Comparison of the magnetic field measurements in solar off-limb prominences with model calculations using HAZEL code

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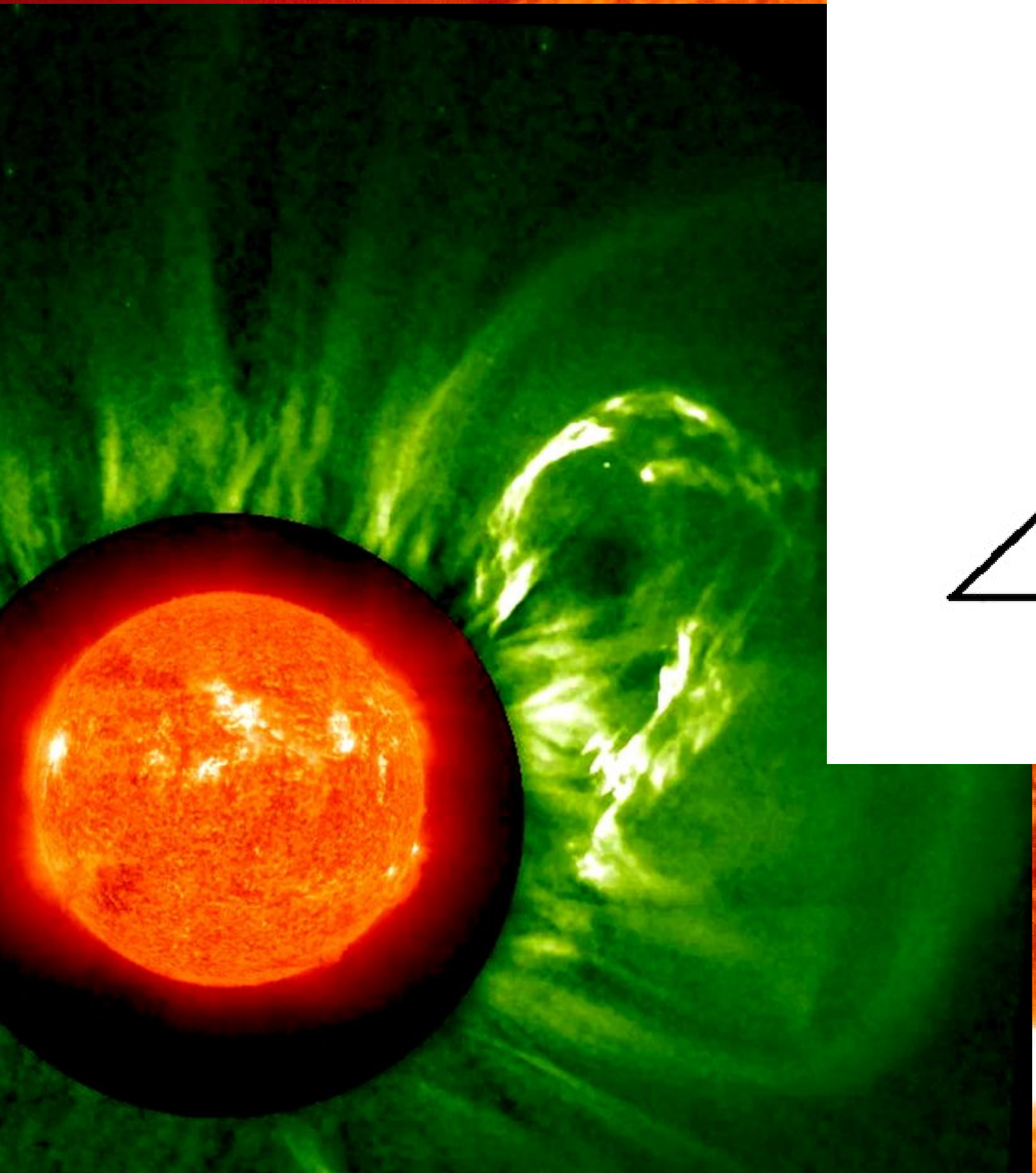
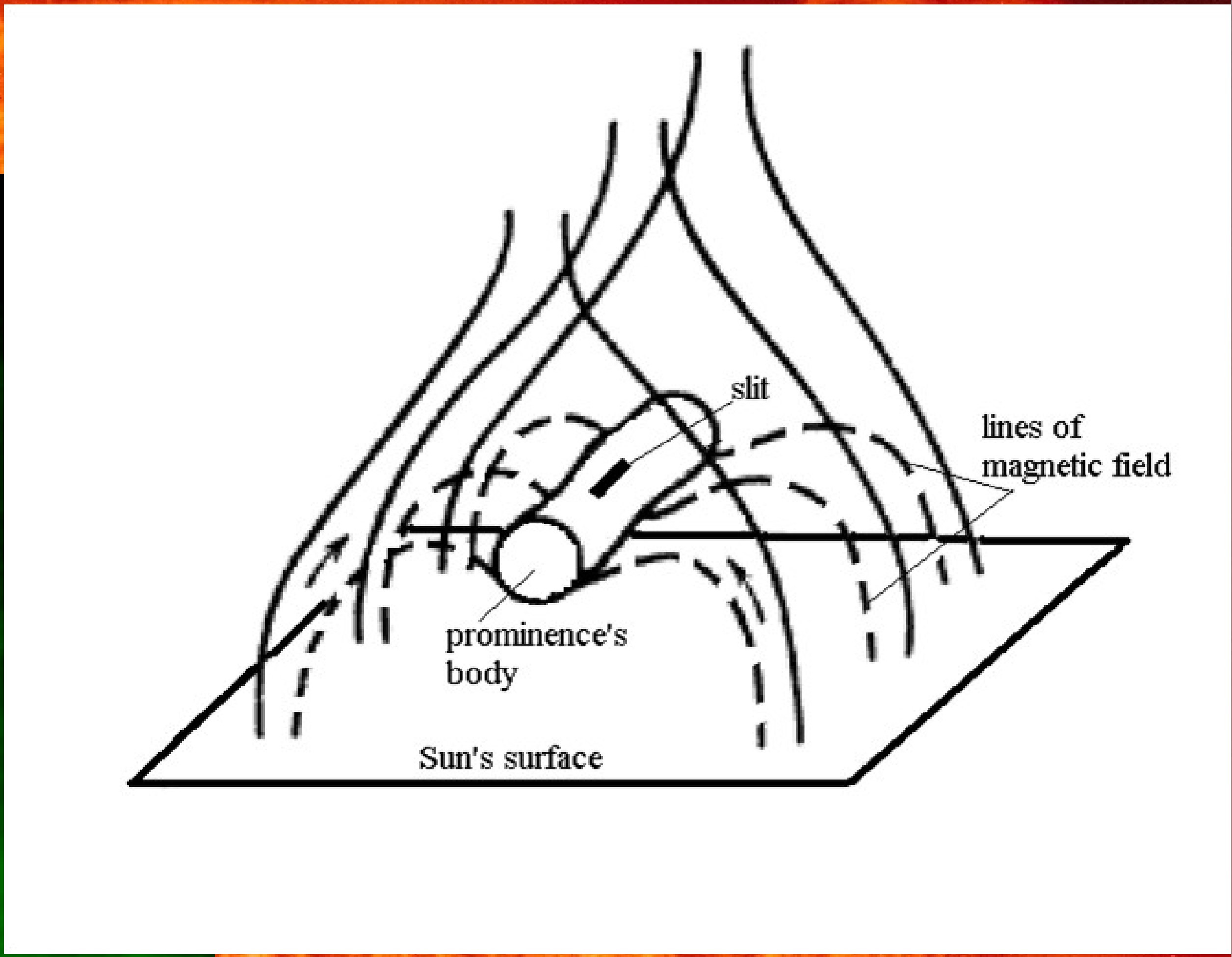
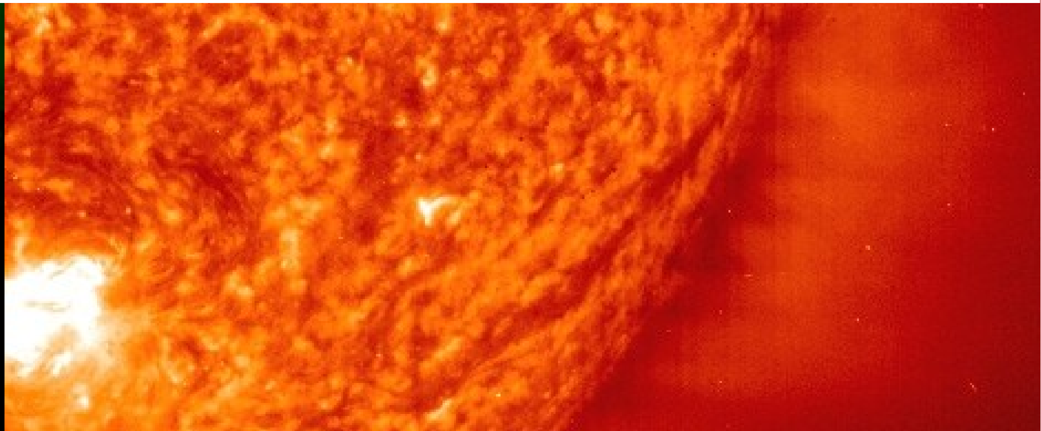
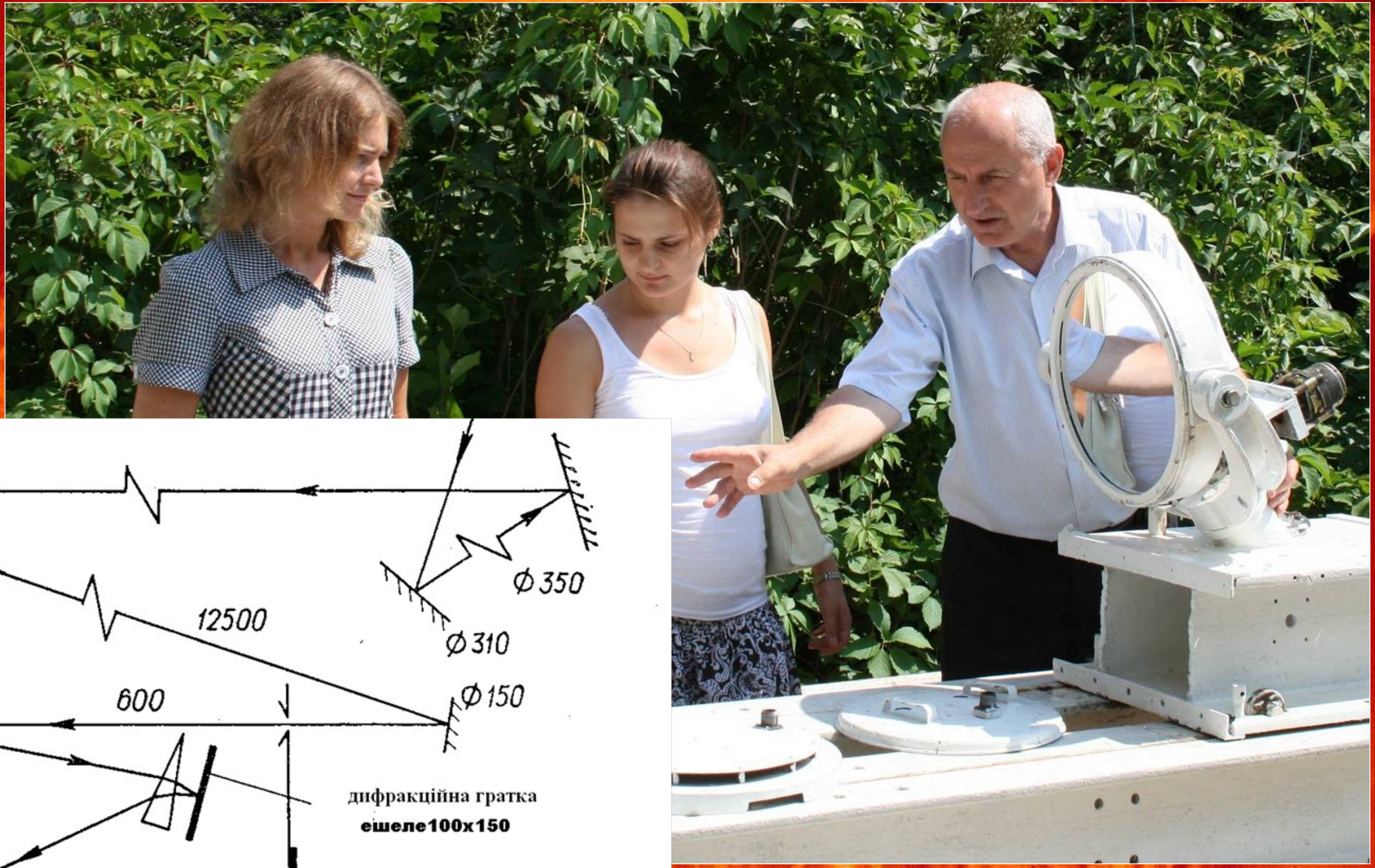
Prominences

