VIRGO SCIENCE PROPOSAL
Investigations of Solar Luminosity Variations

Main Investigator

S.K. Solanki

Co-Investigator

C. Fröhlich, M. Fligge, J. Kuhn, Ph. Scherrer

Objectives

We propose to quantitatively study the connection between magnetic field and brightness, with the aim of finally being able to predict the observed solar brightness on the basis of the measured magnetogram. The predictions from our models are to be compared with VIRGO and MDI data.

Research Plan

At the solar surface the magnetic field is mainly bundled into discrete elements of concentrated flux, often referred to as magnetic flux tubes, which cover only a small fraction of the solar surface. Their brightness signature is a strong function of their size (and position on the Sun): Large flux tubes (Sunspots) are dark, small flux tubes are generally bright. Whereas Sunspots have been well studied, our knowledge of the true brightness of small-scale magnetic features is hampered by insufficient spatial resolution of the observations. For observations that cannot resolve the individual small flux tubes, the flux tube size can be replaced by the magnetic filling factor (fraction of the solar disk covered by magnetic flux tubes). Both the magnetic filling factor and the brightness of magnetic features can be determined from polarized spectra, although this requires a certain modelling effort. Approximately 40 such spectra have been obtained so far using a Fourier Transform spectrometer (FTS). Thus a table can be constructed of the brightness of flux tubes as a function of magnetic filling factor and disk position.

In a next step the filling factor can be replaced by magnetograph signal in the table, since this is the actual observable. Once such a table has been constructed, then each point on a magnetogram of the full solar disk can be replaced by its wavelength-integrated brightness. A solar magnetogram can thus be used to determine the total solar brightness simply by adding together the brightness values of all the pixels. The predictive power of such an approach is to be tested by total solar irradiance measured by VIRGO. In addition brightness images of the solar disk, as provided by MDI, should provide a very stringent test to the models. Particularly exciting is the possibility of using MDI magnetograms as the basis for our synthetic brightness maps.

Such an analysis is expected to lead to a deepening of our understanding of the production of solar irradiance variations, since in this way we should be able to determine the relative contributions to irradiance fluctuations of different types of magnetic features at different positions on the disk. We should also be able to distinguish between the contributions due to variations in spectral line blanketing and in continuum brightness, etc. Finally, our analysis may serve as a test of the basic idea that solar brightness variations are due almost exclusively to variations of the solar magnetic field.

Responsibilities and Management

The main modelling effort will be carried out by M. Fligge and S.K. Solanki. C. Fröhlich is the link to VIRGO and provides access to the relevant data (total solar irradiance). Ph. Scherrer and J. Kuhn are the link to MDI provide access to the relevant data (magnetograms, flux budget data, intensity images). S.K. Solanki will be responsible for the overall integrity and management of the proposed research.