Statistical spectroscopic analysis of quiescent prominence observed in Lyman lines by SoHO/SUMER and MgII h&k lines by IRIS

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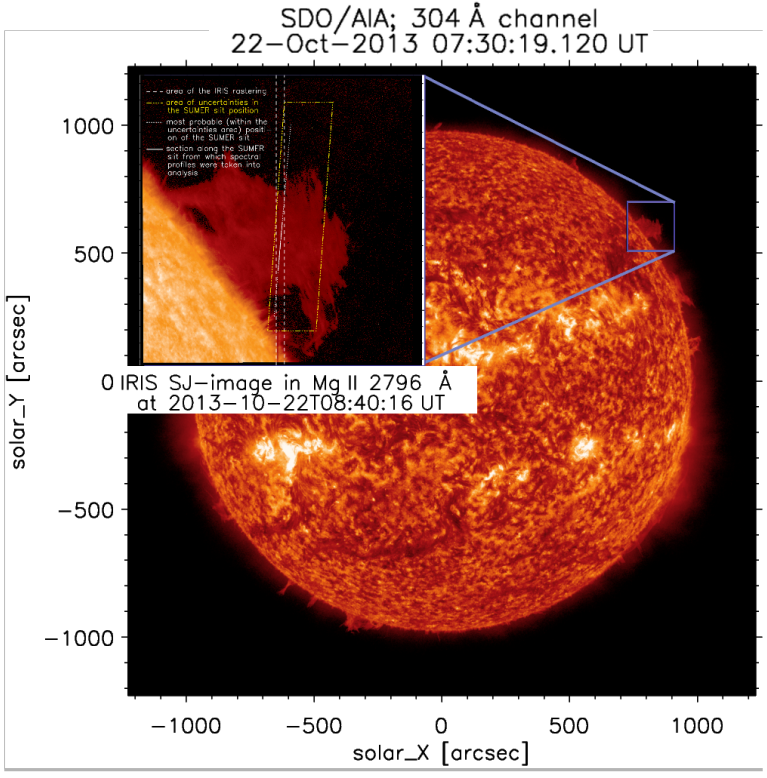
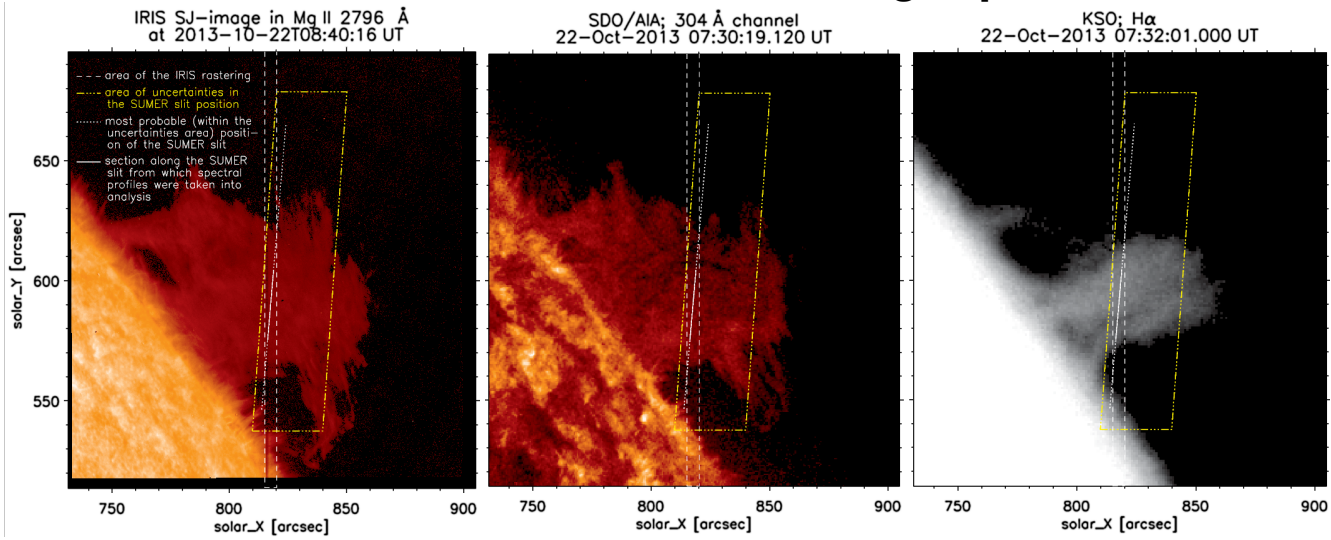
Abstract. A quiescent prominence was observed on October 22, 2013 at NW limb quasi-simultaneously and nearly co-spatially in the Lyman line series of hydrogen by SoHO/SUMER and in MgII h&k UV lines by IRIS. In this contribution we analyze a dense and compact structure of the prominence because this part is quiet and therefore suitable for quasi-static non-LTE modeling. This part of the prominence is also well visible in H_alpha filtrogram images. Spectroscopic analysis of the Lyman line and MgII h&k profiles is done using the following profile characteristics: integral intensities, depth of the central reversal and asymmetry of the peaks. Distributions of the profile characteristics within the studied area of the prominence are statistically analyzed using histograms. The profile characteristics are now defined only for profiles with one peak (purely emissive) or double-peaked. There exist also profiles with more peaks in the observed data from both instruments, thus, statistical analysis of occurrences of different type of profiles – one-, two-, three-, four-and-more-peak profiles and peculiar profiles is also made. Results of the statistical analysis of observed data are to be be compared with the analogous statistical analysis of synthetic profiles obtained using the non-LTE models of the fine structure of prominences.

