High Resolution Observations of Polar Faculae

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Introduction to Polar Faculae

Polar Faculae (PFe) are small-scale bright magnetic features seen in the photosphere near the solar poles ($|\phi| \geq 60°$). They have a unipolar magnetic field in the kilo-Gauss range with an activity cycle shifted 5–6 years with respect to the sunspot cycle and a fast temporal evolution in the order of one minute.

Observations April/May and August 2005

- "Göttingen" 2D Fabry-Pérot spectrometer at the VTT in the Observatorio del Teide, Tenerife. The instrument has been recently improved
  - New Fabry-Pérot etalon and controller.
  - New software.
  - New CCD cameras.
- Use of a Stokes V polarimeter and the Kiepenheuer Adaptative Optics System (KAOS, Kiepenheuer-Institut, Freiburg).
- Quasi-simultaneous ($\Delta t \approx 30s$) observations in Fe I 6173 Å and Hα (6563 Å) lines.

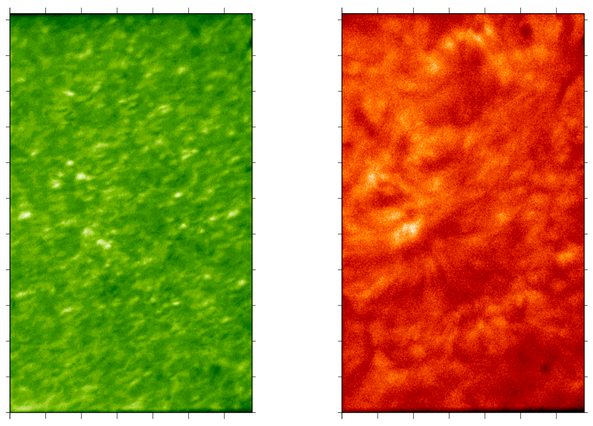

Figure 1. Raw images at the line core of Fe I 6173 Å (left) and Hα (right) from August 2005. FOV = 34″ × 56″. Tickmarks in 5″ intervals.

- Good seeing conditions (Fried parameter $r_0 = 13$ cm).
- Solar north pole almost completely covered with a mosaic of fifteen subfields ($66'' \times 49''$ each). South pole also partially covered.

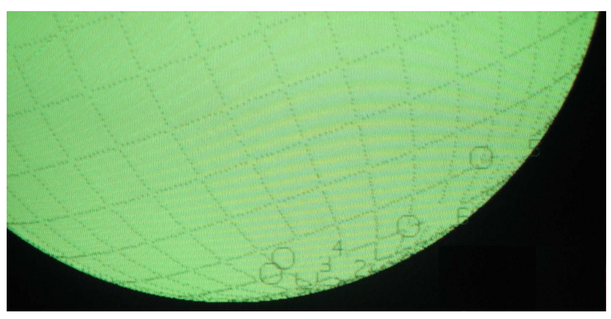

Figure 2: VTT computer image showing center positions of the subfields observed at the south pole during one of the observational campaigns.

- Observations of faculae at the equatorial limb were taken for comparison with PFe.
- A time sequence of a specific PF of 90 minutes length was achieved with 60 seconds cadence between scans.

Data Reduction

- Göttingen speckle reconstruction code applied to the images, yielding a still better resolution than provided by the use of KAOS.

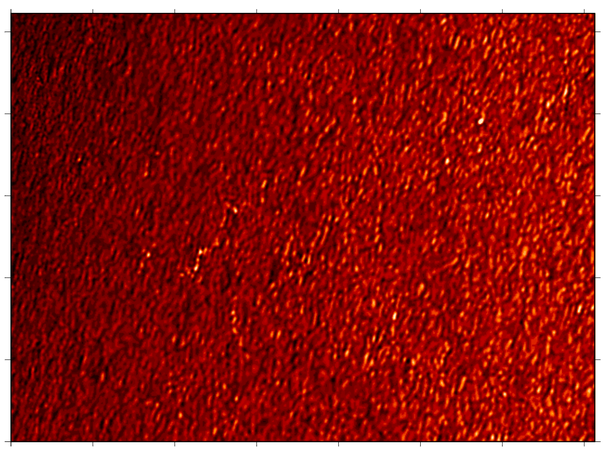

Figure 3. Speckle reconstructed image. The field of view (FOV) is 71″ × 52″ and its center part is located at a heliocentric angle $\theta = 77° \Rightarrow \mu = 0.22$. The tickmarks are in 10″ intervals.