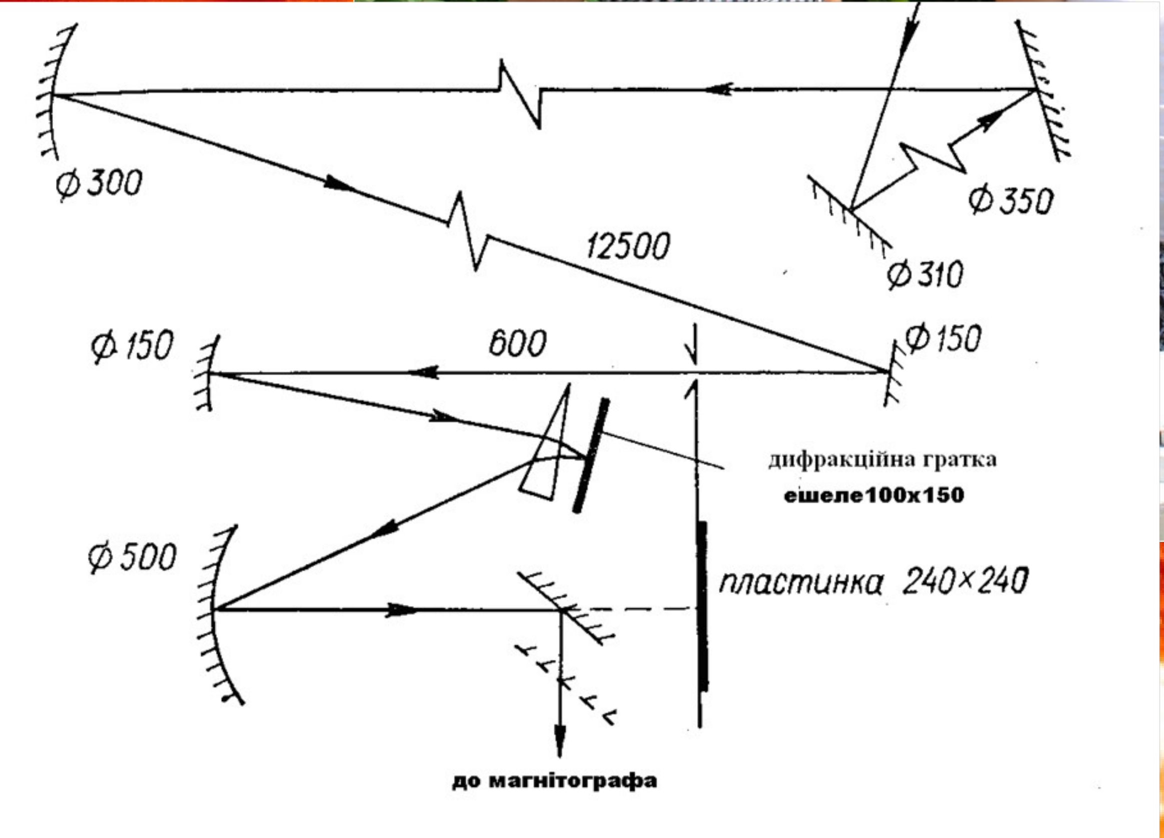




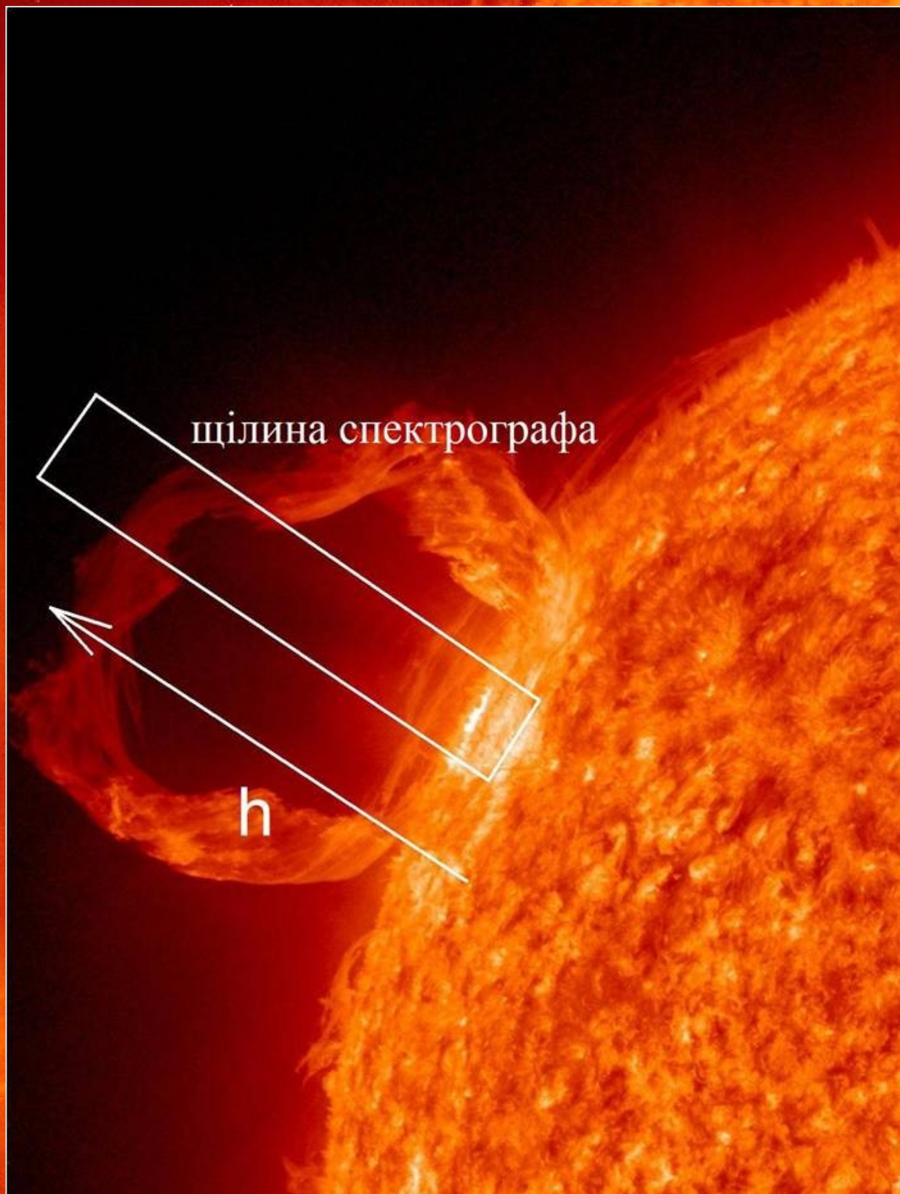


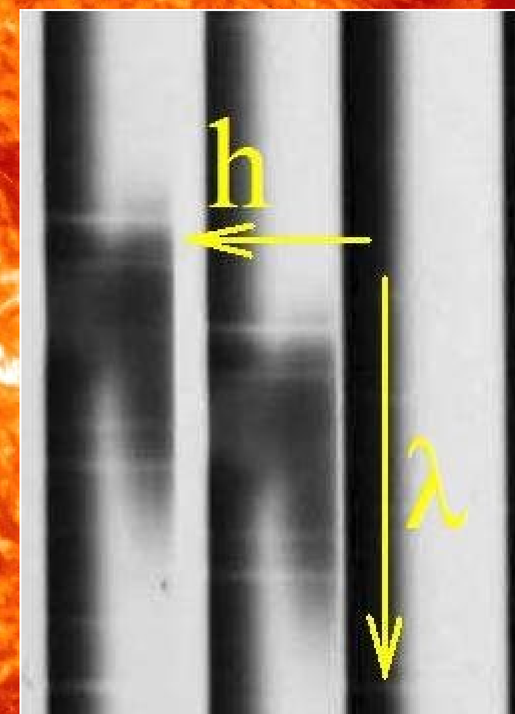
Observations of prominences(1)





Observations of prominences (2)

