The Nature of Light Variations of the Helium Strong Chemically Peculiar Star HD 37776

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Abstract. We calculated spectral energy distribution of the helium strong chemically peculiar star HD 37776 using adequate model atmospheres. We show that the chemical peculiarity influences the stellar energy distribution. Consequently, spots of peculiar chemical composition on the surface of a rotating star may cause detectable light variations of the star. However, the observed light variations are not likely caused by an uneven surface distribution of helium, but may be due to spots of metals (mainly carbon).

1. Introduction

Magnetic chemically peculiar (mCP) stars exhibit periodic light variations, that used to be explained by presence of “photometric” spots with uneven energy distribution on the surface of rotating stars. These photometric spots are likely connected with the “spectroscopic” spots of a peculiar abundance of various chemical elements. The departures of energy distribution in spectra of mCP stars from normal energy distribution are explained as a consequence of line and continuum blanketing originating in the spectroscopic spots with peculiar chemical composition (e.g. Peterson 1970, c.f. Townsend et al. 2005).

To test whether the photometric spots are related to the spectroscopic ones we calculated light variations of the helium strong mCP star HD 37776, for which Vető et al. (1991) by means of Doppler analysis derived a spot model with a helium-rich ring surrounded by two helium-poor spherical caps (Fig. 1).

2. Model atmospheres and calculated flux variations

For LTE atmosphere modelling we opted code TLUSTY (Hubeny & Lanz 1995). The models correspond to the helium rich/poor surface elements on HD 37776 with $N(\text{He})/N(\text{H}) = 0.72$ and 0.02 respectively (Vető et al. 1991). The effective temperature $T_{\text{eff}}$ and the surface gravity $\log g$ of all these models are assumed to be the same and equal to $T_{\text{eff}} = 22000$ K and $\log g = 4.0$, respectively (Groote & Kaufmann 1982).

The emergent radiative flux was calculated with SYNSPEC code. The spectral energy distribution derived for individual surface elements was used to obtain corresponding fluxes in individual colours. Finally, these fluxes are
Integrated over all visible surface and the observed magnitude difference is calculated.

The radiative fluxes calculated for atmospheres with different chemical composition are displayed on (Fig. 2). The flux calculated was convolved with a Gauss function to better demonstrate possible light variations. Apparently, the He-poor surface elements with solar metallicity produce a flux that is lower in the visible region than the flux produced by the He-strong ones. The regions with enhanced metallicity produces a flux highest in the visible region.

3. Observed spectrum variations and predicted light variability

From the spectrum and light variability observations follows that at the maximum stellar brightness, the helium equivalent width have its minimum, whereas
the Si equivalent widths have their maximum. Clearly, the He-rich ring is dimmer and mostly Si-poor, whereas the He-poor spots are brighter and mostly Si-rich. However, the radiative flux from the solar metallicity helium-poor surface elements in the visible region is lower than that from the helium-strong ones (Fig. 2). Consequently, the observed light variability of HD 37776 cannot be explained merely by altering of emergent flux due to the uneven surface distribution of helium. Also surface variations of metallicity should be taken into account. Therefore, we calculated the predicted light variability of HD 37776 assuming that He-poor spots have metallicity thirty times higher relative to the solar one and that the He-strong ring consists from H and He only (Fig. 3).

4. Conclusions

We calculated light curves of the He chemically peculiar star HD 37776. It is possible to explain its observed light variability provided that the He-poor spots have enhanced metallicity whereas the He-strong ring has low metallicity. In such case the observed light variations are mostly due to bound-free transitions of carbon. Although this picture roughly corresponds to the observed data, detailed spectrum observations and model improvement are necessary to test our ideas.

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