Irradiated M Dwarfs

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Abstract. We have calculated atmospheric models of an M Dwarf located near a hot white dwarf (WD). A comparison is made between the use of a black body flux distribution and a realistic synthetic spectrum for the incident radiation. We also present spectra for the irradiated M Dwarf when located at different orbital separations from the WD.

1. Introduction

In this study, we have used our multi-purpose stellar atmosphere code, PHOENIX, to model the effects of external radiation on an M dwarf located near a hot white dwarf (WD). The M dwarf atmospheres have been modeled as one dimensional plane parallel slabs in local thermodynamic equilibrium (LTE), and the outer boundary conditions have been altered to account for the inward directed flux. The flux from the WD was represented by a synthetic spectrum from a recent grid of non-LTE calculations (Barman et al. 2000) and assumed to be isotropic.

2. Results

In the figures below, we show the results for a 3000 K M dwarf irradiated by a 15,000 K WD located at several different orbital separations. The variation in the temperature structure as a function of separation can be seen in Fig. 1. When the WD is located 11 R⊙ from the M dwarf, the outer layers of the atmosphere are heated dramatically and closely resemble a chromospheric transition region. As the WD is brought closer to the M dwarf, the external radiation penetrates further into the atmosphere causing the deepest layers to experience a temperature increase. For comparison, we also show the temperature structures when a 15,000 K black body spectrum is used as the external radiation source instead of a detailed synthetic spectrum.

In Fig. 2, we compare the resulting M dwarf spectra for three orbital separations (11, 2.3, and 1 R⊙) to the spectrum of the non-irradiated M dwarf. The isolated M dwarf has a distinct Na doublet feature and TiO bands in the near infrared. When the WD is 11 R⊙ from the M dwarf, the increase in temperature significantly reduces the TiO abundance. As a result, the near IR TiO bands are no longer present and the strong K I doublet is now visible. As the WD is brought closer, Na and K begin to ionize and the equivalent widths of the neutral Na and K doublets decrease slightly. Also, at 1 R⊙, the hot upper atmosphere produces many narrow Fe and Ti emission features.

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Fig. 1. - Temperature structures for the 3000K M Dwarf.

Fig. 2. - Spectra for the 3000K M dwarf. The top three include irradiation for the distances indicated.
References