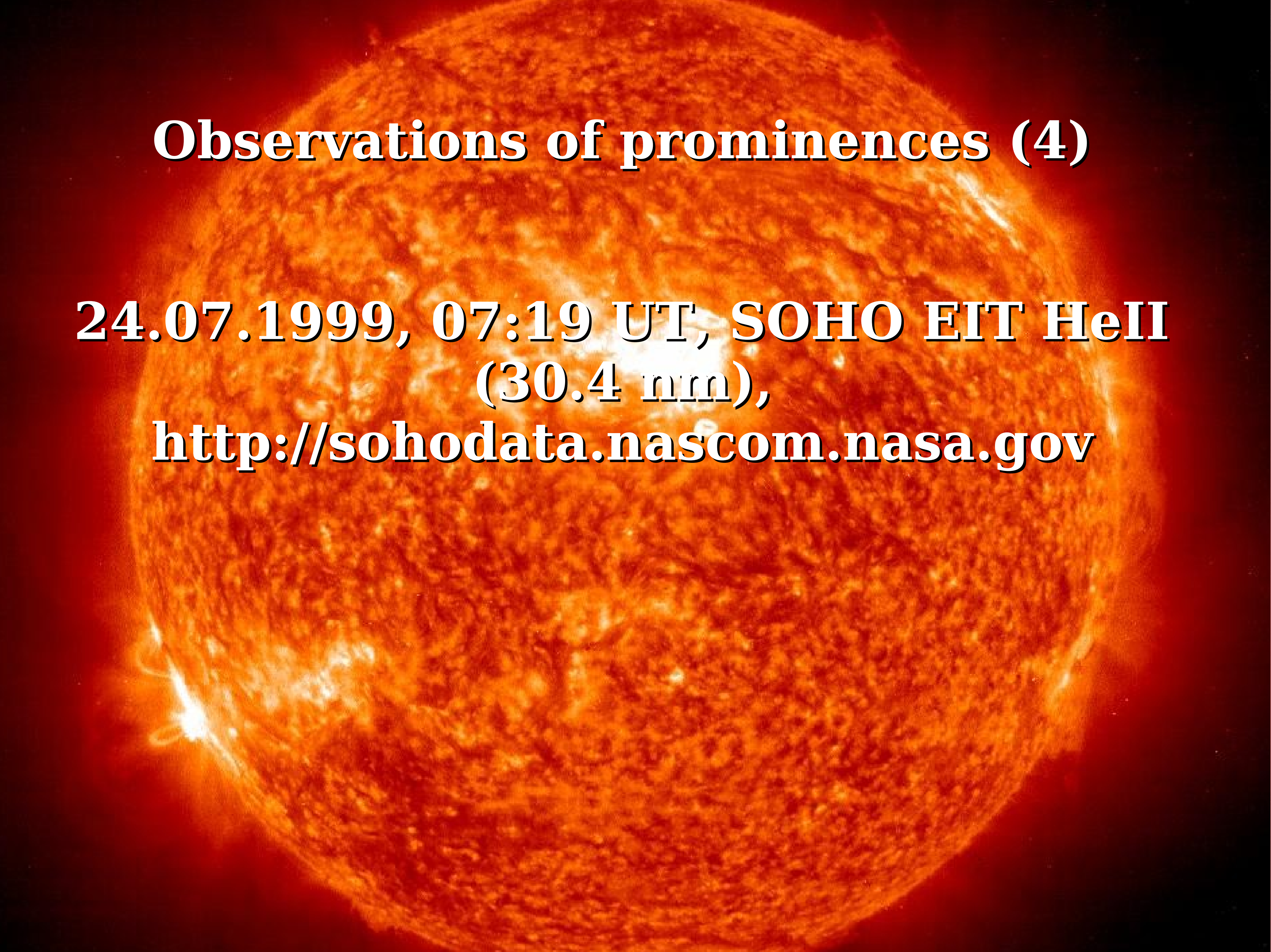




Observations of prominences (3)

Number	Date	Time of exposition	Notes
1	24.07.1981	6:30 UT	Active prominence, sunspots group 345
2	24.07.1999	6:49 UT	Active prominence
3	12.07.2004	8:48:50 UT	Active prominence, which appear after M1.6 solar flare
4	26.09.2011	11:23:25 UT	Quiescent prominence, sunspots group 1295
5	20.10.2011	09:15:25 UT	Quiescent prominence, sunspots group 1316
6	07.11.2011	11:55:25 UT	Quiescent prominence, sunspots group 1343
7	09.11.2011	11:26:17 UT; 11:28:35 UT	Quiescent prominence, sunspots group 1343

Observations of prominences (4)



24.07.1999, 07:19 UT, SOHO EIT HeII (30.4 nm), http://sohodata.nascom.nasa.gov

Stokes parameters

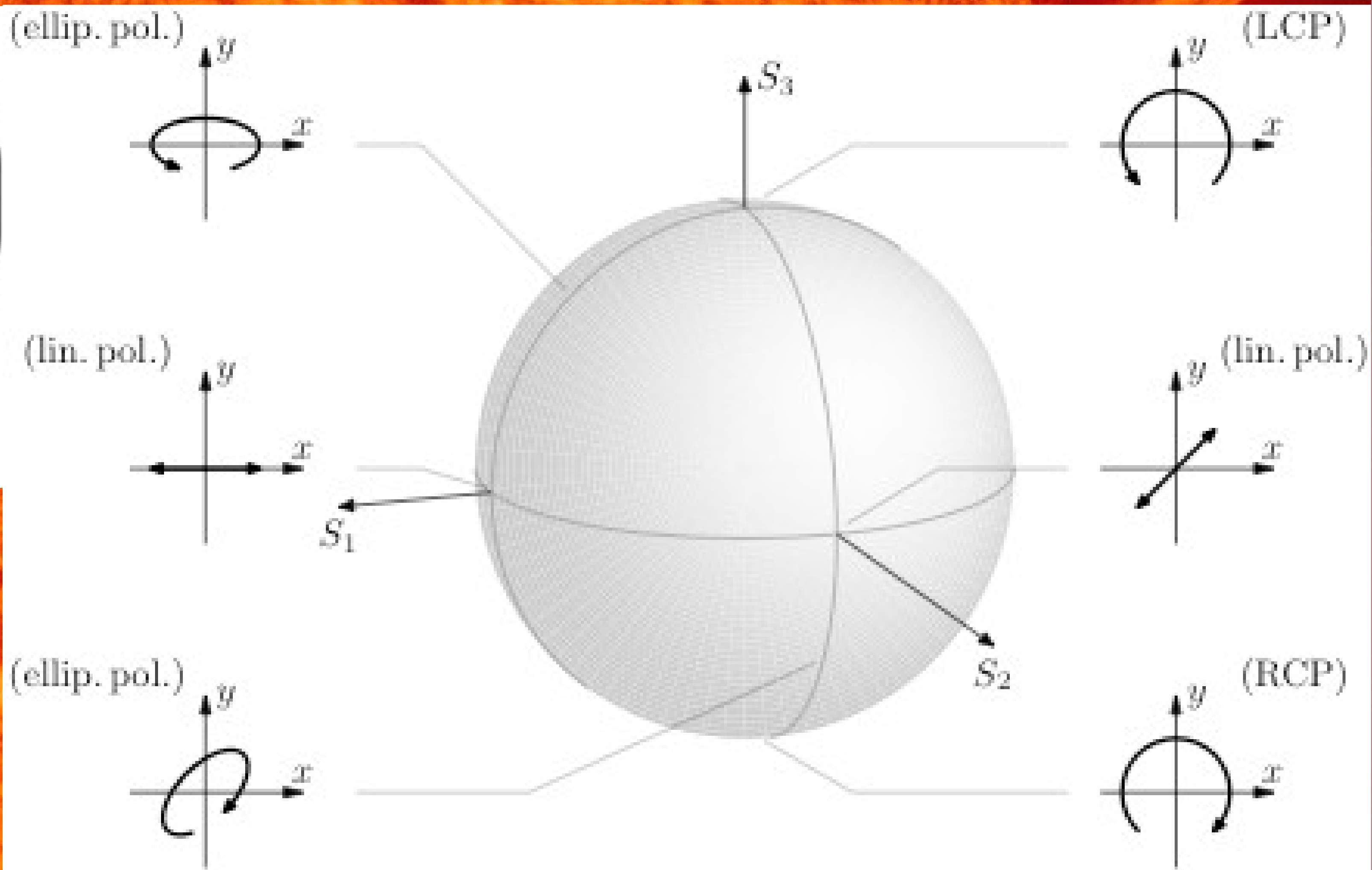
I - total intensity

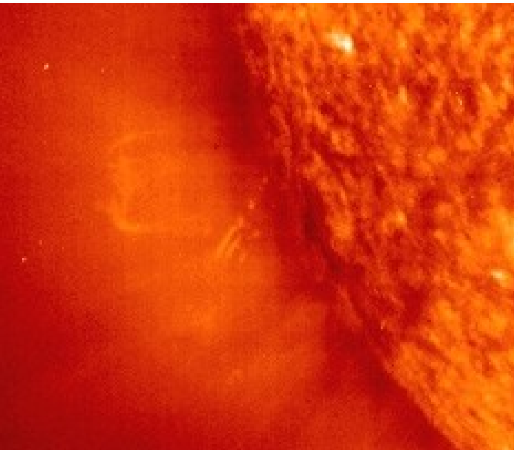
Q - linearly polarized (horizontal or vertical)

U - linearly polarized (+45° or -45°)

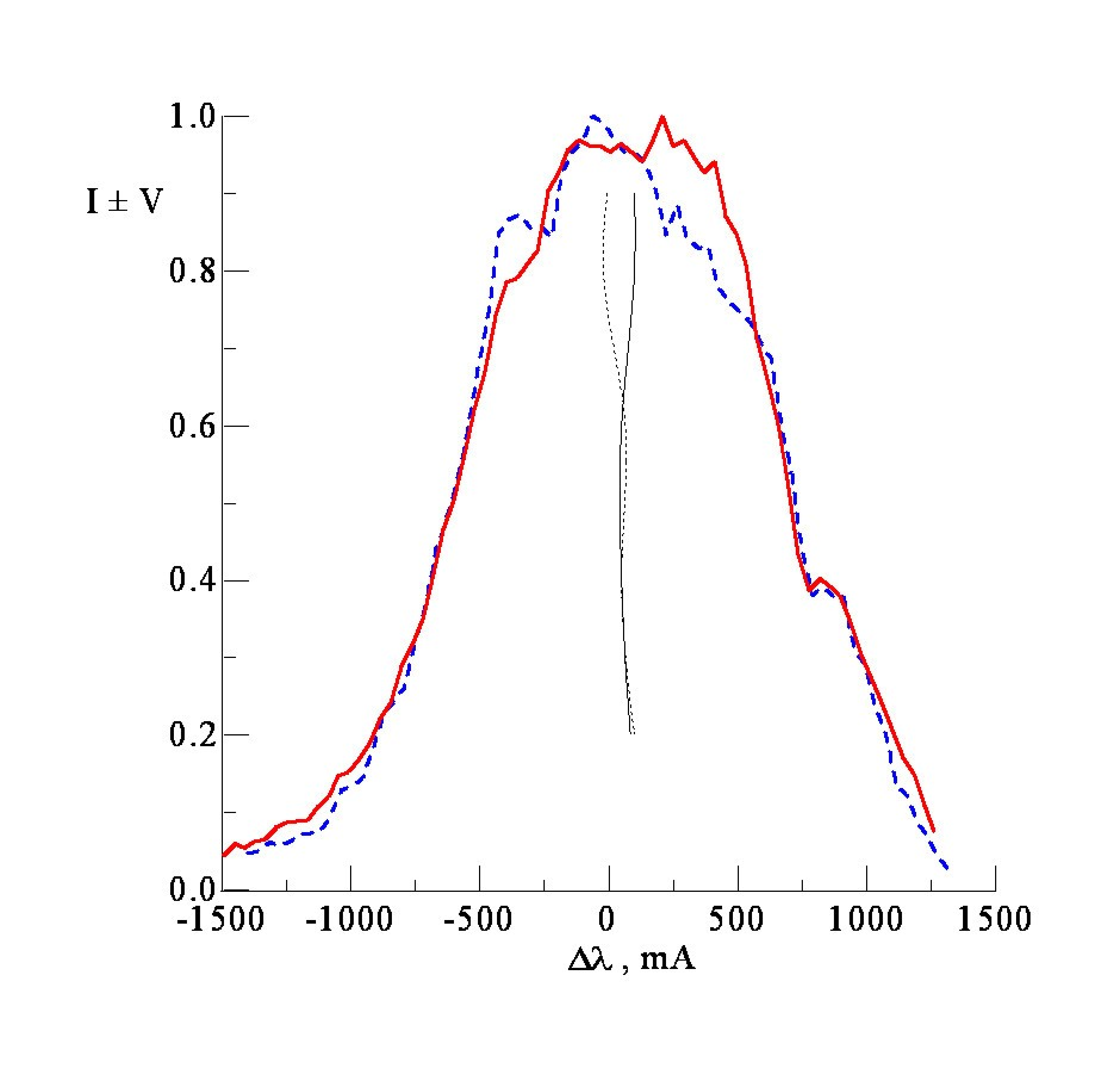
V - circularly polarized (left-hand or right-hand)

