

Spectropolarimetric observations of prominences and spicules

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Abstract: A large set of high precision full-Stokes spectropolarimetric observations of the He-D3 line in prominences and spicules have been performed with the ZIMPOL polarimeter at the Gregory- Coudé Telescope in Locarno. The observational technique allows to obtain measurements free from seeing induced spurious effects. The instrumental polarization is well under control and taken into account in the data analysis. The observed Stokes-profiles are interpreted according to the quantum theory of the Hanle and Zeeman effects with the aim of obtaining information on the magnetic field vector. To this end, we make use of a suitable Stokes inversion strategy technique. The results are presented giving emphasis on a few particularly interesting Stokes-profiles. Finally we show also some novel prominence observations in the H α and H β hydrogen lines.

The observations

The observations were performed at the Gregory-Coudé Telescope (45 cm) at the *Istituto Ricerche Solari Locarno*.

Instrumental setup:

- ZIMPOL (Gandorfer et al. 2004) allows precise measurements free from seeing induced spurious effects (modulation 42 kHz).
- Czerny-Turner spectrograph: 360mm, 300lines/mm, blaze 63°.
- Limb tracker: to keep the limb distance constant
- Derotator: to keep the slit parallel to the limb

Images of simultaneous measurements of Stokes I, V/I and one linear polarization component (alternatively Q/I and U/I) are stored ~every 2 minutes.

Prominence measurements were performed between May 2003 and June 2005.

He-D3: 49 measurements in different positions/prominences

H α : 29 measurements in different positions/prominences

H β : 9 measurements in different positions/prominences

Total exposure time per measurement varying typically from 10 to 50 minutes.

Spicules measurements were performed between November 2004 and June 2005.

He-D3: 53 spicules measurements (at different latitudes and limb distances)

Calibrations measurements performed regularly:

- polarimetric efficiency
- flat fields
- dark current
- spectrum of the scattered light (only for prominences) taken in a nearby region at about the same limb distance.
- measurements of the instrumental polarization (which is a function of declination and stays almost constant over one day).

Inference of the magnetic field from the He-D3 profiles

A database containing the theoretical Stokes profiles for different limb distances, magnetic field orientations and strengths has been created according to the quantum theory of the Hanle and Zeeman effects (see, e.g., Landi Degl'Innocenti & Landolfi 2004). Both structures (spicules and prominences) were assumed to be optically thin.

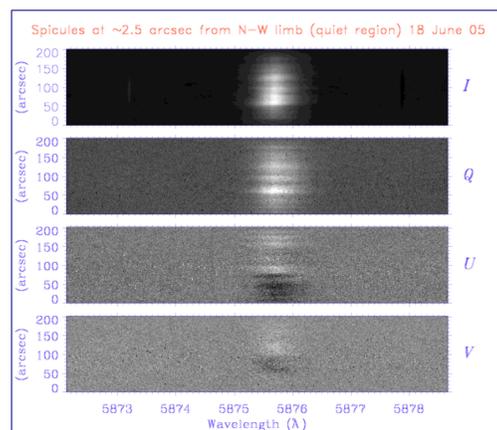
The theoretical profiles that better fit the measured profiles are carefully searched in the database, in order to infer the magnetic field vector.

Preliminary results from the spicule measurements

A preliminary analysis shows that generally the measured Stokes profiles are compatible with a magnetic field strength of 10 Gauss (Fig1-3) which is in accordance with the results obtained from the 10830 He-line by Trujillo Bueno et al. (2005).

Only in one measurement the Stokes profiles indicate magnetic field strengths as high as 50-60 Gauss (Fig 3-6). In this particular case the Stokes V profile shows a typical Zeeman-like antisymmetric shape. It is important to point out that this measurement was obtained near the equator in the proximity of an active region.

Example of observations of Spicules in quiet regions



Measurements in quiet regions indicate magnetic field strengths around 10 Gauss!