Quiescent prominence at the NW limb observed 22 Oct, 2013 – although quiescent , it was also rather dynamical.



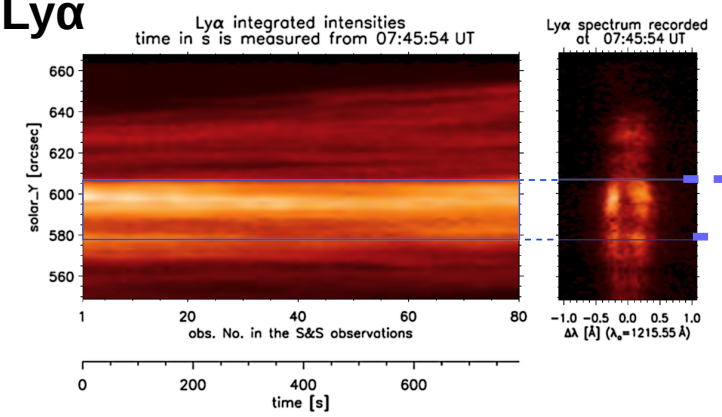


Rather dynamic quiescent prominence was observed on October 22, 2013 at the NW limb quasi-simultaneously and nearly co-spatially in Lyman lines of hydrogen and UV lines of MgII by two space-born spectrographs SoHO/SUMER and IRIS. FOV of the IRIS spectrograph dense rastering (composed of 16 slit positions with the step of 0.35 arcsec) and position of the SUMER slit within its uncertainties during its sit-and-stare (S&S) observationsare shown in the IRIS MgII 2796 Å SJ image, cut-off from the SDO/AIA 304 Å full-disc image and cut-off of the Hα filtergram from KSO. As there is rather large uncertainty in position of the SUMER slit, spectroscopical analysis of data from the two spectrographs are made individually and then the results are compared. Only compact and dense part of the prominence, visible also in the Hα filtergram, is analysed due to lower dynamics occurring there and therefore profiles from this parts are more suitable for our future non-LTE modelling.

Quasi-simultaneous and almost co-spatial observations in H Lyman lines and MgII h&k lines made with the SoHO/SUMER and IRIS UV spectrographs

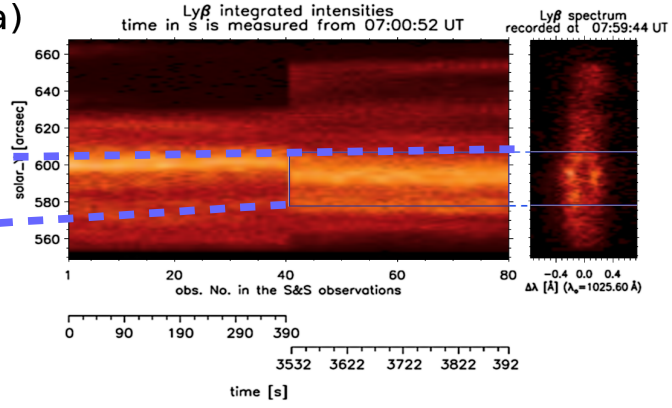
SUMER:

Lyα



analysed data

Lyβ



The Lyγ and Lyδ line SUMER spectra and subsequently profiles from the analysed part of the prominence are very similar to those of Lyβ.