$$\vec{S} = \begin{pmatrix} S_0 \\ S_1 \\ S_2 \\ S_3 \end{pmatrix} = \begin{pmatrix} I \\ Q \\ U \\ V \end{pmatrix}$$

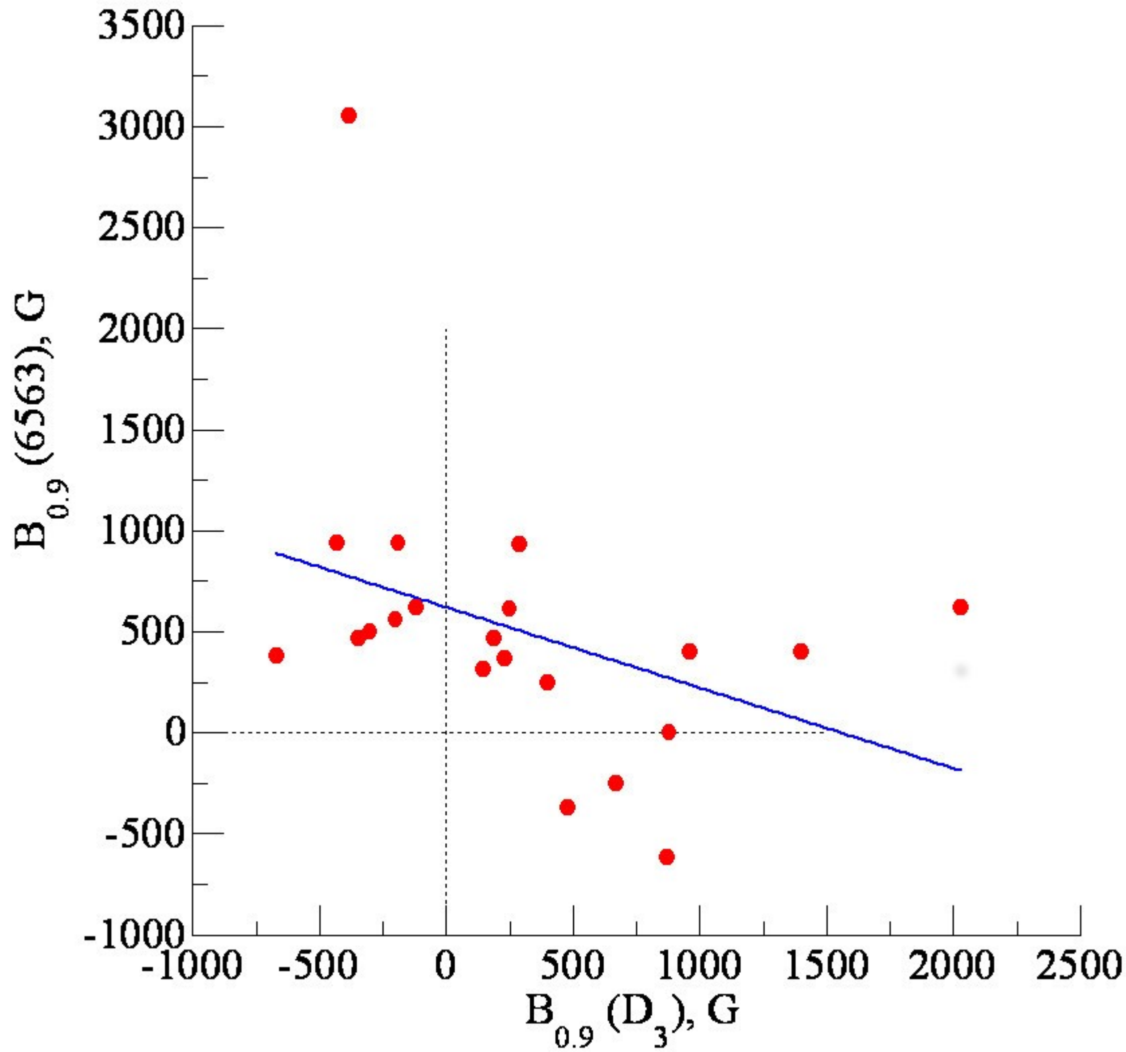




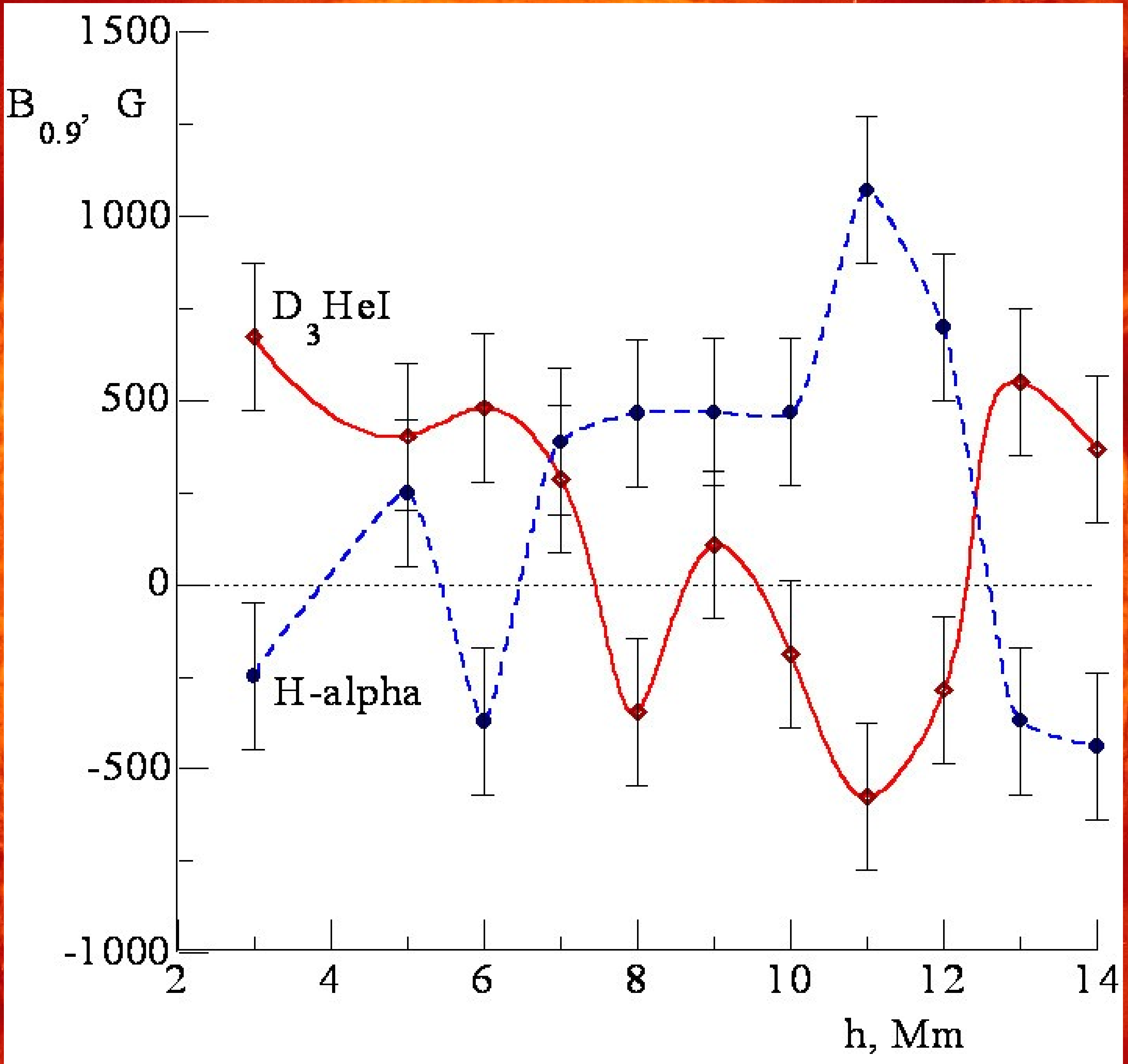
Observations of prominences(5)