- Analysis of spectropolarimetric data (Stokes I and V profiles) after alignment and destretching of the left and right channels (which correspond to the two circular polarisation states of the light) to remove local distortions.

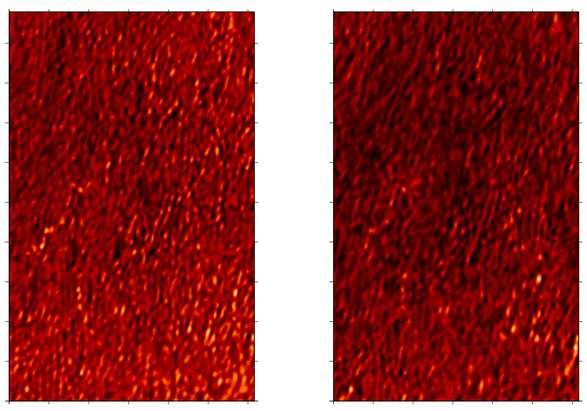

Figure 4. Reconstructed narrowband images in the continuum (left frame) and line core (right frame) of Fe I 6173 Å. FOV = 30″ × 49″. Tickmarks in 5″ intervals.

Future Work

⇒ Observations in Fe I lines around 1.56μ with TIP II.

⇒ Longer time series to estimate PFe life time.

⇒ Study of the penetration of PFe into higher layers by means of images from SoHO, TRACE and Mauna Loa K-Coronameter taken at the same time as our data.

⇒ Analysis of the possible relation between fast solar wind and PFe and the role of the latter as the potential origin of the wind.

Results

Very high spatial resolution achieved. PFe are resolved as small bright points, while not appearing separated at lower spatial resolution.

Many brilliant structures, much more than hitherto observed at one time, are detected as can be seen in Figure 3 and Figure 4.

Life time of a PF is longer than 90 minutes. The PF was still present at the end of the observing sequence.

Magnetic field calculated with the center of gravity method. Contours of different field strength (line of sight components) are shown in Figure 5 superposed on the speckle image.

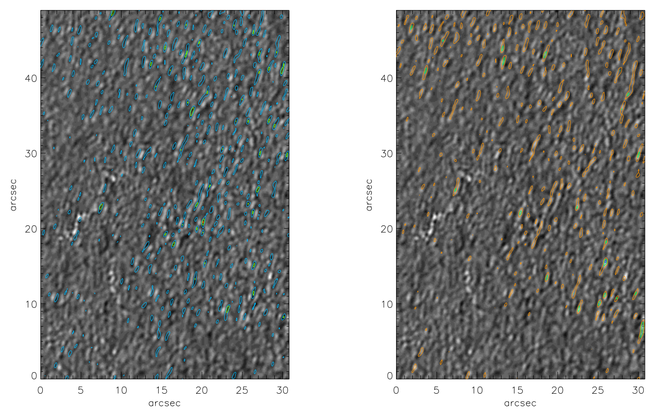

Figure 5. Speckle reconstructed image with contours of positive magnetic field strength (left frame) of 100, 200 and 400 Gauss and negative field strength (right frame) of -300, -200 and -100 Gauss.

LOS velocity map obtained by means of the center of gravity method (Figure 6). The most bright features visible in the speckle image are drawn as contours ovelaid on the velocity map.

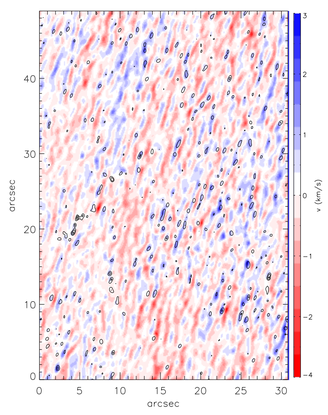

Figure 6. Line of sight velocity map with contours of the most brilliant features apparent in the speckle image. Red colour represents downflows while blue colour shows upflows.