Comm. in Asteroseismology
Vol. 158, 2009, 38th LIAC/HELAS-ESTA/BAG, 2008
A. Noels, C. Aerts, J. Montalbán, A. Miglio and M. Briquet., eds.

Line profile variability in the massive binary HD 152219

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Abstract

HD 152219 is a massive binary system with O9.5 III and B1-2 III/V components and a short orbital period of 4.2 d. In a previous work, we showed that the primary star ($M_{\rm prim} \sim$ 21 $M_\odot$) was presenting clear line profile variabilities (LPVs) that might be caused by nonradial pulsations (NRPs). In the present work, we report on an intensive spectroscopic monitoring, that aimed at unveiling the nature of the detected LPVs. Based on this new data set, we discard the NRPs and point out the Rossiter-McLaughlin effect as being the cause of the observed LPVs. The upper limit derived on the amplitude of undetected NRPs, if any, is set at a couple of part per thousands of the continuum level.

Individual Objects: HD 152219

Introduction

With only a couple of objects known to present pulsations, asteroseismology of massive stars remains essentially a *terra incognita*. This partly results from the limited number of dedicated observational studies and from the difficulty to disentangle possible pulsations from wind effects or co-rotating structures. HD 152219 is an O9 III + B1-2 III/V short period binary ($P \sim 4.2$ d) in the core of the NGC 6231 cluster. In Sana et al. (2006, Paper I), we showed that the primary component was displaying clear line profile variability (LPV). With $\log T_{\rm eff} = 4.504$ and $\log L/L_\odot = 5.07$, the primary star lays in the prolongation of the β Cep instability strip (e.g. Pamyatnykh 1999, Miglio et al. 2007), within the domain of instability predicted by Pamyatnykh (1999) for high-luminosity stars.
In the present paper, we briefly report on a 4-night intensive monitoring campaign (134 spectra with SNR $\sim$ 250-300) using the FEROS spectrograph at La Silla (Chile). As in Paper I, we will focus on the He II λ4686 line as it is the only well isolated, strong primary line that is uncontaminated by the secondary signature or by neighbouring lines. This strategy not only renders the analysis more straightforward, but also allows us to avoid any ill-quantified effects that are hampering spectral disentangling methods in the presence of varying spectral signatures (for an example, see Linder et al. 2008).

Analysis of the He II λ4686 Line Profile Variability

Fig. 1 (a) displays the evolution of the He II λ4686 line profile in the primary reference frame. The main LPV is observed at $\phi \sim 0.79 - 0.91$, which corresponds to the time of the primary eclipse, when the companion is passing in front of the primary (an effect known as the Rossiter-McLaughlin effect). Additional variations are seen during the secondary eclipse ($\phi \sim$

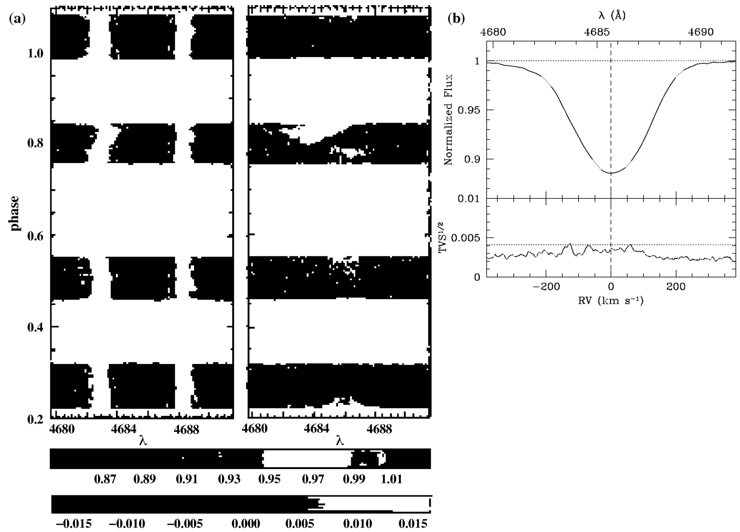

Figure 1: **(a)** *Left panel:* Color-coded image of the evolution of the He II λ4686 profile with the phase. Spectra are displayed in the reference frame of the primary. *Right panel:* same as left panel for the difference spectra, i.e. the spectra minus the median spectrum computed over all non-eclipse phases. Below are the color codings for both panels **(b)** Averaged line profile (upper panel) and square root of the TVS (lower panel). On the upper panel, the dotted line shows the continuum level while the dashed line indicates the primary velocity frame. On the lower panel, the dotted line indicates the variability threshold corresponding to a significance level of 0.01.

0.23 − 0.37), resulting from the changing dilution of the line by the varying continuum. However, there seems to be little or no profile variations outside those phase intervals.
As a second, more quantitative step, we computed the Time Variance Spectrum (TVS, Fullerton et al. 1996) using only spectra obtained outside the eclipse phases. Fig. 1 (b) shows the averaged (outside eclipse) He II λ4686 line profile and the TVS spectrum. Using the formalism proposed by Fullerton et al. (1996), we tested our data against the null hypothesis '*not variable*'. Even adopting a rejection threshold corresponding to a loose significance level of 0.01 ($(\mathrm{TVS})^{1/2}_{\alpha=0.01} = 3.9\times10^{-3}$), one cannot reject the null hypothesis. As a consequence, we consider the null hypothesis to be very likely and conclude that no significant variability is seen in the data (except for the eclipse effects).

Conclusion

From the analysis of the He II λ4686 line profile in the HD 152219 spectra collected over 4 consecutive nights, we cannot detect significant LPV beside the Rossiter-McLaughlin effect. The data displayed a SNR above 300 on average and allow us to place an upper limit for the variability level (thus for the amplitude of possible NRPs) as low as a few parts per thousand of the continuum level. The present result further suggests that the predictions for the location of the high-luminosity end of the β Cep instability strip might need to be refined.

Results from ongoing theoretical works are thus eagerly awaited. The present result however awaits confirmation by the LPV analysis of other He lines. This is left for future work.

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