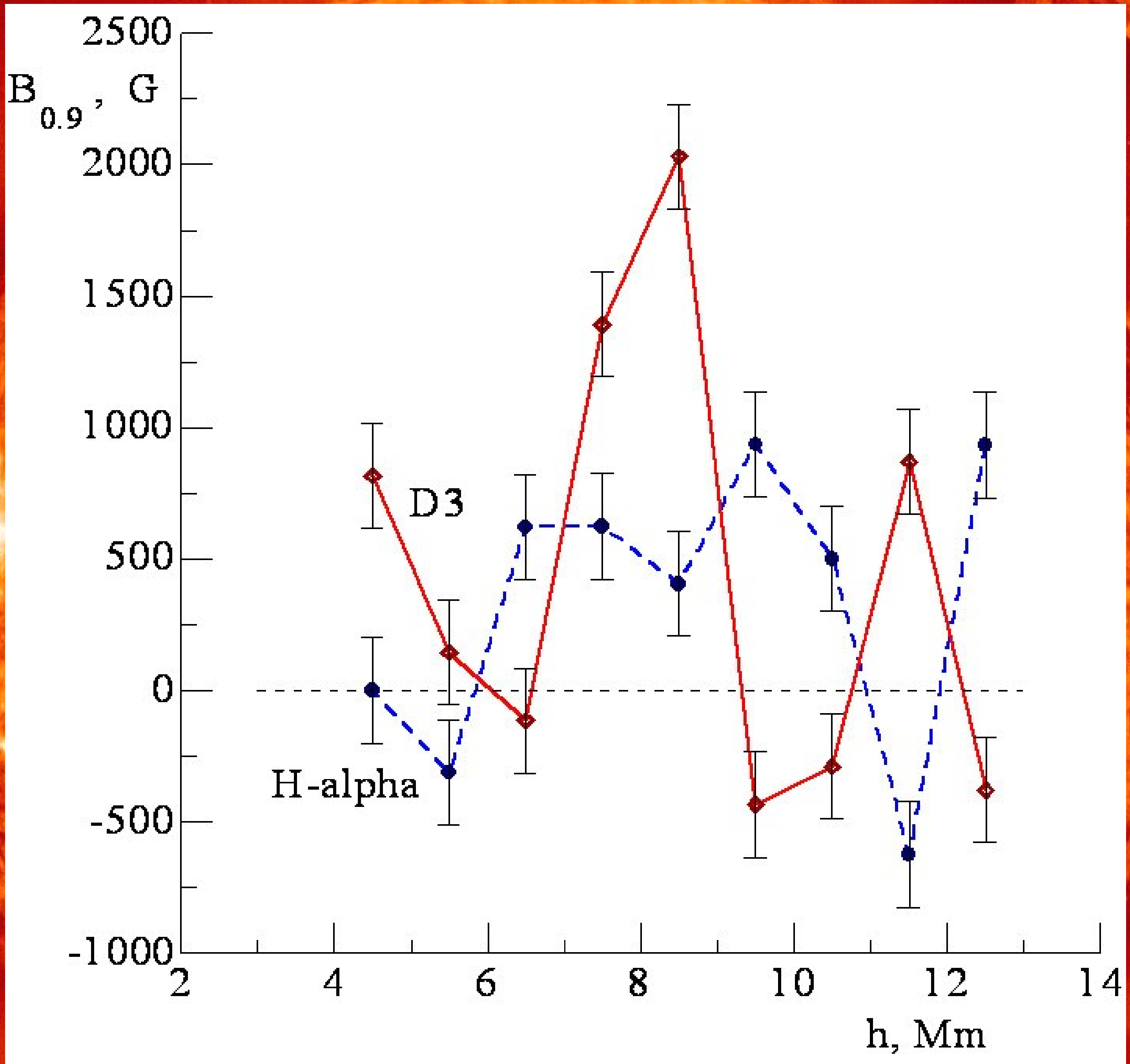
Observations of prominences(6)



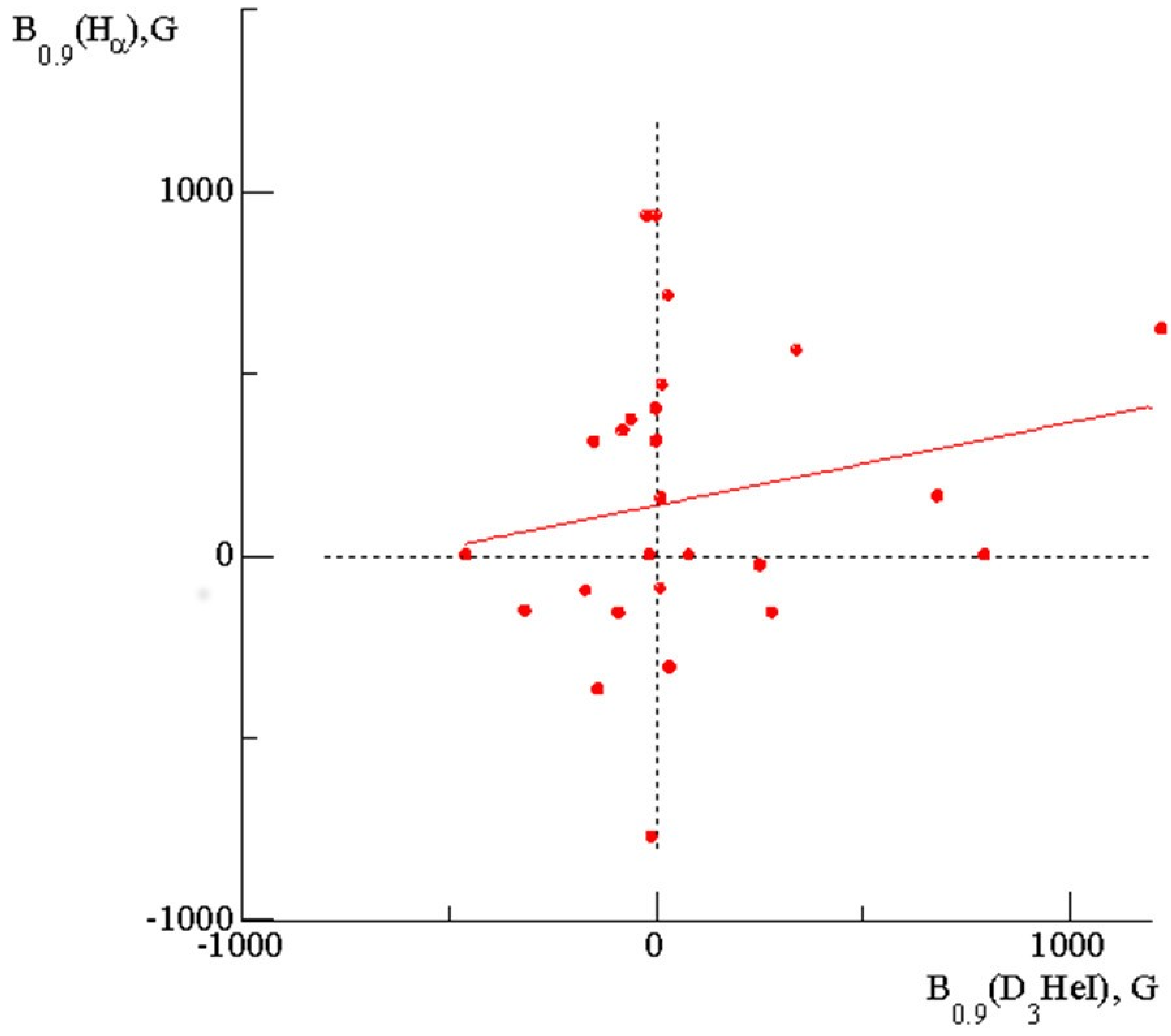
Observations of prominences(7)



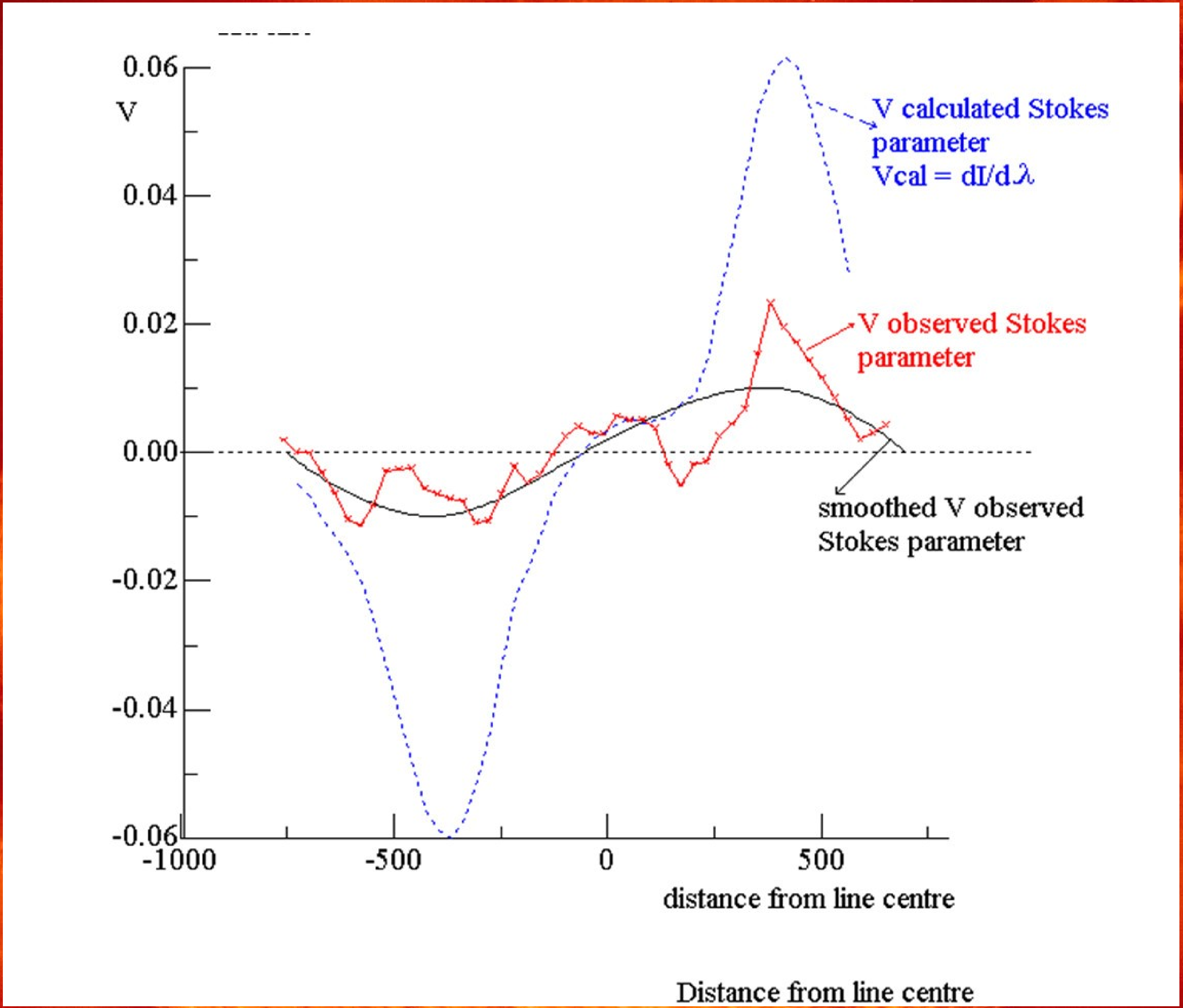
Observations of prominences(8)



Observations of prominences(9)



Observations of prominences(10)



HAZEL (HAnle and ZEeman Light)

is a computer program for the synthesis and inversion of Stokes profiles caused by the joint action of atomic level polariztion and the Hanle and Zeeman effects. It is based on the quantum theory of spectral line polarization, which takes into account rigorously all the relevant physical mechanisms and ingredients: optical pumping, atomic level polarization, level crossings and repulsions, Zeeman, Paschen-Back and Hanle effects (A. Asensio Ramos et al., ApJ, 2008).