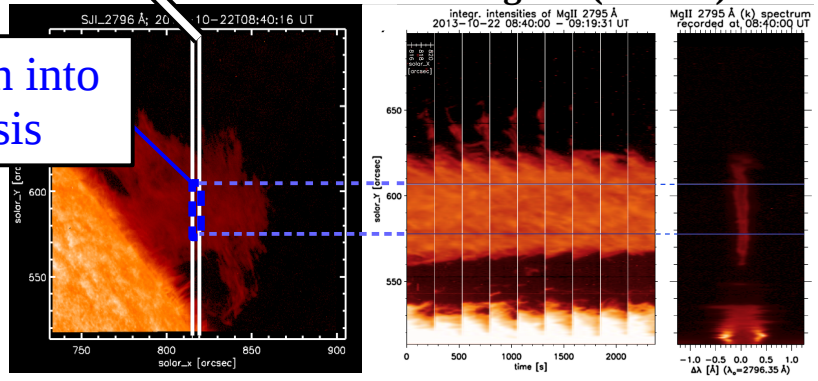
IRIS:

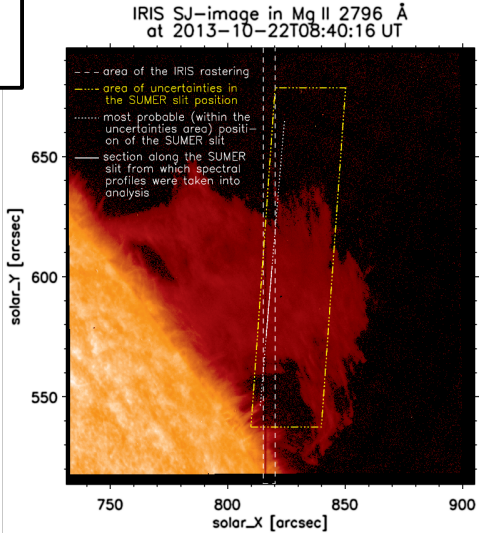
FOV of one IRIS raster

Spectra and maps of integrated intensities of MgII h (2803 Å) are similar to those of MgII k (2796 Å)

data taken into the analysis

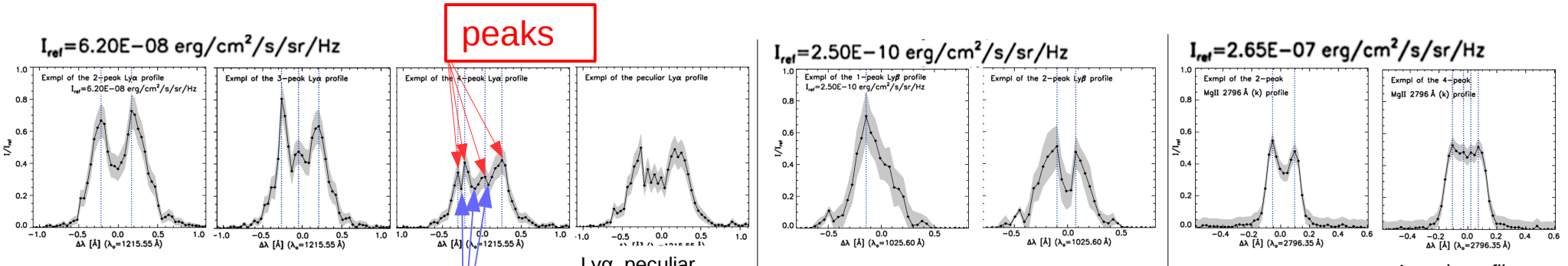
MgII k (2796 Å)



