Prominence fine structure from comparison of the non-LTE modelling with observations

Authors: Pavol Schwartz, Petr Heinzel, Stanislav Gunár, Werner Curdt

Scientific rationale:

Solar prominences are objects formed by relatively cool plasma in hot surrounding corona. Quiescent prominences are often observed as a part of a magnetic structure composed of three parts: prominence itself surrounded by the low-dense cavity and a dense helmet streamer sitting as a cap on cavity. Cool plasma of quiescent prominences occurs mainly in dipped magnetic fields lines. Plasma condensed in a dip is in equilibrium of magnetic pressure acting upward and gravity directed toward the solar surface. In quiescent prominences the magnetic dips form vertical structures called threads. As prominence plasma is composed mainly from hydrogen, spectral lines of hydrogen, especially Lyman lines, carry important information on physical conditions of prominence plasma in different optical depths. It is due to the fact that interval of wavelengths in profile cores within which optical thickness is much larger than unity. This wavelength interval is the widest for Lyα and it gets gradually narrower for higher Lyman lines. The Hα line is also important; due to its relatively low optical thickness (around unity) its intensity in core is emitted from all depths of the prominence – thus its intensity can be used to estimate number of threads through which the line of sight passes. Due to low temperature of formation (around 10000 K), Hα carries information about cool interior of a prominence. The non-LTE modelling of the Lyman line and Hα profiles provides us with diagnostics of plasma throughout all depths of a prominence. Also the fine structure of a prominence composed of several tens of threads, is taken into account in the modelling: One thread is approximated by the 2D vertically infinite slab in magnetic field configuration according to the Kippenhan-Schluetter model. Formal solution of radiative transfer is carried in such a multi-thread model while different shifts and velocities were assigned to individual threads. Such multi-thread models with random shifts and velocities assigned to threads are called realizations. The hydrogen Lyman and Hα profiles calculated using many (around 100) realizations are statistically compared with observations. Using the hydrogen lines only cooler parts of PCTR can be diagnosed as these lines are formed at temperatures below approximately 40 000 K. For diagnostics of hotter parts of the prominence-corona transition regions, UV chromospheric and transition-region lines of other elements that hydrogen can be used. From amount of EUV coronal emission of wavelengths below 912 Å (head of the Lyman continuum) absorbed by a prominence, its mass can be calculated. Contribution to decrease of intensities of EUV coronal lines from the blocking of coronal emissivity by a cool prominence plasma can be estimated using observations in the green coronal line.

Scientific goals, methodology and expected results:

Observations of SUMER in the complete hydrogen Lyman series plus Hα profiles of HSFA2 and SLS ground-based spectrographs will be used for diagnostic of the prominence plasma using statistical comparison of extensive groups of non-LTE models of fine prominence structure with large sets of observations. For estimation of the total mass of prominences from amount of coronal emission absorbed by their plasma, EUV observations of AIA/SDO will be used. As the AIA instruments is obtaining full-disc images in its all channels approximately every 12 s, it is not necessary to include AIA into the observing campaign. To disentangle contribution of the emissivity blocking to decrease of intensities of EUV coronal lines, observations of the COMP-S instrument at the Lomnický Peak observatory in the green coronal line (which is not absorbed by the prominence plasma) will be used.

Targets: quiescent prominences

Observing plan:

Observing slots of about two hours in the 07:00 – 09:00 UT time frame (prime observing time of the Ondřejov and Lomnický Peak observatories), selecting of target of opportunity 2 – 3 times during the campaign.

IRIS:

Type: high resolution dense rasters 5 arcsec wide with 0.33 arcsec sampling (15 positions), tracking between rasters

Selected lines: SiIV 1394 Å, OIV 1410, 1301 and 1405 Å, MgII h and k

Slit camera: SiIV and MgII h/k 2796 Å at < 10 s cadence (5 desired), FOV > 120 arcsec × 120 arcsec

SUMER:

Type sit and stare

Selected lines: Lyman α with partially closed shutter in two wavelength windows per line, the Lyman β, γ and δ lines in separate wavelength windows (one window per line). Observations of the lines in such an order: 40 observations of Lyman β, 40 observations of Lyman γ, 40 observations of Lyman δ, 80 observations of Lyman α, 40 observations of Lyman δ, 40 observations of Lyman γ, 40 observations of Lyman β (total duration of the observations is 1h). Slit positioning plus limb detection made the day before – observations in the CIII line (observed together with Lyman δ in one wavelength window) using the 360 arcsec long slit. Then it is changed to slit No.7 for the Lyman line observations.

Slit: for Lyman line observations slit No.7 with dimensions 0.3 arcsec × 120 arcsec

Exposure: 15 s