HAZEL

$$\rho^{\beta LS}(jM, j'M') = \langle \beta LSjM | \rho | \beta LSj'M' \rangle$$

$$\frac{d}{ds}\boldsymbol{I}(\nu, \boldsymbol{\Omega}) = \boldsymbol{\epsilon}(\nu, \boldsymbol{\Omega}) - \mathbf{K}(\nu, \boldsymbol{\Omega})\boldsymbol{I}(\nu, \boldsymbol{\Omega})$$

$$\boldsymbol{\epsilon}(\nu, \boldsymbol{\Omega}) = (\epsilon_I, \epsilon_Q, \epsilon_U, \epsilon_V)^T$$

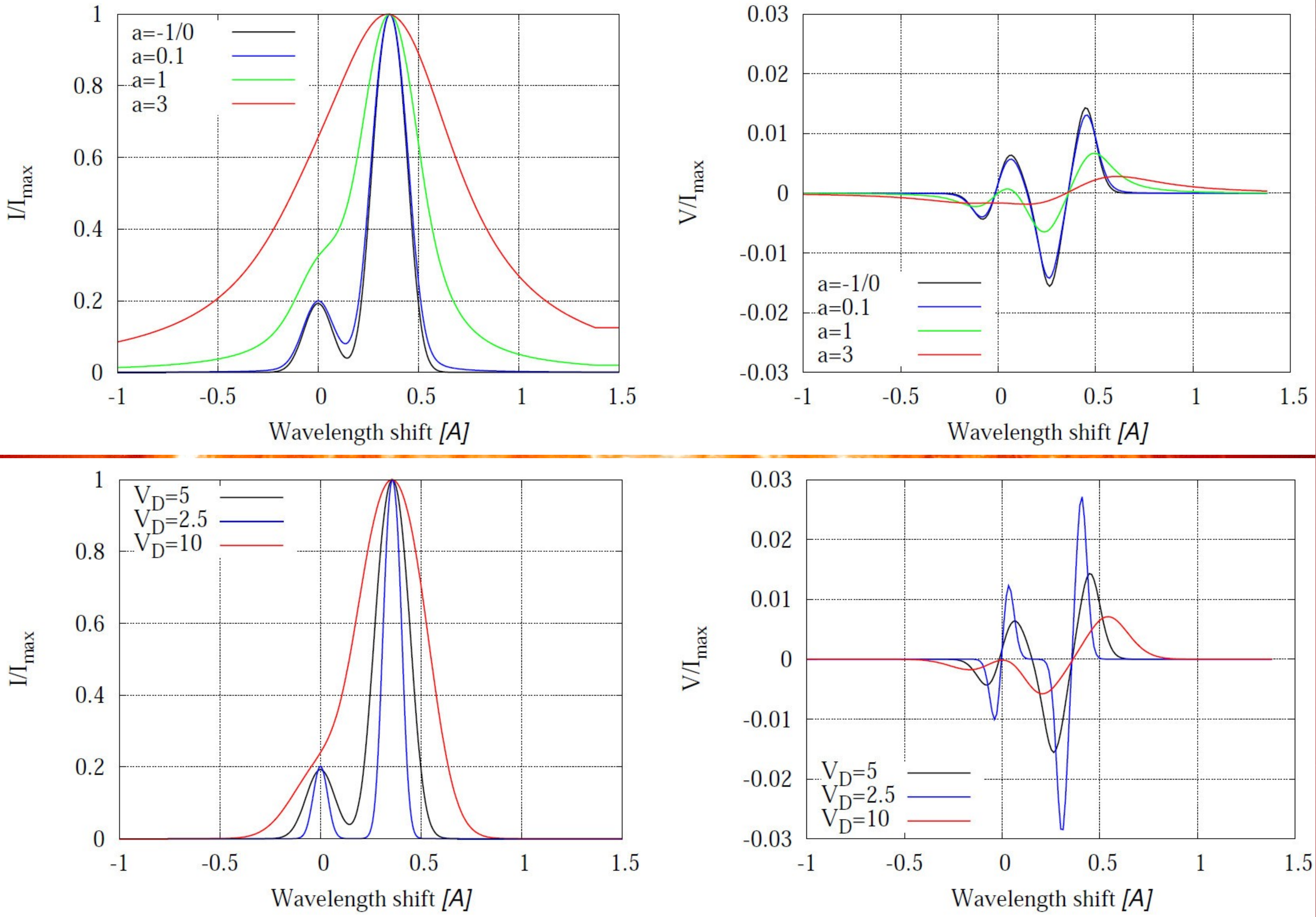
$$\mathbf{K} = \begin{pmatrix} \eta_I & \eta_Q & \eta_U & \eta_V \\ \eta_Q & \eta_I & \rho_V & -\rho_U \\ \eta_U & -\rho_V & \eta_I & \rho_Q \\ \eta_V & \rho_U & -\rho_Q & \eta_I \end{pmatrix}$$

$$\begin{aligned}
\frac{d}{dt}\rho^K_Q(J, J') = \\
&- 2\pi i \sum_{K'Q'} \sum_{J''J'''} N_{\beta LS}(KQJJ', K'Q'J''J''')\, {}^{\beta LS}\rho^{K'}_{Q'}(J'', J''') \\
&+ \sum_{\beta_l L_l K_l Q_l J_l J_l'} {}^{\beta_l L_l S}\rho^{K_l}_{Q_l}(J_l, J_l')\, \mathbb{T}_A(\beta LSKQJJ', \beta_l L_l S K_l Q_l J_l J_l') \\
&+ \sum_{\beta_u L_u K_u Q_u J_u J_u'} {}^{\beta_u L_u S}\rho^{K_u}_{Q_u}(J_u, J_u') \big[\mathbb{T}_E(\beta LSKQJJ', \beta_u L_u S K_u Q_u J_u J_u') \\
&+ \mathbb{T}_S(\beta LSKQJJ', \beta_u L_u S K_u Q_u J_u J_u') \big] \\
&- \sum_{K'Q'J''J'''} {}^{\beta LS}\rho^{K'}_{Q'}(J'', J''') \big[\mathbb{R}_A(\beta LSKQJJ'K'Q'J''J''') \\
&+ \mathbb{R}_E(\beta LSKQJJ'K'Q'J''J''') + \mathbb{R}_S(\beta LSKQJJ'K'Q'J''J''') \big].
\end{aligned}$$

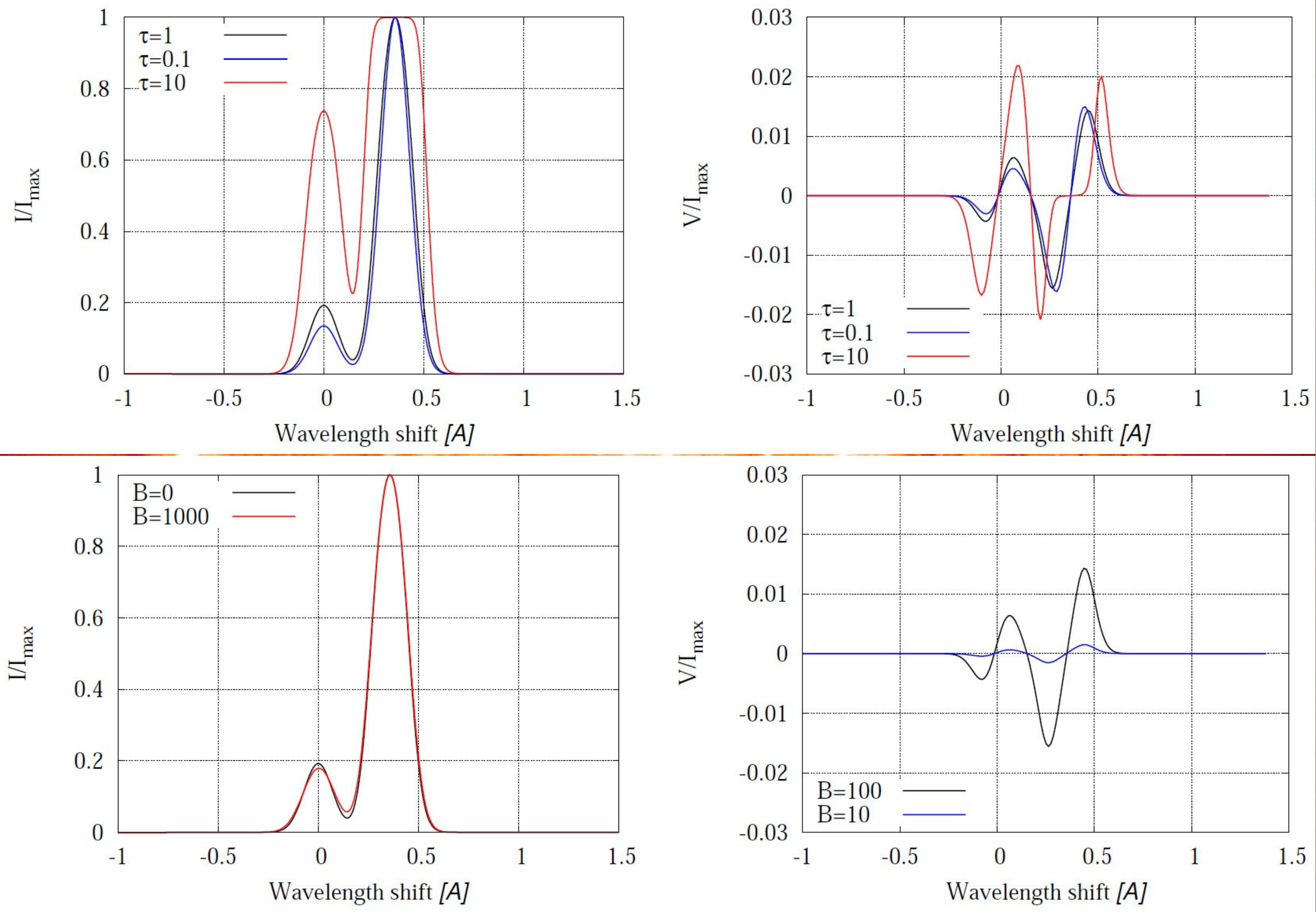
Modelling

As a typical physical conditions of observed off-limb prominences were
for I profiles:
height above the Sun's disk 10”, background I=0, optical depth t=1, damping a=0, velocity of turbulent motions V=0 km/s, macroscopic velocity = 0 km/s, horizontal magnetic field of 100 G;
for V profiles:
height above the Sun's disk 10”, background I=0, optical depth =1, damping a=0, velocity of turbulent motions V=0 km/s, horizontal magnetic field of 100 G