Fig.1

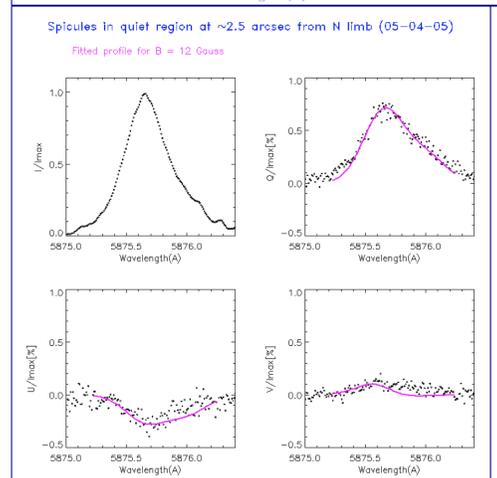


Fig.2

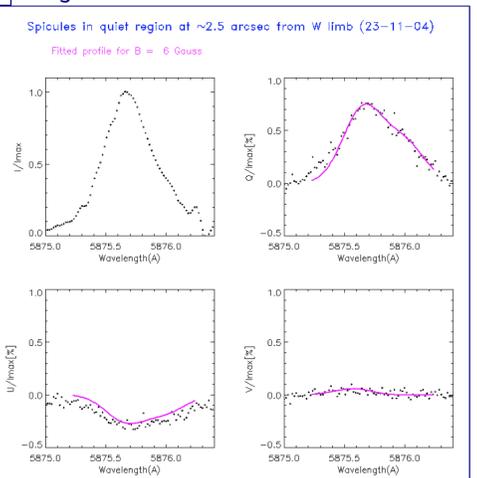
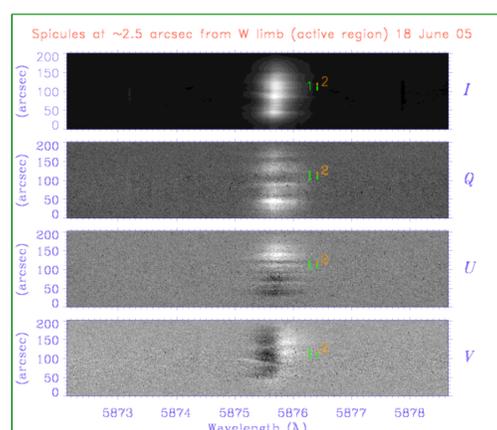


Fig.3

Example of observations of Spicules in active regions



A spicules measurement near an active region shows antisymmetric Zeeman-like Stokes V profiles indicating stronger magnetic fields!

Fig.4

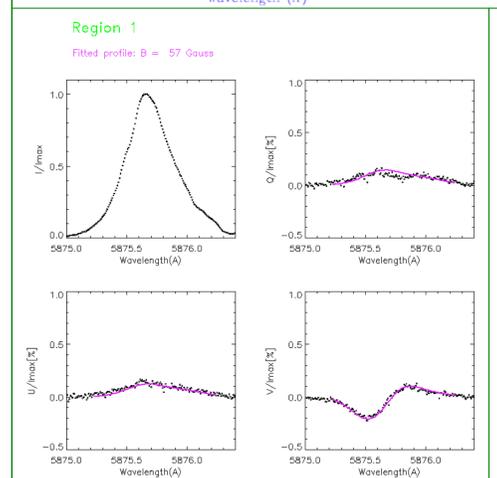


Fig.5

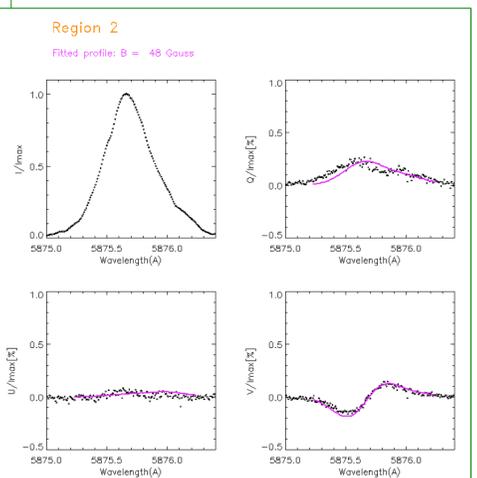


Fig.6

References:

- Gandorfer A. et al., A&A **422** (2004) 703.
Landi Degl'Innocenti E. & Landolfi M., 2004 Polarization in Spectral Lines (Dordrecht: Kluwer)
Trujillo Bueno J. et al., ApJ **619** (2005) L191.

Results in Prominences

Examples of He-D3 Stokes profiles with inversion

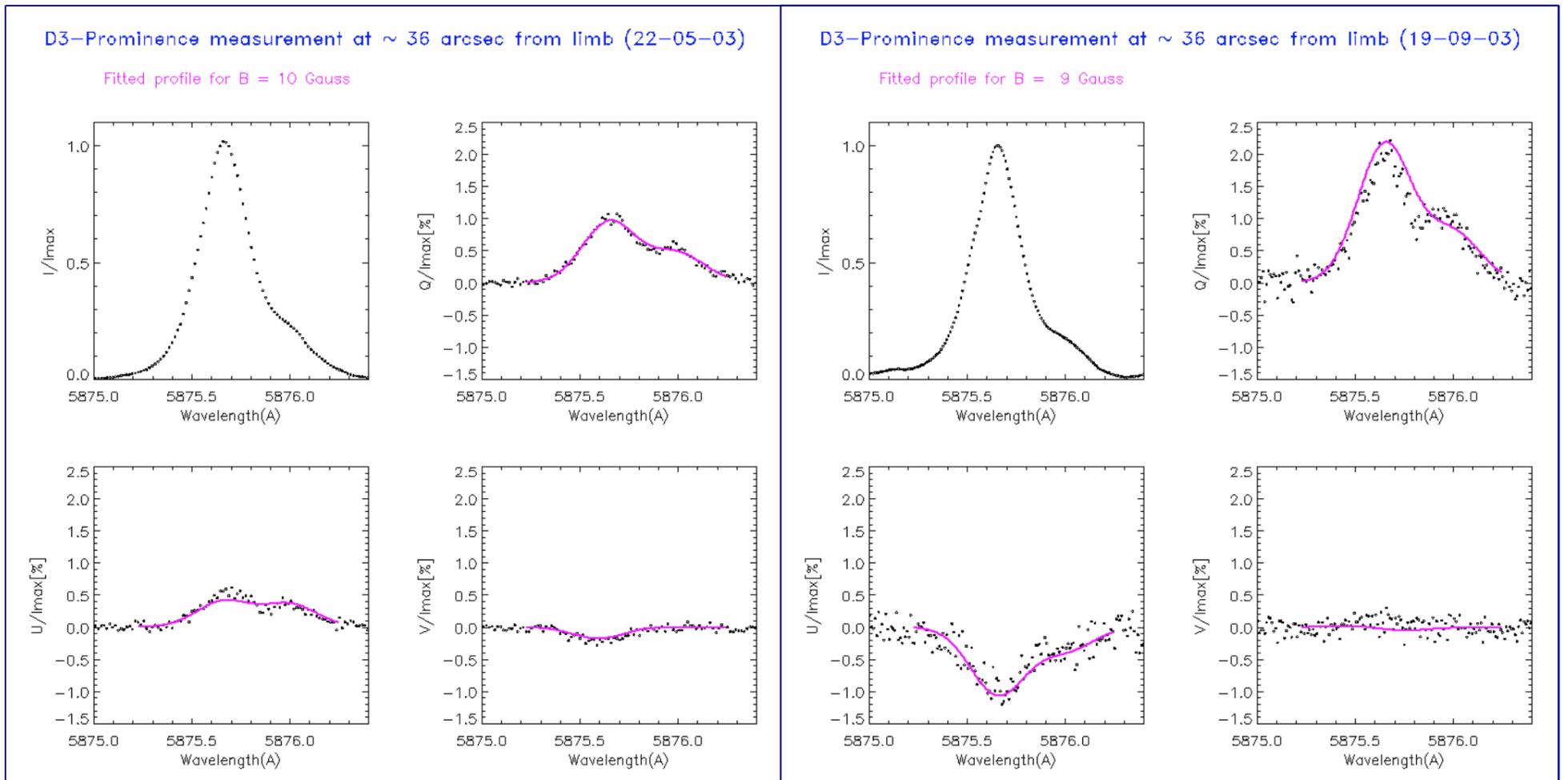


Fig.7

Fig.8

Examples of H β Stokes Profiles

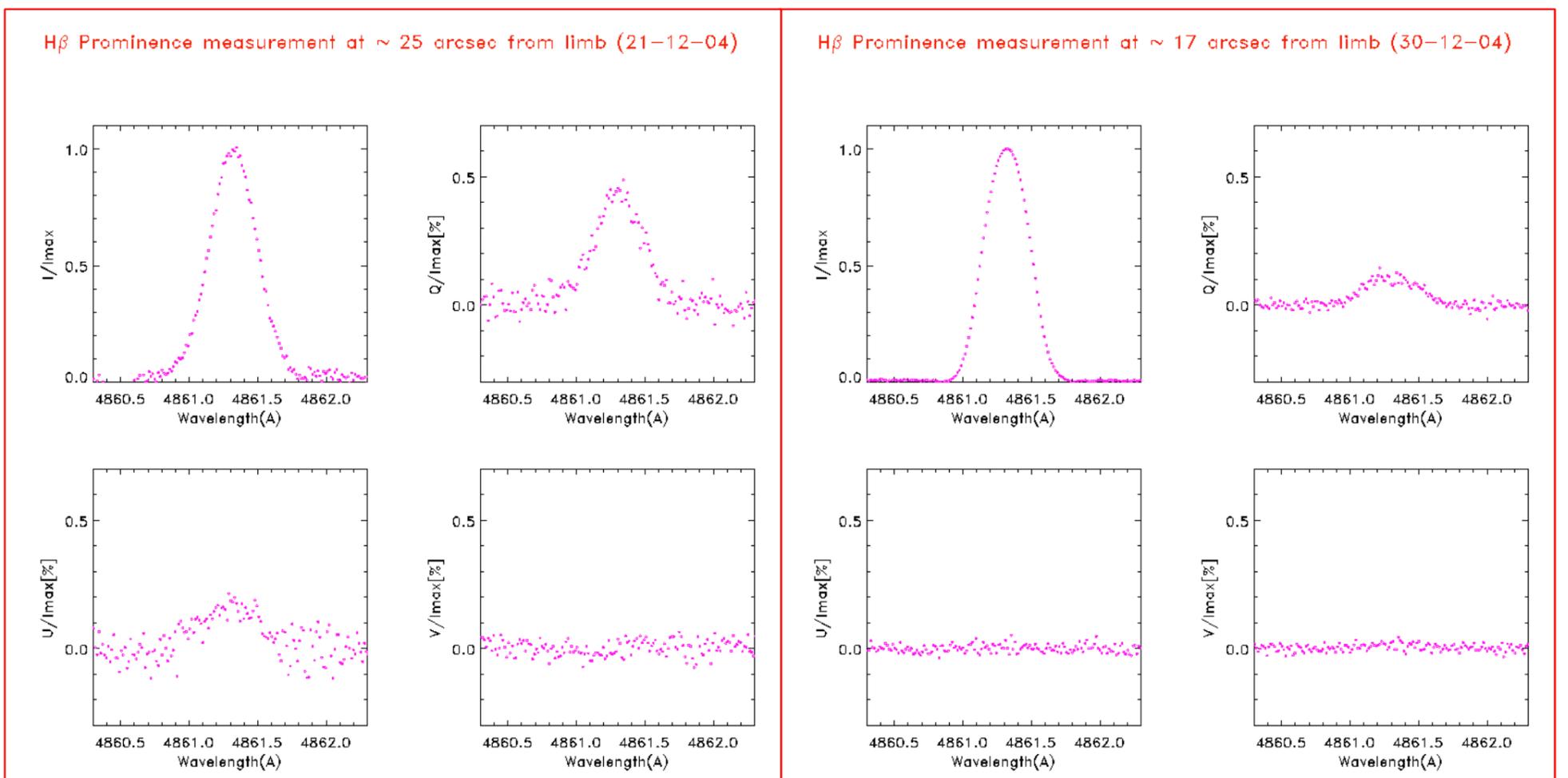
