Synthetic DEM curves of Prominence Fine Structures

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Introduction

In our previous papers we have demonstrated the ability of our 2D prominence fine structure models to reproduce the observed hydrogen Lyman spectra. Gunár et al. (2007) showed the comparison of the observed and synthetic Lyman spectra on a profile-to-profile basis and concluded that a multi-thread modelling is needed to obtain a good agreement of the synthetic Lyman line profiles with the observed spectra. Gunár et al. (2008) demonstrated the ability of these 2D multi-thread models to reproduce also the asymmetries of the Lyman line profiles. Recently, Gunár et al. (2010) compared the observed and synthetic Lyman spectra on a statistical basis and showed that the large set of Lyman line observations can be reproduced by multi-thread models with a given set of plasma parameters.

In the present study we use the temperature and electron density stuctures (see Fig. 1) resulting from our models to derive the synthetic differential emission measure (DEM) corresponding to the single-thread and the multi-thread prominence fine structure models.

Prominence fine-structure models

For this study we have selected two different models which produce synthetic hydrogen Lyman spectra in good agreement with two different observed prominences. MODEL1 corresponds to the prominence observed on May 25 and 26, 2005, as shown by our previous work and model A4 to the prominence observed on April 26, 2007 as indicated by our recent study in progress. The imput parameters of the models are listed in Table 1.

We study the synthetic DEM curves for a single thread model for two orientations of the LOS (parallel and perpendicular to the magnetic field lines) and also the DEM curves resulting from multi-thread models for the LOS perpendicular to the magnetic field. Our multi-thread model consists of a set of identical single threads arranged perpendicularly to the LOS along individual field lines (see Fig. 2). Each thread is randomly shifted with respect to the foremost thread (as in Gunár et al. 2007, 2008 and 2010) and the synthetic DEM curve is derived for one randomly generated realization.

Synthetic DEM curves

To obtain numerically synthetic DEM curves along a given line-of-sight (h) we divide T into sufficiently small temperature bins with bin-width ΔT_i. For a given bin T_i we obtain the DEM as

$$\mathrm{DEM}(T_i) = \sum_n N_e^2(i,n) \frac{\Delta h_i(n)}{\Delta T_i} \qquad (1)$$

where we sum over all positions along the LOS where we encounter the given temperature bin (see e.g. Frazin et al. 2005).

We compute the synthetic DEM in the temperature range of 7000 K (respectivelly 8000 K) to the boundary temperature of 100 000 K.

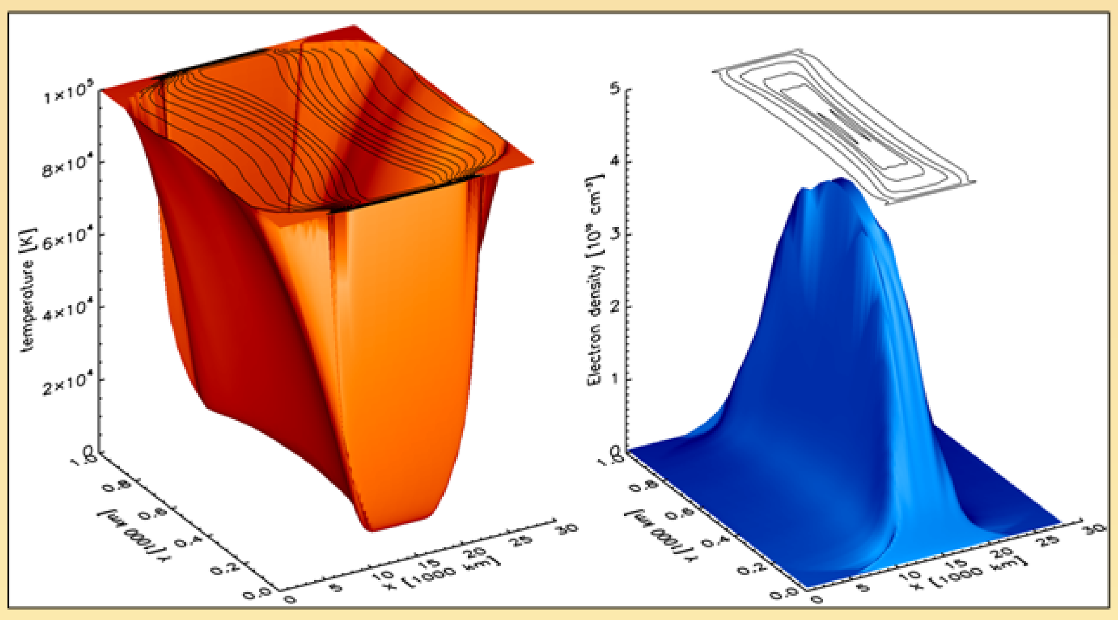

Fig. 1 Temperature (left) and electron density (right) structure of the MODEL1.