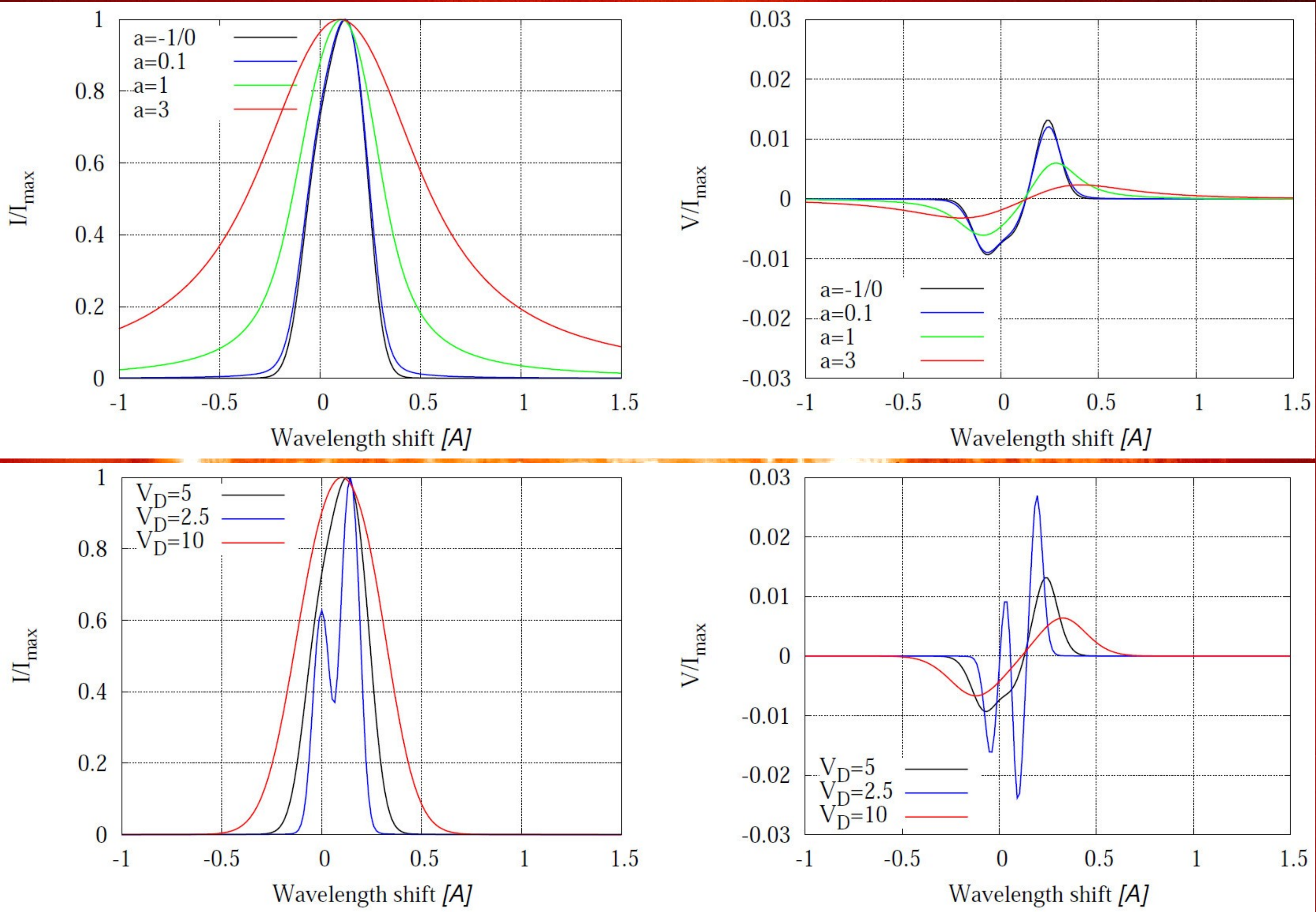
Results of D3 HeI modelling(1)



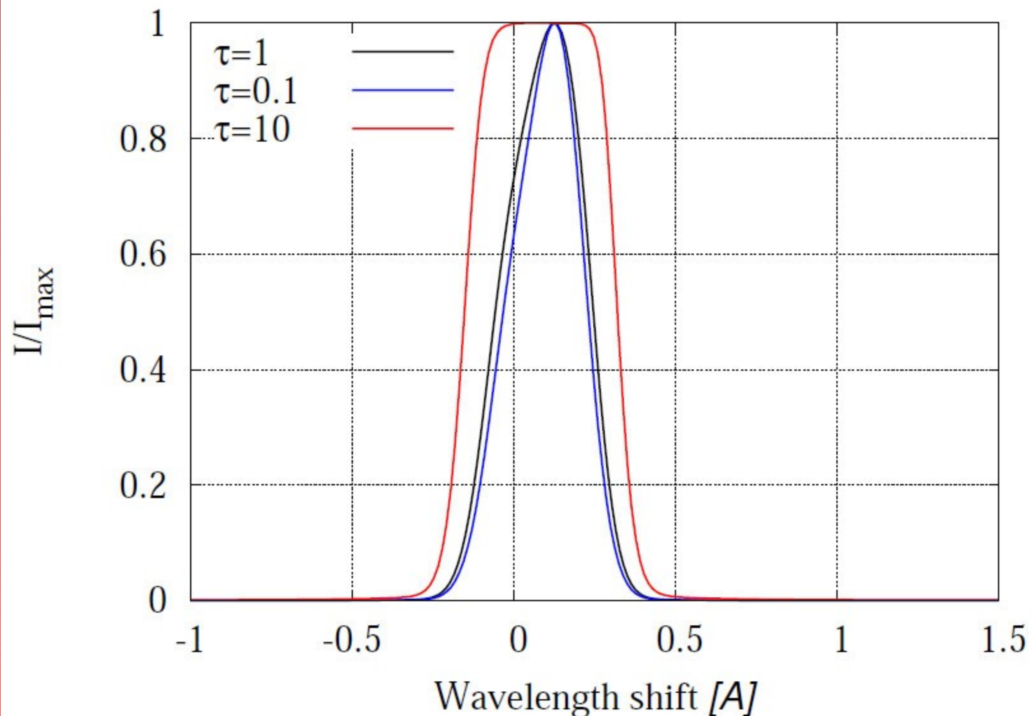
Results of D3 HeI modelling (2)

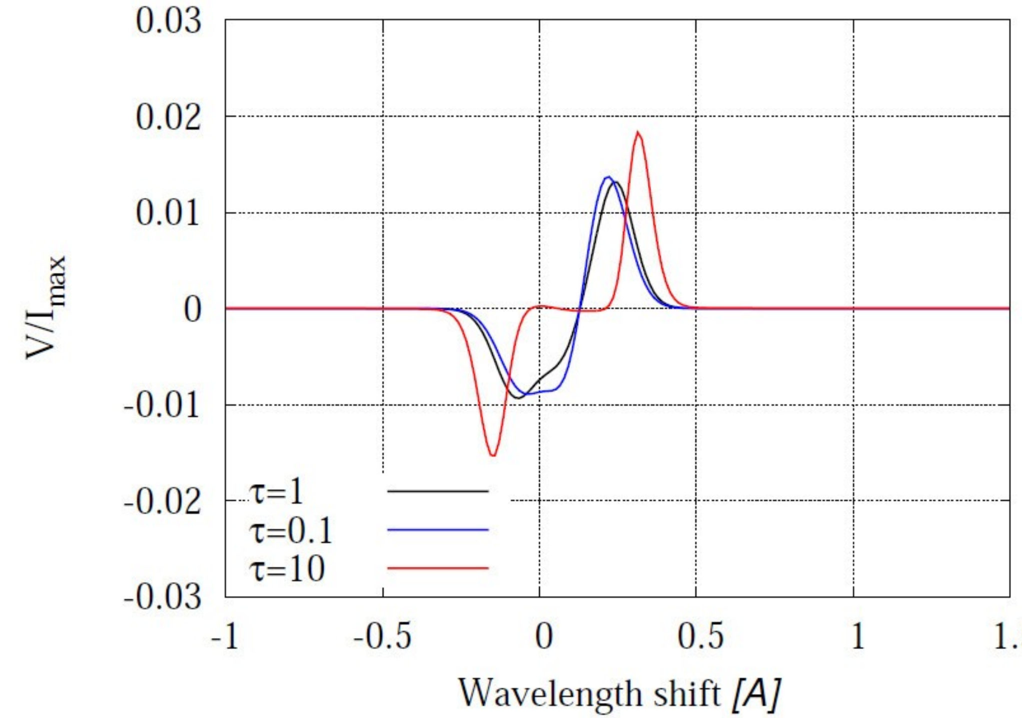


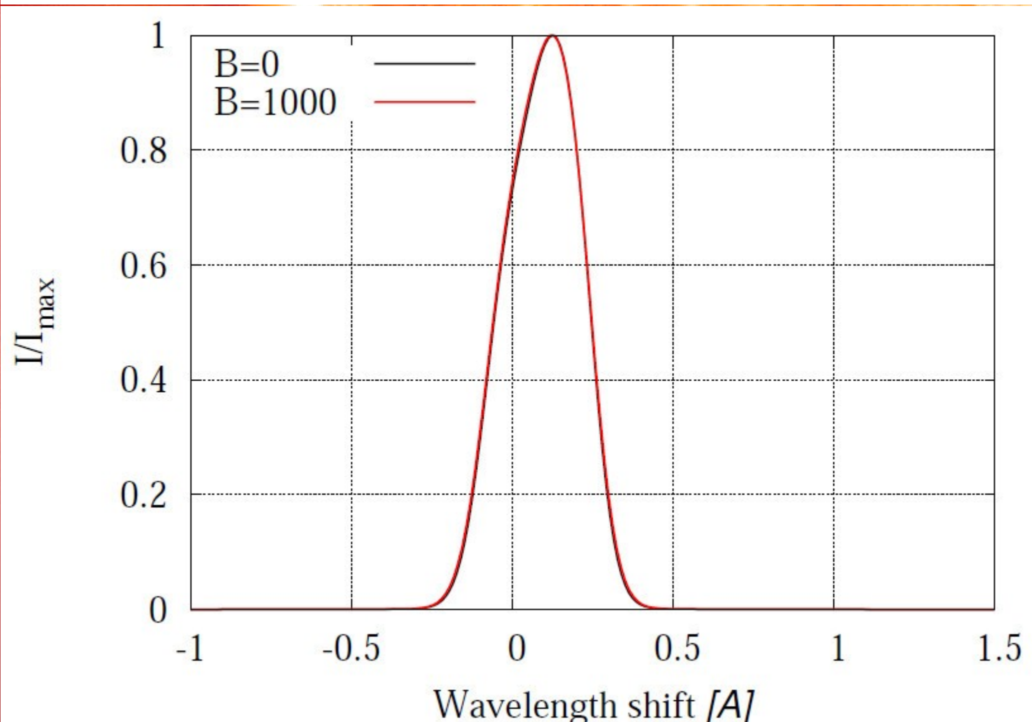
Results of H alpha modelling (1)

