is not known.

These activities on the surface of the star are driven by magnetic fields created by the interaction of flow and seed magnetic fields below the photosphere (dynamo mechanism). The magnetic field strength on the surface of the Sun exceeds 1kG, while that at the bottom of the convection zone may exceed 100kG. They are too strong, far stronger than the *equi-partition magnetic field strength*, the energy of which is the same as that of the local convection motion. Though a dynamo mechanism can amplify field strength upto the equi-partition field strength, it is perceived possible to have field strength beyond that threshold. Such too-strong magnetic fields can be found elsewhere in the universe, namely pulsers (10^{12}G), magneters (10^{15}G), galaxies and clusters of galaxies (a few micro G), which is again too strong in terms of that in early universe (10^{-17}G). The dynamo mechanism for the sun and these objects is poorly understood.

The *Hinode* spacecraft was successfully launched in September 2006 from the Uchinoura Space Center in Japan using a JAXA's M-V launch vehicle. It comprises an observatory style set of instruments that function together to answer the fundamental questions of how magnetic fields are formed and how they dissipate to create the solar corona. This subsequently addresses all the phenomena that have an impact on the Sun-Earth system, such as the formation of the solar winds, triggering of flares with intense non-thermal acceleration and coronal mass ejections, and formation and maintenance of filaments and prominences. The concept of *Hinode* is that two X-ray and EUV telescopes observe the dissipation part of the magnetic life-cycle, while the visible light telescope simultaneously observes the generation and transport of magnetic field. *Hinode* is the Japan's third solar mission with participation of NASA and UK STFC (then PPARC).

The activity on the Sun is known to be driven by the magnetic fields that are prevalent everywhere. *Hinode* has higher temporal, spatial and velocity resolution than any satellite previously and is probing wavelength regimes that have never had such continuous time coverage available. This has allowed us to discover MHD waves in spicules, prominences and on the photosphere, ubiquitous jets in chromospheres, ubiquitous transient horizontal magnetic fields on the photosphere suggesting local dynamo process, supersonic down-flow and convective collapse resulting in *super equi-partition magnetic field strength*, emergence of large-scale flux rope from below the photosphere, kG-magnetic patches in the polar regions, identification of the origin of slow solar wind, and enigmatic fine-scale flows in the prominence. This talk summarizes how these new results from Hinode are addressing these critical questions as well as probing fundamental physical processes that will have applications in many other scenarios across the universe.