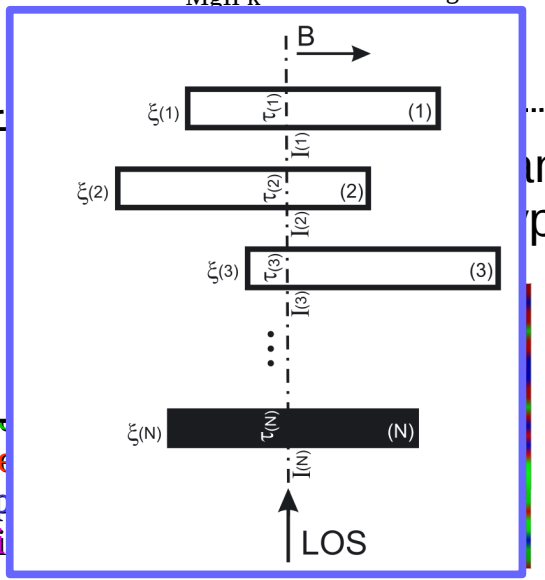


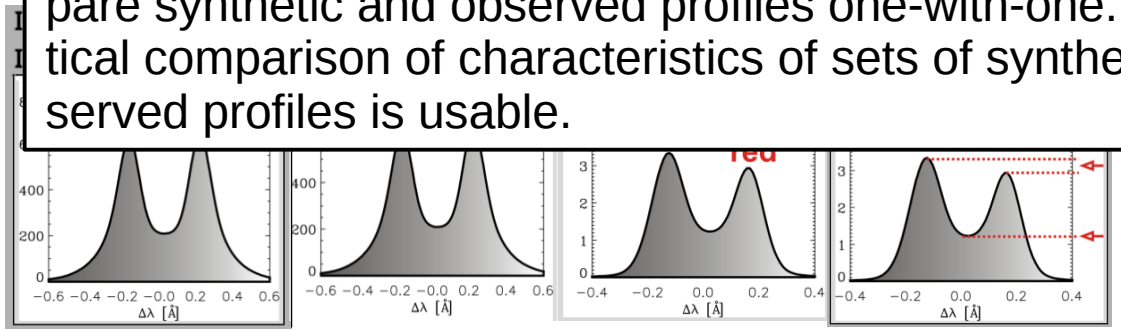
Profile characteristics and statistics of profile types

Examples of profiles of the H Lyman lines and MgII h&k lines



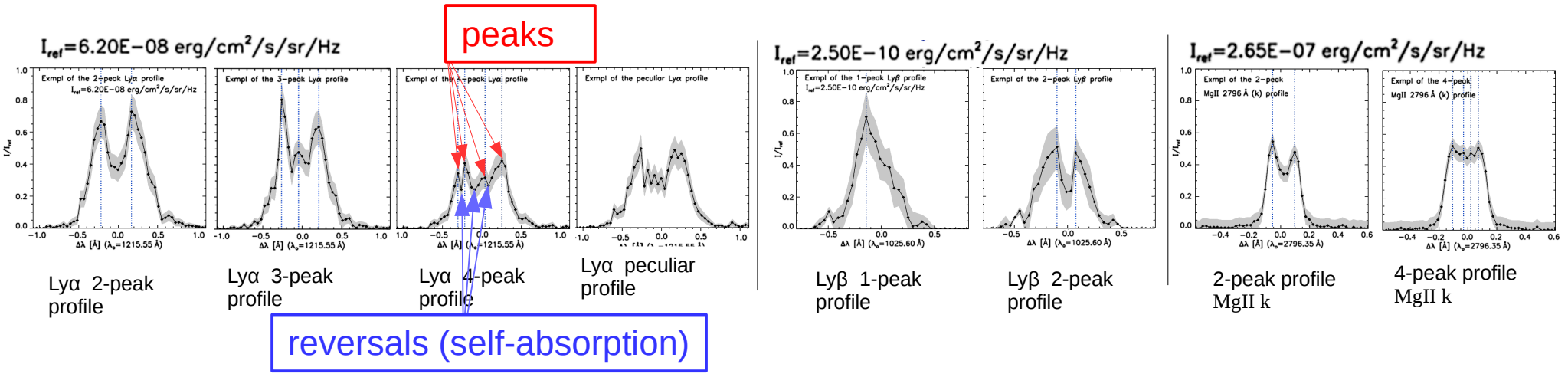
Because of large amount of free parameters of the non-LTE model of the prominence fine structure it is not possible to compare synthetic and observed profiles one-with-one. Thus, statistical comparison of characteristics of sets of synthetic and observed profiles is usable.