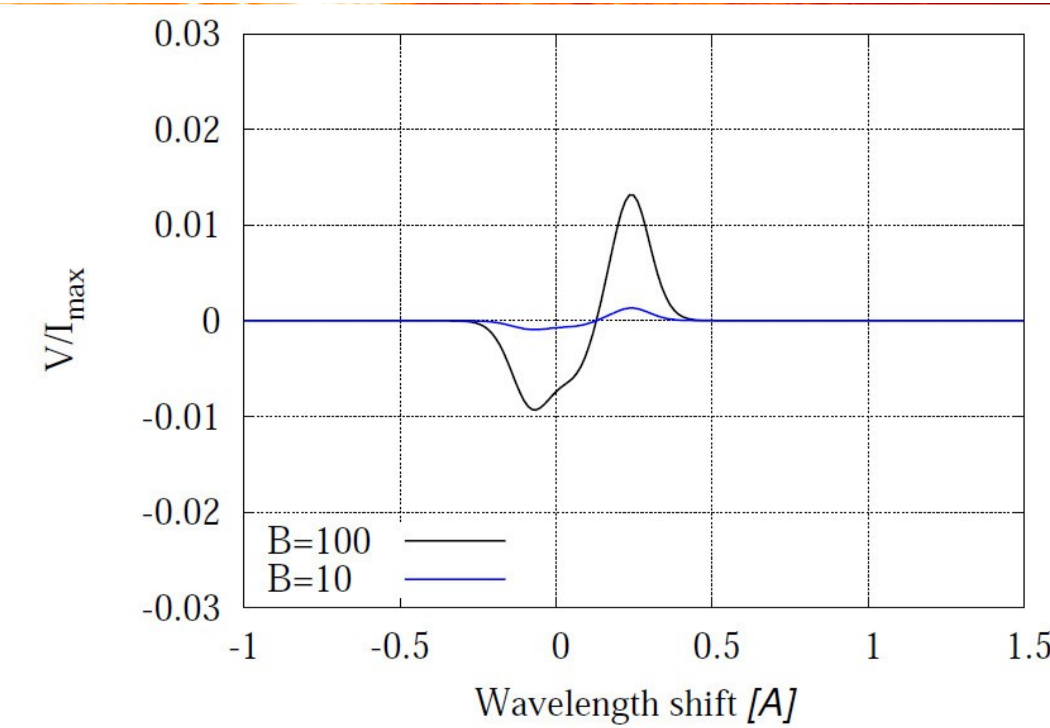


Results of H alpha modelling (2)

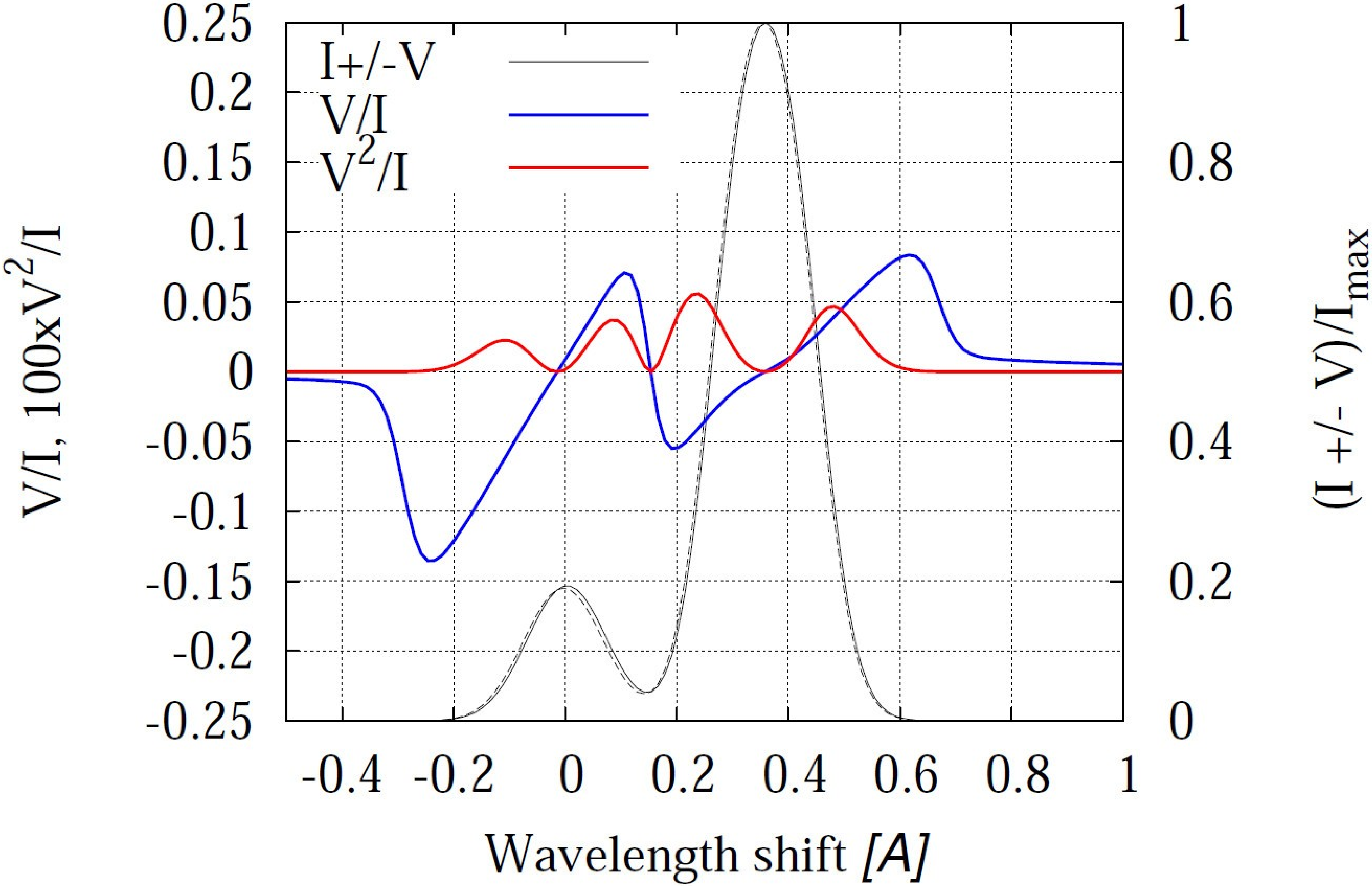




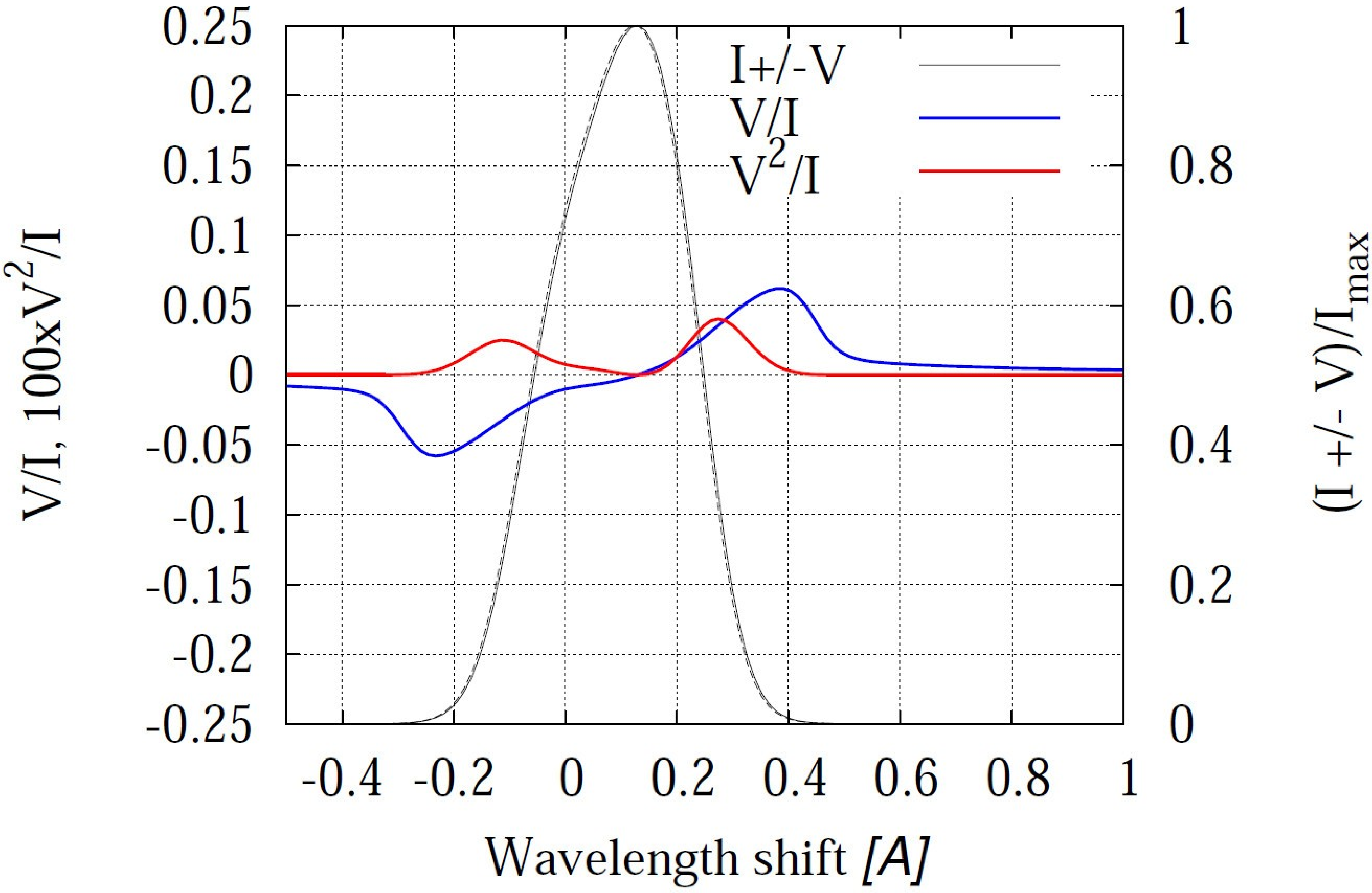




Results of D3 HeI modelling (3)



Results of H alpha modelling (3)



Conclusions (1)

According to obtained data in observed active prominences the averaged magnetic field was in the range of -600 to +1500 G (the average measurement error 100 G).

The anti-correlation effect of magnetic fields on the lines D3 and H alpha was found in case of active prominences.

Conclusions (2)

The amplitude values of the local magnetic field of quiescent prominences were in the range of 0 to 1240 G for the line 6563 Å, and from 0 to 1220 G for the line 5875,6 Å. In contrast to the case of an active prominences, anticorrelation effect of the measured values of the magnetic field in D3 and H alpha was not observed in quiescent prominences.


Thank you for attention!