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DETECTION OF A 1.59H PERIOD IN THE B SUPERGIANT STAR HD 202850

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Abstract. Photospheric lines of B-type supergiants show variability in their profile shapes. In addition, their widths are much larger than purely due to stellar rotation. This excess broadening is often referred to as macroturbulence. Both effects have been linked to stellar oscillations, however B supergiants have not been systematically searched yet for the presence of especially short-term variability caused by stellar pulsations. We obtained four time-series of high-quality optical spectra for the Galactic B supergiant HD 202850 with Ondřejov 2-m telescope. The spectral coverage of about 500 Å around H_α encompasses the Si II (6347, 6371 Å) and He I (6678 Å) photospheric lines. Their time-series display a simultaneous, periodic variability in their profile shapes. Proper analysis using the moment method revealed a period of 1.59 hours in all three lines. This period is found to be stable with time over the observed span of 19 months. This period is much shorter than the rotation period of the star and might be ascribed to stellar oscillations. Since the star seems to fall outside the currently known pulsational instability domains, the nature of the discovered oscillation remains unclear.

1. INTRODUCTION

Massive stars are very important for stellar and galactic evolution. As they end their lives in supernova explosions, they enrich the interstellar medium with heavier elements and deposit large amounts of energy and momentum into their surroundings. B supergiants are massive stars. It has been reported that they show both photometric and spectroscopic variability (Lefever et al. 2007, Markova & Puls 2008). Their lines are also much wider than expected from pure stellar rotation, and this phenomenon is usually called macroturbulence (Simón-Díaz et al. 2010). Both macroturbulence and line profile variability (LPV) had been linked to stellar pulsations. So, together with the LPV the presence of macroturbulence in a star points towards stellar pulsation. Pulsating stars are restricted to several regions of the Hertzsprung-Russell diagram; these regions are called instability domains. Recently, a new instability domain in the region of B-type supergiants has been found (Saio et al. 2006).
Here we report on the discovery of a short-term variability in the late-type B supergiant HD 202850 (= σ Cyg). This star has been classified as B9 Iab. It is located in

the OB association Cyg OB 4 at a distance of ≈ 1kpc. Its stellar parameters are given in Table 1. With these parameters, it falls outside the instability domain for evolved massive stars calculated by Siao at al. (2011).

Table 1: Stellar parameters for HD 202850. References: (1) Markova & Puls (2008), (2) this work.

T_{eff}	$\log L/L_{\odot}$	$\log g$	R_*	M	$v \sin i$	v_{macro}	Reference
[K]		[cgs]	[$R_{\odot}$]	[$M_{\odot}$]	[km/s]	[km/s]	
11000	4.59	1.87	54	8^{+4}_{-3}	33 ± 2	33 ± 2	(1)
					23 ± 1	33 ± 7	(2)

2. OBSERVATION

We observed HD202850 on 2010 September 6, 11, and 12 and on 2012 April 30 (see Table 2), using the Coudé spectrograph attached to the 2-m telescope at Ondřejov Observatory (Šlechta & Škoda 2002). We used the 830.77 lines mm^{-1} grating with a SITe 2030 × 800 CCD that delivered a spectral resolution of $R \approx 13000$ in the H_{α} region with a wavelength coverage from 6253 Å to 6764 Å. For wavelength calibration, a comparison spectrum of a ThAr lamp was taken immediately after each exposure. The stability of the wavelength scale was verified by measuring the wavelength centroids of OI sky lines. The velocity scale remained stable within $1\,km\,s^{-1}$.
The data were reduced and heliocentric velocity corrected using standard IRAF tasks. On each night we also observed a rapidly rotating star (HR7880, Regulus) to perform the telluric correction. Final ranges in signal-to-noise ratios (SNR) are 250-500, and the data with the highest quality were those obtained on 2010 September 12.

Table 2: Observing journals.

HJD	t_{exp}	HJD	t_{exp}		t_{exp}	HJD	t_{exp}	HJD	t_{exp}		t_{exp}
(2455466+)	[s]	(2455466+)	[s]	HJD(2455466+)	[s]	(2455466+)	[s]	(2455466+)	[s]	HJD(2455466+)	[s]
0.37462	600	0.47388	600	5.53004	600	6.38528	300	582.50304	300	582.56252	300
0.38362	600	0.48296	600	6.32982	250	6.39076	300	582.50843	300	582.56794	300
0.39268	600	0.49201	600	6.33502	300	6.39631	300	582.51384	300	582.57336	300
0.40173	600	0.50103	600	6.34064	300	6.40179	300	582.51925	300	582.57877	300
0.41073	600	0.51002	600	6.3461	300	6.40736	300	582.52465	300	582.58416	300
0.41974	600	5.47616	600	6.35213	300	6.41293	300	582.53005	300	582.58957	300
0.42877	600	5.48516	600	6.35767	300	6.4185	300	582.53547	300	582.59496	300
0.43781	600	5.49411	600	6.36317	300	6.4241	300	582.54087	300	582.60036	300
0.44683	600	5.50312	600	6.36868	300	6.42976	300	582.54629	300	582.60576	300
0.45582	600	5.51209	600	6.37426	300	582.49219	300	582.5517	300	582.61125	300
0.46486	600	5.52107	600	6.37977	300	582.49762	300	582.5571	300		

3. RESULTS

3. 1. MACROTURBULENCE

We applied two methods to the data to confirm the pulsation period. To prove the presence of macroturbulence we measured half width half maximum (HWHM) values. Then we calculated the projected rotational velocity ($v \sin i$) with the Fourier method and, using these $v \sin i$ values, we calculated the expected HWHM values. Those were compared to the measured ones. The large deviation confirms the presence of macroturbulence. Our values obtained for both $v \sin i$ and v_{macro} are listed in Table 1 together with those of Markova & Puls (2008).

