THEORETICAL CORRELATIONS BETWEEN VARIOUS PROMINENCE PARAMETERS

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Abstract. Starting from our extensive numerical modeling of the NLTE conditions in solar prominences, we present here some examples of important correlations between the prominence plasma parameters and radiation properties. For example, the plasma emission measure was found to be closely related to the integrated H\alpha line intensity which provides a new diagnostic tool for determination of plasma densities.

Key words: Prominences – Plasma Parameters – Radiation

1. Introduction

Recently a set of 140 prominence NLTE models has been constructed using the best available numerical techniques, i.e., the multilevel hydrogen atomic model, realistic incident radiation, partial frequency redistribution in Lyman lines etc. (40 of these models have been published by Gouttebroze \textit{et al.} (1993), the full set of models exists in the form of IAS - Preprint (tables)). All models are represented by 1D vertically-standing slab with uniform gas pressure (in the range 0.01 - 1.0 dyn cm\textsuperscript{-2}) and the temperature (4,300 - 15,000 K) as the input model parameters. Other parameters are the geometrical thickness of the prominence slab (in the range 200 - 10,000 km), microturbulent velocity equal to 5 km s\textsuperscript{-1} for all models and the height above the solar surface $H = 10,000$ km. As the output we have obtained several plasma parameters, namely the depth-varying hydrogen and electron densities, together with the radiation properties (the hydrogen spectrum). After a series of numerical tests we have decided to use a 20-level plus continuum hydrogen model atom which gives rather precise line and continue intensities. As a next step, several important correlations between the plasma parameters themselves and between plasma and radiation properties of prominence-like structures have been derived (Heinzel \textit{et al.}, 1994). Here we present two examples of such correlations and briefly comment on them.

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Figure 1. Integrated Hα line intensity $E$ versus the emission measure $EM$. $E$ is in units of erg cm$^{-2}$ s$^{-1}$ sr$^{-1}$, $EM$ is in cm$^{-5}$. Individual symbols correspond to the following temperatures: circles - 4,300 K, squares - 6,000 K, triangles - 8,000 K, losanges - 10,000 K and stars - 15,000 K.

2. Theoretical Correlations

An important relation between the integrated Hα intensity (for the radiation emergent normally to the slab surface) and the emission measure $EM = \langle n_e \rangle^2$. $D$ is demonstrated in Fig. 1 (here $\langle n_e \rangle$ is a mean electron density along the line-of-sight and $D$ represents the effective geometrical thickness of the prominence). Almost unique correlation between $E$(Hα) and $EM$ was revealed from this kind of plot, providing us with an important diagnostic tool for the electron density determination. In Fig. 1, all 140 models are used. Although we typically don’t know $D$, the estimate of the electron density is rather good since $EM$ depends on $n_e^2$ - for discussion of this point see Wiik et al., this issue. Further, by using this relation, one can estimate - just from the measured Hα intensity - the plasma radiation losses, provided that the geometrical thickness and the degree of hydrogen ionization are somehow known or estimated.

Second example shows the variation of electron density $n_e$ in the middle of the slab versus total hydrogen density $n_H$, also at the slab center. For low-density models, the ionization degree defined as $n_e/n_H$ is only weakly model-dependent. Note relatively small scatter of values for a given temperature (symbol). This scatter is mainly due to
geometrical thickness variations and individual groups of identical symbols correspond to specific gas pressures.

Figure 2. Correlation between electron density and total hydrogen density (ionization degree), again for all 140 models. The densities are in units of cm⁻³.

3. Conclusions

The relations presented in this paper represent some examples of important correlations derived on base of extensive numerical NLTE modeling of solar prominences. It seems that this is the only way how to reveal such laws which, in turn, are crucial for reliable plasma diagnostics of solar prominences and prominence-like structures in the coronal environment.

References