

Radiative Hydrodynamic Simulations of He I 10830 Å

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Abstract. We study the properties of the He I 10830 Å line under the bombardment of non-thermal electron beam. Using radiative hydrodynamics method, we obtain the line profiles from different model atmospheres by varying the electron beam fluxes. Below a certain electron flux, the spectra become much more absorptions as nonthermal flux increases. Above the threshold, the spectral intensities increase as the flux goes up. We also investigate the temporal evolution of the spectra under the nonthermal heating. For weak electron flux, the profiles evolve from weak absorptions to strong absorptions. For strong nonthermal heating, the profiles can be significantly changed from absorptions to emissions. The spectra also show red or blue asymmetries.

Keywords. methods: numerical, radiative transfer, sun: atmosphere, sun: flares

1. Introduction

Solar flare is one of the most energetic phenomena in the solar atmosphere. Its spectrum provides us valuable information to study the heating process. Although the He I 10830 Å line is much weaker than the H α and Ca II lines, it is still an important line in the spectroscopy of solar active phenomena. Many authors have studied the formation of this line (You *et al.* 1998; Ding *et al.* 2005; Du & Li 2008). In this paper, we study the He I 10830 Å line responds to the bombardment of the nonthermal electron beam by using radiative hydrodynamic simulations.

2. Numerical Method

We perform radiative hydrodynamic modeling using code RADYN with application to solar flares as described in detail in Abbett (1999). The infrared triplet of neutral helium is considered. Two initial atmospheric models are displayed in Figure 1a. We vary the nonthermal electron beam fluxes from 10^9 to 3×10^{10} ergs cm⁻² s⁻¹. The nonthermal electron beam is assumed to have a power-law distribution with a spectral index of $\delta = 5$ and low energy cutoff of $E_c = 40$ keV. More simulation details see Abbett (1999).

3. Results

The purpose of our simulation is to investigate the properties of the He I 10830 Å line in a flaring atmosphere. We obtain the line profiles using radiative hydrodynamic simulations for different atmospheric models. The main results are as follows: (1) below a certain electron flux, the profiles evolve from weak absorptions to strong absorptions as nonthermal effects get stronger; above the certain flux, the intensities increase as fluxes increase (Figure 1b). (2) for the weak case, the profiles keep absorptions as heating lasts; for the strong flux, the profiles can be significantly turned from absorptions to emissions

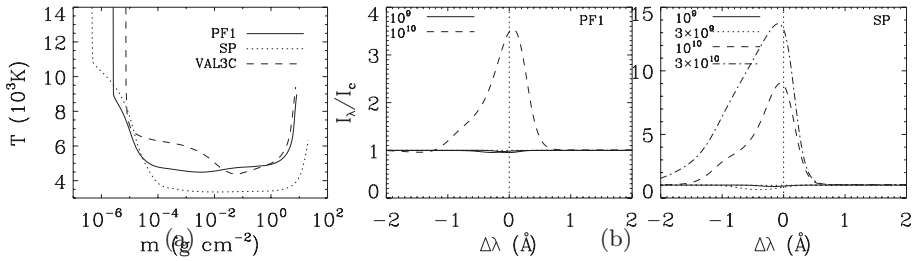


Figure 1. (a) Temperature distributions for three initial atmospheric models: SP for sunspot, PF1 used by Abbett & Hawley (1999), and VAL3C for the quiet sun. (b) Line profiles of He I 10830 Å depending on the atmospheric models and nonthermal electron beams. The left panel is based on PF1 model, while the right is for SP model. The heating is lasted for 20 s. The profiles are computed at solar disk center and normalized to the nearby continuum.

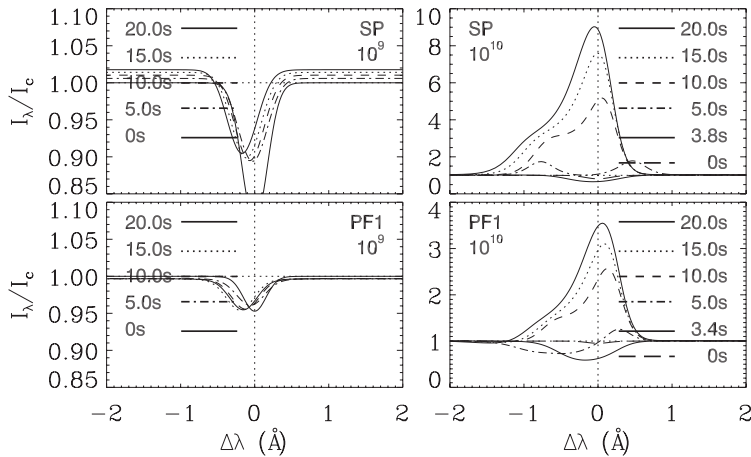


Figure 2. Line profiles of He I 10830 Å evolve at different heating times with nonthermal electron fluxes. For the left panels, as heating continues, the profiles keep absorptions. For the right panels, the profiles become more absorptions in the first several seconds, and then turn to emissions and increase continuously afterwards.

in a hot and condensed atmosphere (Figure 2). This is consistent with Du & Li (2008) who suggested that only when GOES X-ray flux reaches a certain threshold, that excess emission is detected in this line (You et al. 1993), but the threshold found here is slightly higher than their value. Red or blue asymmetries also occur in our simulations.

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