3. 2. LINE PROFILE VARIABILITY

The time-series of the line profiles are shown in Figure 1. Visual inspection shows already a shift in central wavelength coupled with a temporal progression of asymmetries. These are typical characteristics for pulsations. To confirm the presence of pulsations, we apply the moment method. Each spectral line can be fully characterised by its line profile moments (Aerts et al. 2010). Each moment has a physical meaning. The zeroth moment represents equivalent width, the first moment ($< v^1 >$) represents radial velocity, the second moment ($< v^2 >$) gives a measure of the line width, and the third moment ($< v^3 >$) gives a measure of the line asymmetry. This method is very efficient in proving the pulsation modes, but it requires a high SNR and a medium to high spectral resolution. The second moment especially suffers from the noise.

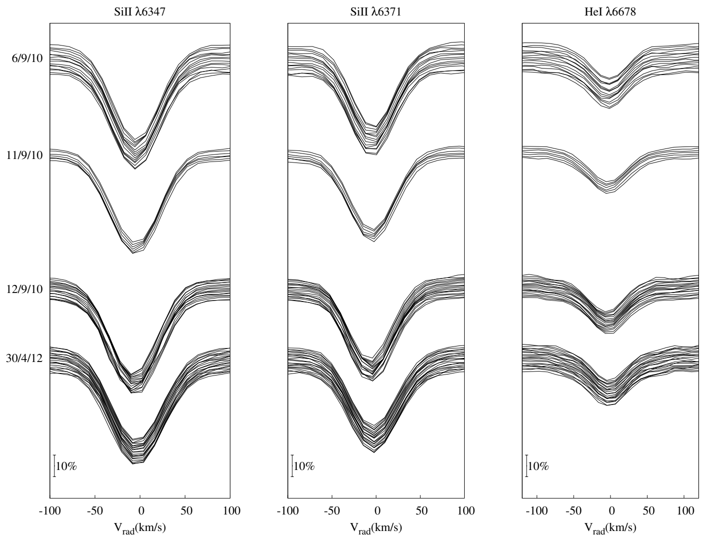

Figure 1: Time-series of line profiles of three photospheric lines we analysed. Time increases from top to bottom.

The results from our moment computations are shown in Figure 2. Obviously, the first and third moments vary in phase. To find the period to which the moments are phased, we applied two independent methods: a Fourier transformation of the moments and a simple sine curve fit. Both delivered the same period of $P = 1.59 \pm 0.01\,\mathrm{h}$ for all three lines (see Kraus et al. 2012). The second moment is phased as well, but it was too noisy to recover any period.

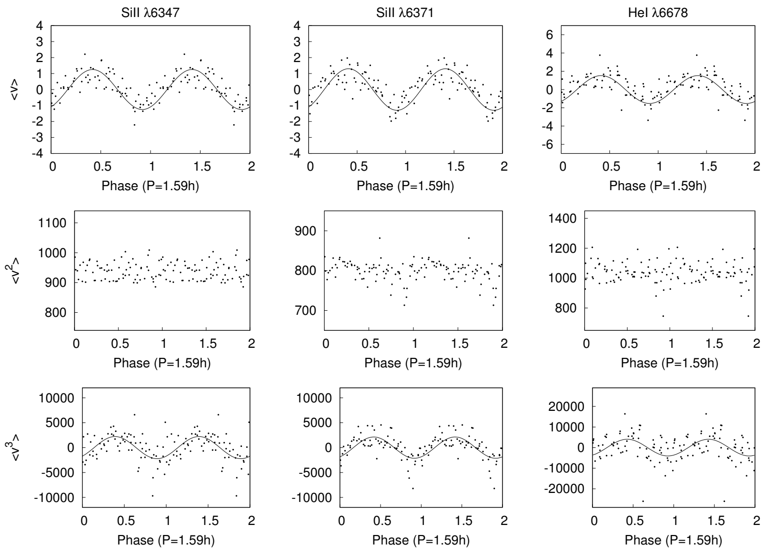

Figure 2: Calculated moments for all three photospheric lines plotted versus phase.

4. CONCLUSION

We observed periodic changes in the first and third moments of photospheric lines in the B supergiant HD 202850. The discovered 1.59 h period is stable over the period of 2 years. Three photospheric lines of two different elements change in the same manner and in the same phase. Together with the macroturbulence in these lines, this leads to the conclusion that there is a stable pulsation with 1.59 h period present in this star. It is not possible to determine the type of the pulsation because the second moment is badly affected by the noise. Also the nature of the variability remains unclear, because this star is not in a region of any known instability.

References

Aerts, C., Christensen-Dalsgaard, J. & Kurtz, D.W., : 2010, *Astroseismology*, Springer
Kraus, M., Tomić, S., Oksala, M. & Smole, M. : 2012, *A&A*, **542**, L 32
Lefever, K., Puls, J., & Aerts, C., : 2007, *A&A*, **463**, 1093
Markova, N. & Puls, J. : 2008, *A&A*, **478**, 823.
Saio, H., Kusching, R., Gautschy, A. et al, : 2006 *ApJ*, **650**, 1111 S
Saio, H. : 2011, *Proceedings IAU Symposium No. 272*
Simón-Díaz, S., Herrero, A., Uytterhoeven et al., : 2010, *ApJ*, **720**, L 174
Šlecha, M., & Škoda, P., : 2002, *Publ. Astron. Inst. Acad. Sci. Czech Republic*, vol90,1