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Detailed Line-Profile Modeling of B Stars with Chemical Inhomogeneities[1]

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Abstract. We report monoperiodic variability for the four B-type stars HD 131120, HD 105382, HD 138769 and HD 55522, which we explain by rotational modulation rather than by pulsation. Consequently these variables are removed from the list of candidate Slowly Pulsating B stars.

1. Introduction

In the course of 1996 the group studying variable stars in the K.U.Leuven started a long-term photometric and spectroscopic monitoring for 25 selected stars, which were classified as candidate Slowly Pulsating B stars (SPBs) from Hipparcos photometry (De Cat, these proceedings; Mathias et al., these proceedings). In the selected sample, four stars are distinguishable from the other confirmed SPBs: HD 131120, HD 105382, HD 138769 and HD 55522. We here present the results of our modeling efforts for the data on these stars.

The paper is organised as follows. In Sect. 2, we describe the observations and we give the outcome of the period analysis. In Sect. 3, we look at the first three moments of line profiles for both a silicon line and a helium line and we reject the pulsation model. In Sect. 4, we compare the line-profile variations with a rotational modulation model. Finally, our future plans are given in Sect. 5.

2. Data and period analysis

We have three data sets at our disposal: Hipparcos photometry, multicolour Geneva photometry and high-resolution spectroscopic data. The spectral domain was [4115,4135] Å in order to get the SiII-doublet with lines at $\lambda\lambda\, 4128, 4130$ Å, so that we also have the He 4121 Å line. For a complete description of the observations and data reductions we refer to De Cat (2001).

The photometry and spectroscopy lead to the same period, which is 1.569 days for HD 131120, 1.295 days for HD 105382, 2.089 days for HD 138769 and

[1]Based on observations obtained with the Swiss photometric telescope and ESO's CAT/CES telescope, both situated at La Silla, Chile

2.769 days for HD 55522. Such periods are expected for SPBs. However, the four stars appear to be monoperiodic while we found that the other SPBs of the sample are multiperiodic (De Cat, 2001).

3. The line profiles and their moments

We calculated the first three observed moments of a line profile $\langle v^1 \rangle$, $\langle v^2 \rangle$ and $\langle v^3 \rangle$ (see Aerts et al. 1992). Phase diagrams for these moments of both the Si and He lines are shown in Fig. 1 for HD 131120. The first moment is not a sine and varies with the frequency f but also with the frequency $2f$, which does not correspond to a linear monoperiodic pulsation model. Moreover, the first moments computed from the silicon line and from the helium line do not have the same shape and are not even in phase. We conclude that the behaviour of the moments of this star is not compatible with that of a pulsating star. We also computed the moment of order zero, which is the equivalent width of the line (see Fig. 1). The relative equivalent width variation of the silicon line is about 10%. This is a large value compared to the ones of other SPBs of the sample (De Cat, 2001), which cannot be reproduced by pulsation (De Ridder et al., these proceedings). The behaviour of the moments of the three other stars is very similar to the one of HD 131120, so that a pulsation model is excluded for the four stars.

4. Rotational modulation

In order to explain the observed variations, we considered a rotational modulation model. We computed the line-profile variations of a spotted star by using of a code kindly put at our disposal by Dr. Luis Balona. We show here the outcome for HD 131120. In order to reproduce the frequency f and its harmonic $2f$ found in the moments, we consider two spots of the same element which have a longitude difference of 180° and we consider that the flux in the first spot differs from the flux in the second spot. We also tested the case for which the radius of the first spot differs from the radius of the second spot. We tested a large grid of the values of the parameters and we chose the model for which the theoretical moments of spectra best fit the observed moments.

The comparison between the best spot model and the observed moments is shown in Fig. 1. In Fig. 2 we show the comparison between the observed line profiles and the theoretical ones. For the values of the parameters, we refer to Briquet et al. (2001). We found a model for which the silicon is overabundant in the spots and helium is underabundant in the spots compared to the rest of the surface. A model with surface inhomogenities is a good explanation for the line-profile variations of the star. The outcome for the three other stars will be shown in a forthcoming paper.

In the literature, it appears that HD 131120 is a helium-weak Si star. We also found that HD 138769 is a Bp star. The two others are not known as being special. However, the equivalent widths of their silicon line are larger than expected for their effective temperature compared to other SPBs.