Profile characteristics and statistics of profile types

Examples of profiles of the H Lyman lines and MgII h&k lines



Lyα 2-peak profile

Lyα 3-peak profile

Lyα 4-peak profile

Lyα peculiar profile

Lyβ 1-peak profile

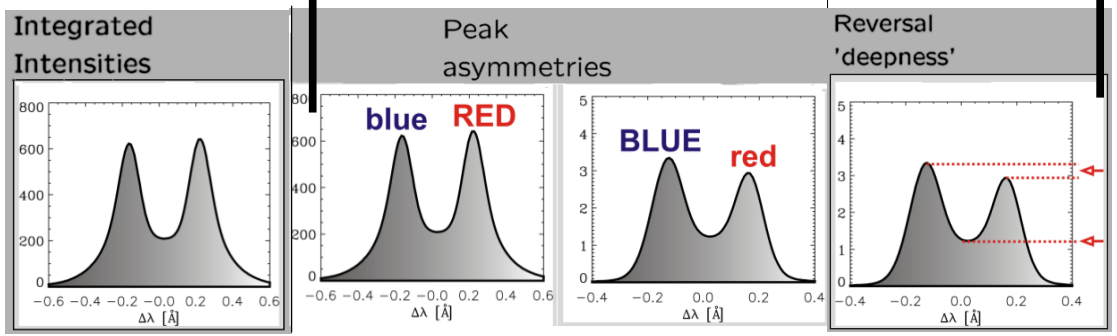
Lyβ 2-peak profile

2-peak profile MgII k

4-peak profile MgII k

Profile characteristics are used only for 1- and 2-peaks profiles:

so far defined only for 1- & 2-peak profiles



Profiles with more peaks than 2 can be included in statistics of the profile types

Maps for statistics of Lyα profile types:

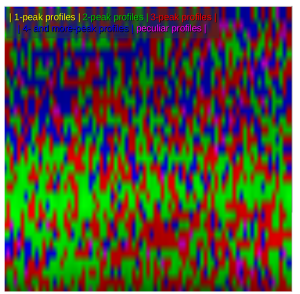
1-peak profiles

2-peak profiles

3-peak profiles

4- and more peak profiles

peculiar profiles



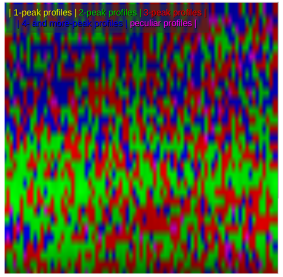
Maps for statistics of profile types:

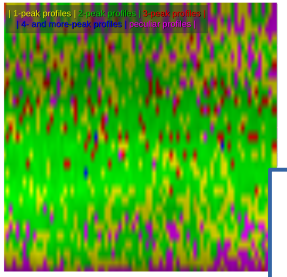
1-peak profiles 2-peak profiles 3-peak profiles 4- and more peak pro-files peculiar profiles

all peaks in profiles taken into account

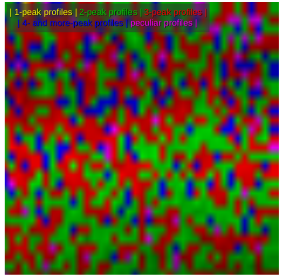
only peaks not lost in errors taken into account, that is (I(peak) ─ error)) > (I(adjacent reversal) + error)