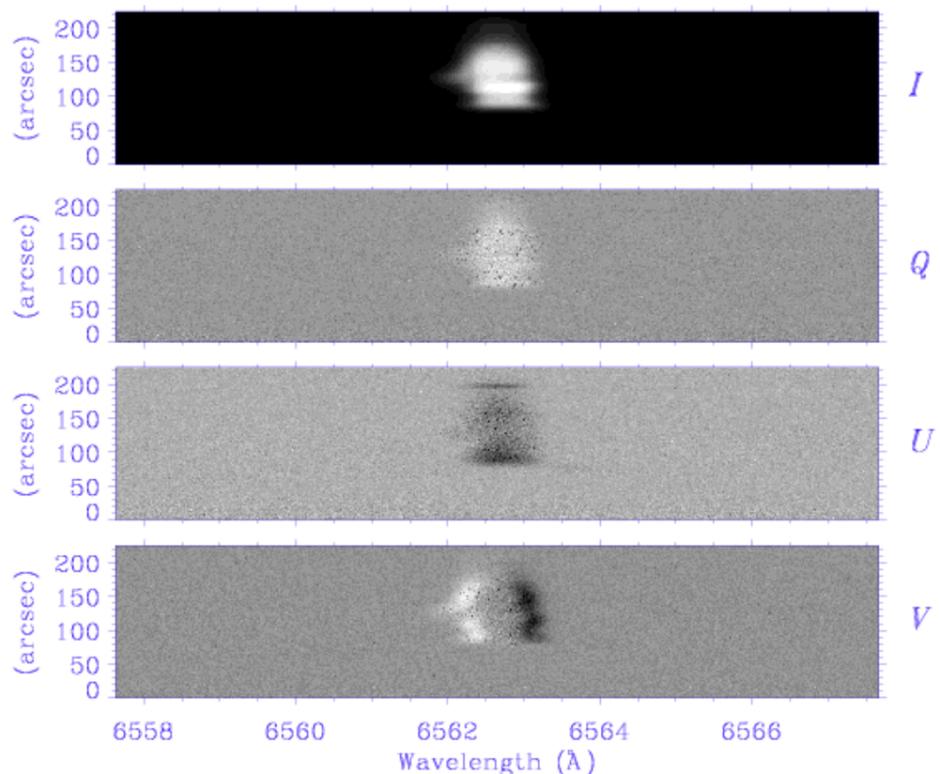


Fig.9

Fig.10

Examples of H α measurements in prominences

Prominence at ~ 48 arcsec from limb, 26 August 04 (H α)



Prominence at ~ 18 arcsec from limb, 23 May 03 (H α)