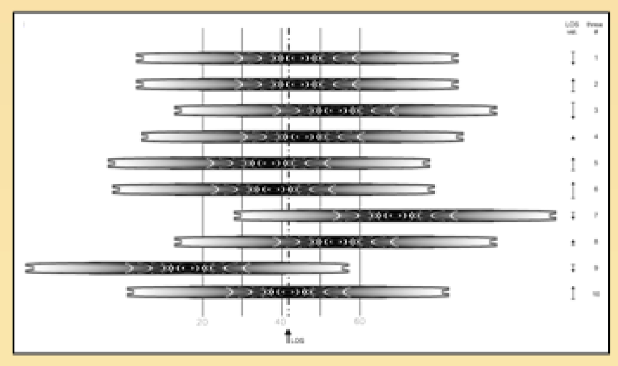

Fig. 2 A set-up of one random realization of the multi-thread model. The sketch is drawn in proper geometrical scale.

MODEL1	T_0=7000 K; T_{tr}=100 000 K; $B_x(0)$=6 Gauss; p_0=0.015 dyn cm^{-2}; M_0=1.1 × 10^{-4} g cm^{-2}	γ_1=10 γ_2=60
A4	T_0=8000 K; T_{tr}=100 000 K; $B_x(0)$=1 Gauss; M_0=5 × 10^{-6} g cm^{-2}	γ_1=5 γ_2=30

Table 1 T_0 is the minimum central temperature, T_{tr} the maximum boundary temperature, $B_x(0)$ is the magnetic field strength in the middle of the thread, p_0 is the boundary pressure. γ_1 and γ_2 prescribe gradients of the temperature along and across the magnetic field. and M_0 the maximum column density.

Results

In all panels of the Figs. 3 and 4 the observed DEM curve of Parenti & Vial (2007) is shown in red, the results of Cirigliano et al. (2004) are indicated by the blue crosses. Our synthetic curves are drawn in black. We noted the following properties:

1. The DEM curve derived by Parenti & Vial is very steep; the values obtained by Cirigliano et al. would imply a somewhat less steep curve.
2. All our theoretical curves are too shallow,but they would agree better with the Cirigliano et al. data.
3. For most of our calculated curves also the the absolute DEM values are too large. For our Model1 we get only good agreement in the case of a single thread observed accoss the field. Our model A1 leads to a good matching only for a single thread seen accross and a gas pressure of 0.03 dyn cm^{-2}; or alternatively a very low gas pressure of 0.01 dyn cm^{-2} for a single thread observed along the field, or 10 threads seen accross the field.

These results indicate the very large importance of an exact determination of the gas pressure inside the PCTR.

Conclusions

Our multi-thread models can reproduce well the hydrogen Lyman spectra, which originates at temperatures below 20000 K. Thus we could expect that the temperature and density structures of our models at temperatures below 20000 K are also in agreement with that of the observed prominences and so the resulting synthetic DEM curves would correspond with the reality of the observed prominences. On the other hand, the DEM curves derived from observations are reliable only above 20000 K due to higher optical thickness of the spectral lines originating below this temperature (see e.g. review of Labrosse et al. 2010). Thus the observed DEM curves could be used to constrain the temperature structure above 20000 K of our models while the synthetic DEM curves can complement the observed DEM curves at temperatures below 20000 K. However, there are only few DEM curves derived from the observations, which can be found in publications. Moreover, they can be rather different, so there is a need for more detailed study of DEM of observed quiescent prominences which could be qualitatively compared with a synthetic DEM curves.