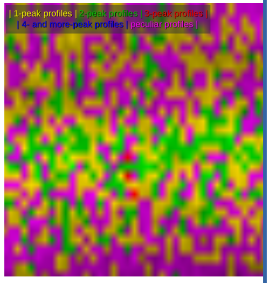
Lyα

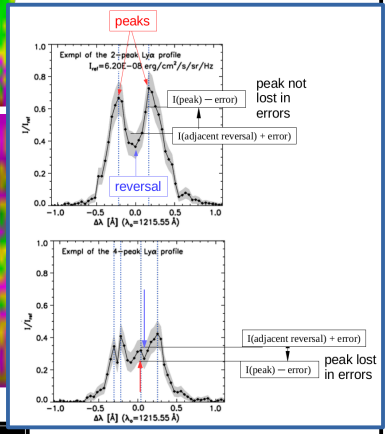




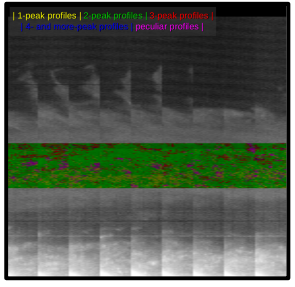
Lyβ

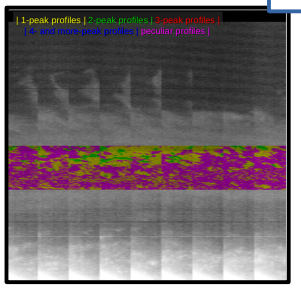




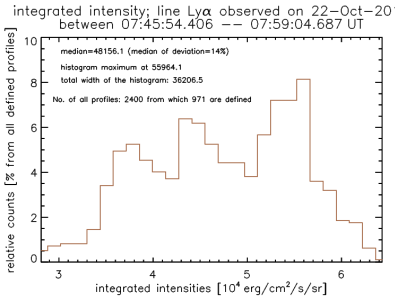


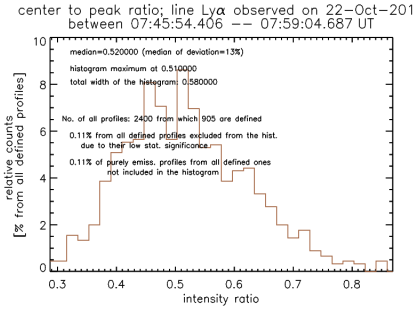
MgII k (2796 Å)

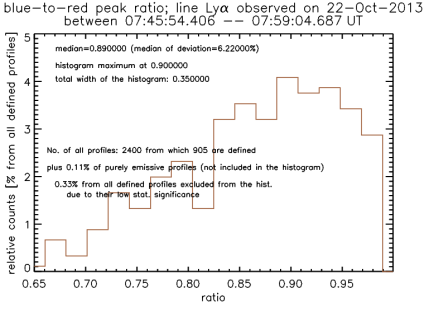


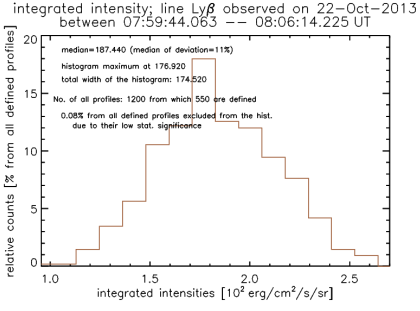


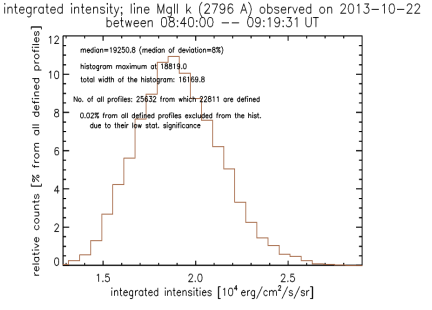
Examples of histograms of distribution of profiles characteristics of the 1- & 2-peak profiles – all peaks taken into account

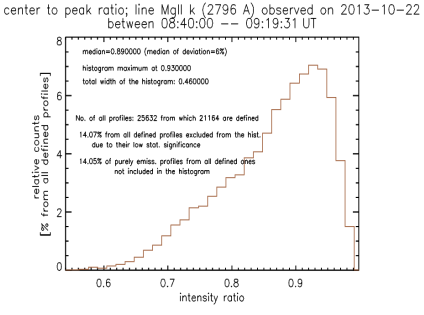








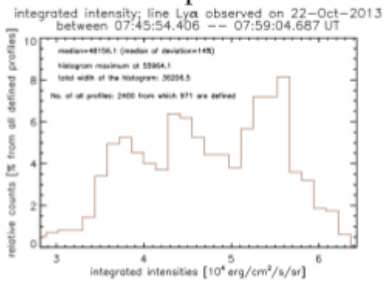




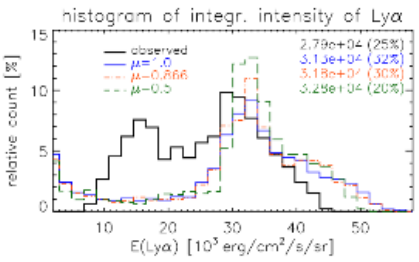
Comparison of the results of the spectroscopic analysis in the H Lyman lines with results obtained for another quiescent prominences

- histogram of integr. intensities of Lyα has more than one peak similarly as it was for the prominence observed on 15 May 2015 where structures containing plasma in different physical conditions are projected together on limb. Values of integrated intensities are higher in 22Oct2013 prominence than in the prominence observed by SUMER in 15May2005 (Schwartz et al. 2015)

