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Infrared Stokes Spectro-Polarimeter at the National Astronomical Observatory of Japan

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The magnetic field is the ultimate source of energy that will drive solar activity. Solar flares are believed to be a process of releasing the magnetic energy stored in active regions. As an indicator of the amount of stored magnetic energy, often used is the magnetic shear angle. Recently a more fundamental quantity, namely the magnetic helicity, has attracted attention. Coronal mass ejections are large-scale phenomena primarily responsible for geomagnetic storms. Recently an interesting idea has been proposed that CMEs are a process of ejecting the over-loaded magnetic helicity into the interplanetary space.

The evaluation of magnetic shear or magnetic helicity requires measurements of magnetic field vector on the solar surface. We have been conducting such measurements from 1982 to 1995 at the Okayama Astrophysical Observatory/NAOJ and since 1992 at the Mitaka campus of NAOJ. The instrument operated at Mitaka is a filter-based magnetograph working at the wavelength of 6 30.25 nm, which we call the Solar Flare Telescope. Its field of view is roughly 300x400 arcsec and is limited to active regions.

In 2005 we started the construction of an infrared spectro-polarimeter to be installed on the Solar Flare Telescope. The spectro-polarimeter observes two wavelength bands, one near 1.56 micron and the other near 1083 nm. The former band includes a Zeeman-sensitive spectral line of Fe I and will be used to measure photospheric magnetic fields. Generally the Zeeman effect favors a longer wavelength, and the 1.56 micron provides roughly three times higher sensitivity in magnetic field measurements compared to the visible wavelengths. The latter band includes the He I 1083 nm line and will be used to map coronal holes and to measure chromospheric magnetic fields. The instrument records full Stokes profiles, and a Stokes inversion process will give information on the strength and orientation of the magnetic field vector.

The infrared detector we are using is an InGaAs camera manufactured by a Belgian company Xenics. Its format is 512x640 pixels and has more than 80% quantum efficiency in the wavelength range of 0.9 to 1.7 micron. Its read-out speed is 90 frames/s. The solar disk will be covered by two swaths (the northern and southern hemispheres) of 640 pixels each. The final magnetic maps will be made of 1200x1200 pixels with a pixel size of 1.75 arcsec. The grating used is 11x12 cm in size with 87 grooves/mm, made by the Richardson Gratings. The spectral resolving powers are 2. $3x10^5$at the 1.56 micron band (13-th order spectrum) and $3.4x10^5$at the 1083 nm band (19-th order spectrum).

The instrument is now under adjustments, and soon we will be able to generate full-disk vector maps of solar magnetic fields (a few maps per day). Our ultimate goal is to derive the distribution of magnetic helicity over the whole surface of the Sun, not only in sunspots and active regions.
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