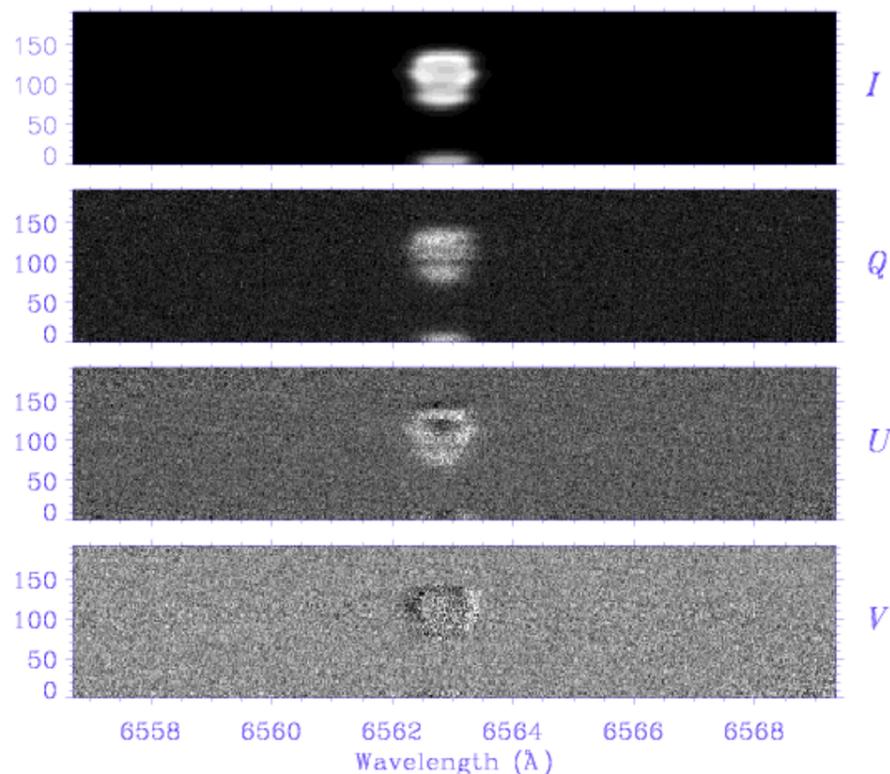
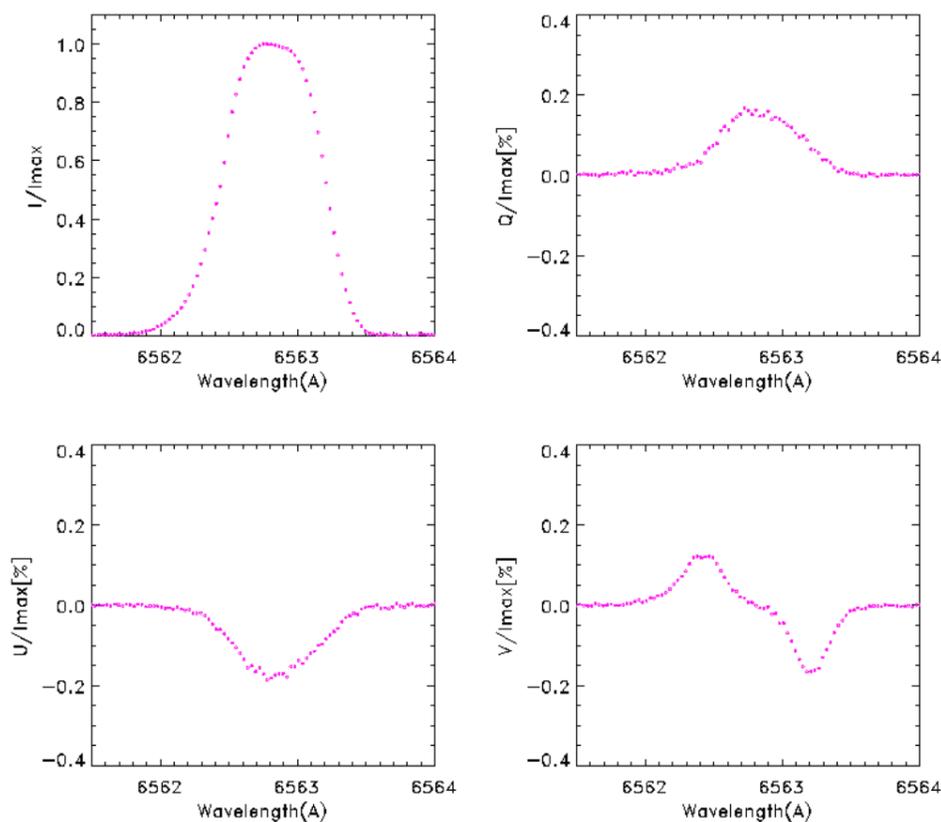


