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

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Scientific rationale:

Solar prominences are objects formed by a relatively cool plasma in hot surrounding corona. Quiescent prominences are often observed as a part of magnetic structure composed of three parts: prominence itself surrounded by a low-dense cavity and dense helmet streamer sitting as a cap on the cavity. Cool plasma of quiescent prominences occurs in dipped magnetic fields lines. Plasma condensed in a dip is supported by the magnetic pressure what prevents the fall of the plasma due to the gravity. In quiescent prominences the magnetic dips form vertical structures called threads. As the prominence plasma is composed mainly from hydrogen, spectral lines of hydrogen especially the 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, 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 10 000 K), Hα carries mainly information about a 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 then carried out in such a multi-thread model while different shifts and velocities are assigned to individual threads. Such multi-thread models with random shifts and velocities assigned to threads are called realizations. The hydrogen Lyman-line and Hα profiles calculated using many (around 100) such realizations are statistically compared with observations. Using the hydrogen lines, only cooler parts of prominences 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, e.g. the Mg II h and k, O IV 1410, 1301, 1405 Å lines. 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 the 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 cool (temperatures up to 40 000 K) prominence plasma using statistical comparison of extensive groups of non-LTE models of fine prominence structure with large sets of observations. For estimations of temperature of hotter plasma in prominence shells, IRIS observations in the O IV UV lines will be used, as ratios of intensities of these lines are temperature sensitive. Plasma of prominences is to be diagnosed also from observations in the Mg II h and k lines using a spectroscopic model created just for this purpose. 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 using the slit No.7 with dimensions 0.3 arcsec × 120 arcsec

Exposure: 15 s