22Oct2013 prominence

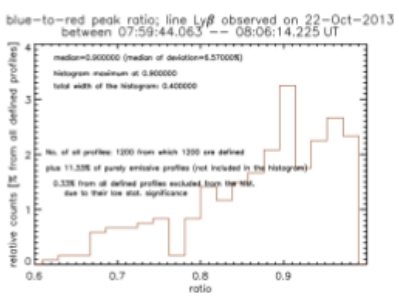


15May2005 prominence

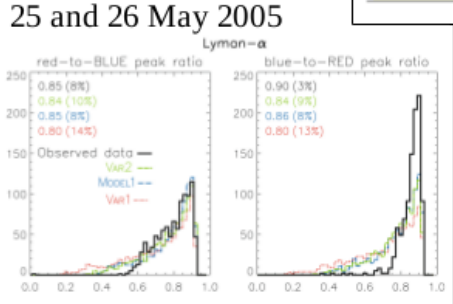


Histograms of asymmetry of peaks of the Lyman line profiles for the 22Oct2013 prominence have maximum at lower values than it was for previously studied prominences:

22Oct2013 prominence

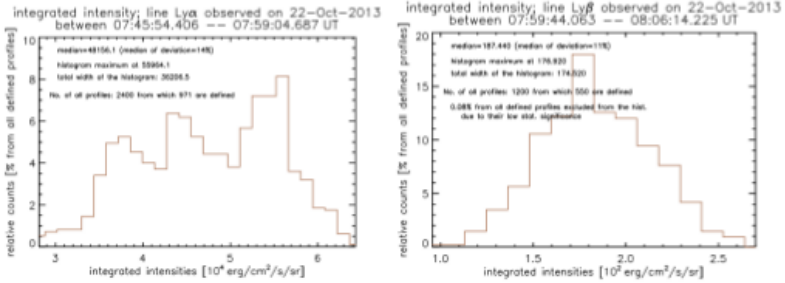


prominence observed on 25 and 26 May 2005

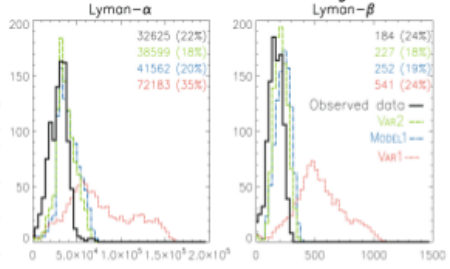


- histograms of integr. intensities of Lyα and Lyβ for the 22 Oct 2013 prominence are comparable to values in the hi- stogram obtained for the prominence observed on 26 and 26 May 2005.

22Oct2013 prominence



prominence observed on 25 and 26 May 2005



(Gunár et al. 2010)

Label	Set of input parameters: Common to all models	
MODEL1	$T_0 = 7000$ K; $T_e = 100\,000$ K; $B_x(0) = 6$ Gauss; $p_0 = 0.015$ dyn cm^{-2}; $M_0 = 1.1 \times 10^{-4}$ g cm^{-2}	$\gamma_1 = 10$, $\gamma_2 = 60$
VAR1		$\gamma_1 = 5$, $\gamma_2 = 30$
VAR2		$\gamma_1 = 10$, $\gamma_2 = 30$

Non-LTE model of the prominence fine structure is already available for hydrogen but a new background irradiation taking into account its variability with solar cycle (see poster of Gunár et al., poster session 7.4) is not fully applied in the model yet. As for the model for the MgII plasma, it is still in preparation and background irradiation is not applied in the MgII model yet although already in course of preparation (see posters of Gunár et al., poster session 7.4 and Koza et al., poster session 3.1) taking into account also its variabili- ty with solar cycle.

Conclusions

Non-LTE modelling of the prominence fine structure in the MgII h&k lines has not been made previously, thus, our results of the spectroscopic analysis in these two lines cannot be compared to similar results obtained for other prominences. It can be only stated that shapes of the histograms for profile characteristics of the MgII h&k lines observed in the 22Oct2013 prominence resemble well histograms obtained for the H Lyman line observations of other prominences. And in the other hand, some of the histograms of profile characteristics of the H Lyman lines observed in the 22Oct2013 prominence differ much in shape from the histograms obtained for H Lyman line observations of other prominence. The detectors of the SUMER spectrograph could be already affected by agingin the year 2013, thus, comparison of result of the non-LTE modelling of observations made by the both SUMER and IRIS spectrographs can show also whether the SUMER observations from that time are still usable.