Fig.11

Fig.12

H α Prominence measurement at ~ 48 arcsec from limb (26-08-04)



H α Prominence measurement at ~ 57 arcsec from limb (18-07-03)

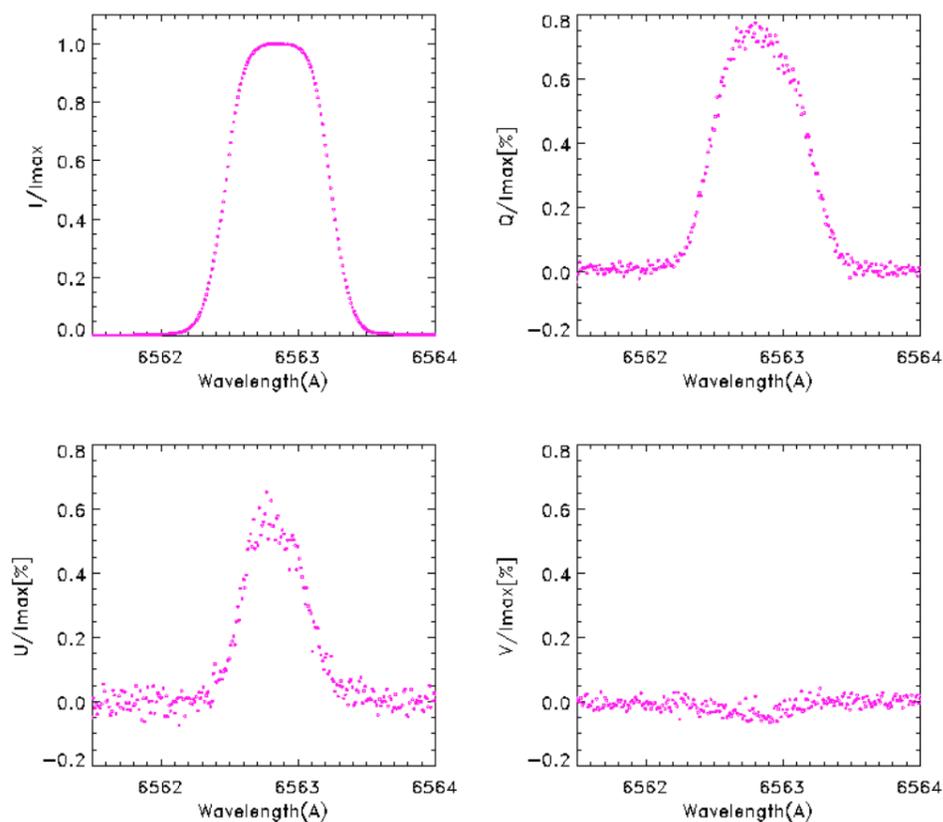


Fig.13

Fig.14

Comments:

- The H α Stokes V profiles found in our measurements show usually a typical antisymmetric Zeeman like structure (e.g Fig 11-13). In the only example we have found with a symmetric shaped Stokes V profile (Fig.14), the amplitude was very small (few 10^{-4}). Therefore our observational results are not in agreement with those presented by Lopez Ariste et al. (2005).
- Often selfabsorption is noted in the center of the line (e.g. Fig 12).