VIRGO Science Proposal E5
Contribution to the understanding of the 11 year cycle of solar irradiance variations, using the LOI and MDI data.

Main Investigator

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Co-Investigators

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Objectives

To detect changes in the latitudinal radiance of the Sun with the LOI sector structure as a function of time.

Rationale

- The magnetic field in the convection zone (CZ) is responsible of the solar constant variations.
- The main magnetic field is located at the base of the CZ.
- The magnetic field is not uniformly distributed in the convection zone. The shape of its distribution changes through the solar cycle. The convection of the heat flux in the CZ is an-isotropic, and there is controversy on whether the conduction/convection of heat is greater through the concentrated magnetic field or lower (e.g. Kuhn, Sofia, Spruit papers)
- As a working assumption we can assume that the surface temperature would be higher above the concentrated B. This should be observable by photometric observations as partially done and proposed by Kuhn. Highly stable differential photometry is needed as provided by the LOI. It is limited in its resolution, but the shape of its pixels may just be adequate to prove or disprove the theory. In a B that moves equator-wards from start to end of cycle, it should be possible to see a significant change of the ratio between the radiance observed in the polar pixels versus the radiance seen in the band of equatorial pixels.
- If the start of solar cycle 23 is similar to the start of solar cycle 22, the largest differential variation in time of the solar irradiance will take place around 1997-1998.

Work plan

- Demonstrate that the differential radiances measured by LOI, at 500 nm, is directly related to the total radiance (thermal argument).
- For getting the temperature effect, we can use the LOI proxy of MDI at 676.8 nm. (Similar to Kuhn's scheme).
- Find a good theoretical background for the thermal conduction/convection in the CZ and develop it if possible.
- Determine evolution of the differential latitudinal temperature in the Sun from the LOI and the MDI LOI observations.
- Determine and correct effect of sunspots and plage, having into account the limb darkening effects.
- Determine predicted shape of main magnetic field in CZ from other sources:
  - MDI convection zone structural calculations . Magnetograms (MDI, Kitt Peak, Big Bear Solar Observatories)
  - Activity maps
  - CaII K images from NSO/Sac Peak, Mt. Wilson Observatory, Big Bear Solar Observatory, San Fernando Observatory
  - White light images, IAC, Tenerife, Mt. Wilson Obs. San Fernando Obs., Precision Solar Photometric Telescopes (PSPT) at NSO/Sac Peak

Outstanding problems

- A good evaluation of the effects of the active features (sunspots, plage, etc) as they evolve across the disk. For studying the effect of various solar features, state-of-the art software for the automated processing and analysis of the images using machine- learning and pattern recognition techniques is under development. This technique will be applied on the SOHO LOI and MDI images as well as ground-based high resolution observations. This technique will make it possible to automate the detection, measurement and cataloguing the intensity, area, position of solar surface objects (sun- spots, faculae, network,) and will provide a uniform method to analyse space-borne and ground-based images. Classification of the listed solar features is planned as a function of their distribution over the solar disk.
- Evaluation of the representativity of LOI versus solar irradiance. **Study the relation between LOI, solar irradiance and magnetic flux data at the beginning of the ascending phase of solar cycle 23. It has been found that solar irradiance (both bolometric and at UV wavelengths started to rise about 8-10 months

prior the solar magnetic flux. Confirmation of this result and more detailed studies will provide further understanding of the role of solar magnetic activity in irradiance changes.

- Progress into theoretical understanding of CZ heat propagation.
- Find what has to be done and who is doing it in MDI to obtain the structure of B in the CZ.

Responsibilities and Management

V. Domingo will be responsible for the overall integrity and management. He will perform the differential analysis in latitude of the LOI data including the statistical considerations, before and after correcting for observational effects (active features). Will try first with Tenerife data.

J. Pap will participate in the application of the automated image processing technique for evaluating the contribution of solar magnetic features. She also will participate in the data analysis and statistical considerations. The automated image processing program is being tested on the San Fernando CaII K and white light images as well as on the CaK spectroheliograms from Sac Peak.

T.Appourchaux will be responsible for providing the LOI data detrended from any instrumental or other non-solar effects.

T.Hoeksema will be responsible for providing the MDI LOI proxy and the MDI magnetograms. A deeper involvement may depend on his interest.