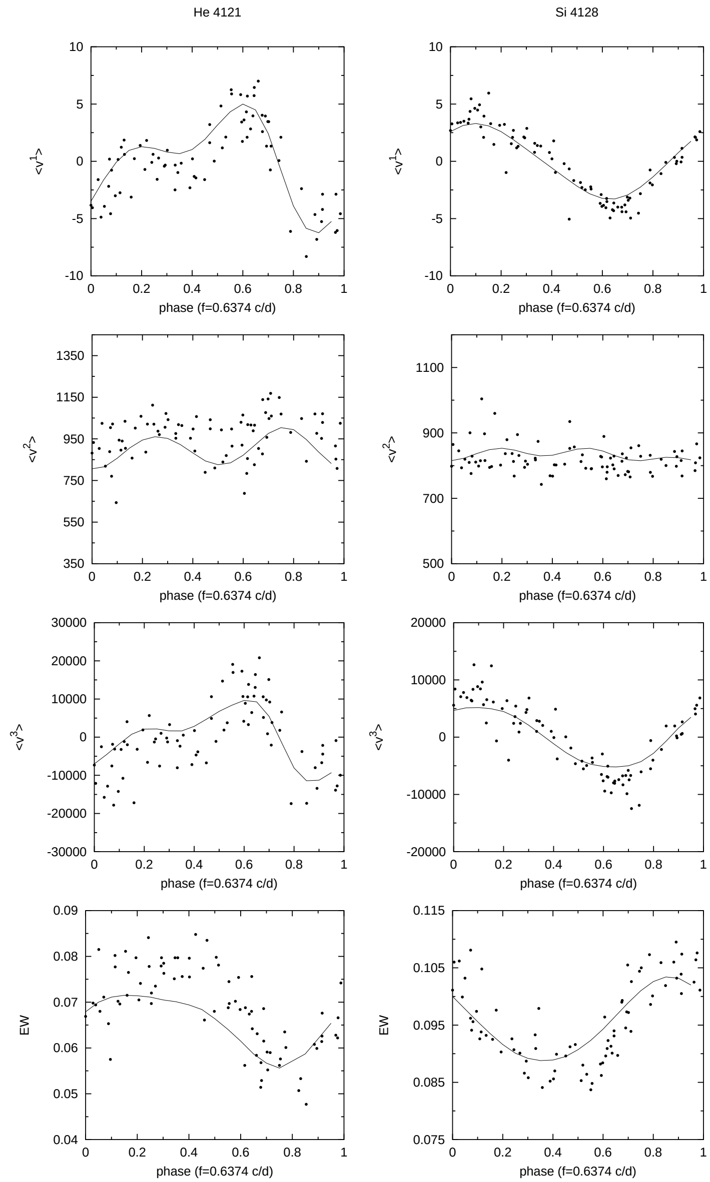

Figure 1. Phase diagrams of the first three moments (expressed in km s^{-1}, (km s^{-1})^2 and (km s^{-1})^3 respectively) and of the equivalent width (expressed in Å) for both the He 4121 Å line (left) and the Si 4128 Å line (right) for HD 131120. We show the observed values (dots) and those corresponding to the best spot model (solid line).

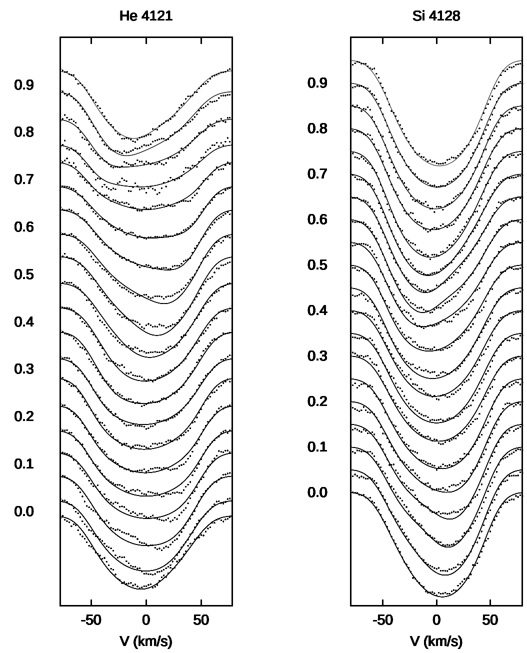

Figure 2. Observed line profiles (dots) of HD 131120 for the He 4121 Å line (left) and for the Si II 4128 Å line (right) averaged over phase bins of 0.05, best spot model with two spots (solid line).

5. Future work

We plan to search for a physical explanation of the presence of such surface chemical inhomogeneities, by first performing Doppler Imaging on our spectral line variations.

References

Aerts, C., De Pauw, M., Waelkens, C., 1992, A&A, 266, 294

Briquet, M., De Cat, P., Aerts, C., Scuflaire, R., 2001, A&A, in press

De Cat, P., 2001, PhD Thesis, Katholieke Universiteit Leuven, Belgium

Discussion

R. Townsend : Do you intend to take more spectra ? Because at the moment, your interpretation of silicon overabundance is based on only one silicon profile and one helium profile.

M. Briquet : The stars are currently observed with an Echelle spectrograph.