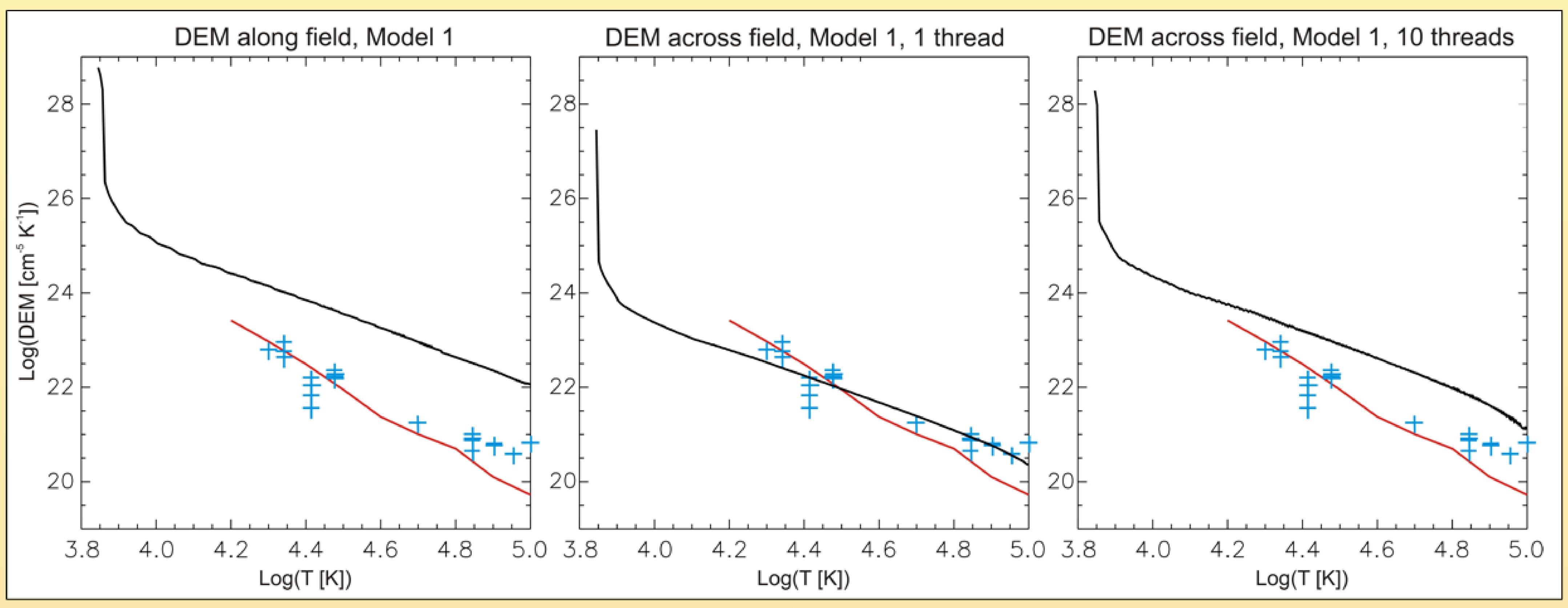

Fig. 3 Comaprison of the synthetic DEMs for MODEL1 (black) and DEMs derived from observations (red - Parenti & Vial 2007; blue crosses - Cirigliano et al. 2004).

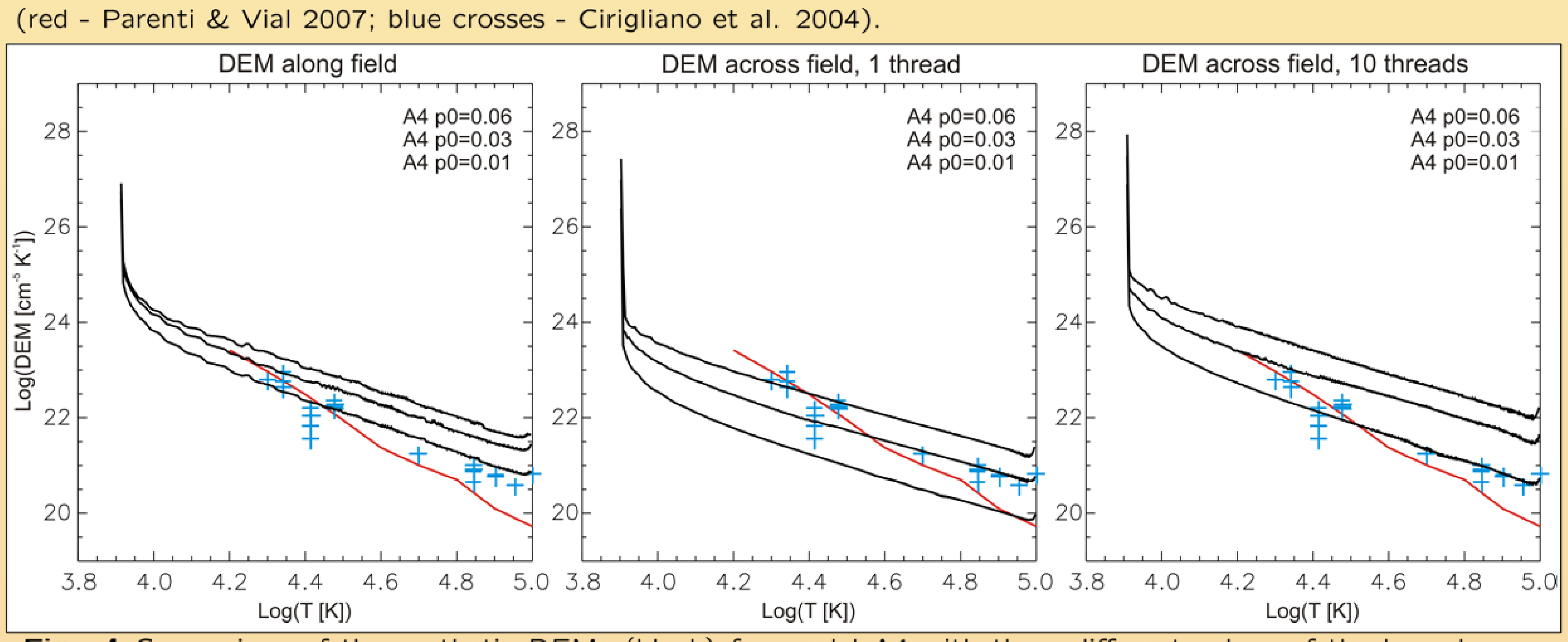

Fig. 4 Comaprison of the synthetic DEMs (black) for model A4 with three different values of the boundary pressure and DEMs derived from observations (red - Parenti & Vial 2007; blue crosses - Cirigliano et al. 2004).

Acknowledgements

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