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Study of a sample of periodically variable B-type supergiants

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Abstract. One of the pleasing results obtained from the ESA HIPPARCOS space mission was the discovery of a large number of new B-type variables. We were involved in their classification and found some 30 new B-type supergiants with α Cyg-like behaviour. The most natural way of explaining this kind of variability is oscillations (see Waelkens et al. (1998)). As a follow-up project, we have gathered high-resolution spectroscopic data including the H, He and Si lines for most of these targets. Our aim was to determine from these lines their basic stellar parameters, such as effective temperature, gravity, luminosity, helium abundance and wind characteristics with unprecedented accuracy. For this purpose we use the method of line profile fitting based on the NLTE atmosphere and line formation code FASTWIND (see Puls et al. (2005)). Once the parameters are fixed, we will search for correlations among them to help reveal more about the variability mechanism and we will deduce a new calibration for the stellar parameters of galactic B-type supergiants.

Key words. Stars: atmospheres – Stars: early type – Stars: fundamental parameters – Stars: mass loss – Stars: winds, outflows – Stars: variables: other

1. Introduction and Observations

The ESA HIPPARCOS (HIgh Precision PARallax COllecting Satellite) space mission has been succesfull in many ways. Designed to determine very precisely the position, parallax and proper motion of some 120 000 primary targets, it supplied us with a gigantic amount of photometric data. These were subject to many studies and led to the discovery of an impressive number of new variable stars, among which also some thirty new α Cyg type variables (Waelkens et al. 1998). These B-type supergiants show periodic microvariations at relatively short periods of one to a few days. The current posterpaper contains a follow-up study of the latter sample. Our sample consists of 28 stars of luminosity class I or II brighter than 9th mag in the sample by Waelkens et al. (1998). The spectra of the stars were gathered with the CES spectrograph attached to the CAT telescope at La Silla during numerous observing runs spread over 2 years. For most targets, we obtained two exposures of the Hα line in different seasons (in order to check for its variability), one of the Hγ line, one of the

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HeI 6678Å line and one of the HeI 4471Å line. Besides these, we observed one silicon line for each star with the goal to obtain an accurate temperature estimate. Depending on their spectral type, it concerned the SiII 4130Å doublet or the SiIII 4560Å triplet.

2. Fundamental Parameter Determination

First of all, the 28 sample stars were subjected to a detailed period search by means of the Scargle and Phase Dispersion Minimisation method. Afterwards, to determine the basic stellar and wind parameters of all sample stars, we used the method of line profile fitting. For this purpose we rely on the latest version of the non-LTE atmosphere and line prediction code FASTWIND (Puls et al. 2005). We use the Si II/III profile to determine the effective temperatures and the Hγ line to derive the surface gravities. These are the two main parameters needed to place the stars in the Hertzsprung-Russell diagram (HRD). Luminosities are calculated from $T_{\rm eff}$ and R_*, for which we took a 'typical' value for the derived ($T_{\rm eff}$, log g) combination based on evolutionary tracks. From the broadening of the Si-line, we fix the projected rotational velocity and from their shape we estimate the microturbulent velocity $\xi_{\rm turb}$. The Hα line takes a typical P Cygni shaped profile when affected by a stellar wind. Therefore this is the perfect line to derive the wind parameters such as the mass loss rate $\dot{M}$, the terminal wind velocity v_∞ and β defining the wind velocity law.

In the poster paper we showed that it is not always possible to derive the correct fundamental parameters. The main reason is their interdependency. Another reason is the lack of decisive spectral lines, as we do not cover the complete visual spectrum, but only have some well chosen spectral lines. Several models in a completely different range of the parameter space produce similar line profiles for all lines at our disposal. For the late type stars, Si II 4128-4130 in combination with Hγ gives us a unique solution for Teff and log g, whereas for the early type stars in our sample, we only have at our disposal a Si III profile. Depending on the surface gravity, the line strength of Si III reaches a maximum between 20 000 and 22 000K, producing similar profiles on each side of the top. We would need either Si II or Si IV to see at what side of the hill the correct model is situated. To partly solve this duality, we rely on the spectral type of the stars, which is determined from the O II / O III ratio, to make a choice between both of them. Based on these results, we define a new calibration for galactic B-type supergiants. For the comparison stars, for which only H and He lines are available, we will use this calibration to fix the stellar parameters. An overview of all resulting parameters for each of the sample stars can be found in Lefever et al. (2005, in prep.).

3. Results and Conclusions

Up to now, none of the proposed excitation possibilities for variable supergiants have been confirmed nor excluded unambiguously by observational results. Therefore it is of great importance to situate the supergiants that show α Cyg-type variability as accurately as possible in the HRD and compare this position with stars of which we do know the cause of the pulsations. Our spectroscopically determined stellar parameters position the supergiants in the high-luminosity region among the previously known α Cyg variable supergiants, rather than intermediate between main-sequence SPB and β Cephei stars as in Waelkens et al. (1998), who used less accurate photometric calibrations. Thus, on the view-point of position in the HRD, we have no longer reason to assume a common cause of variability (i.e. the κ mechanism) for these different groups of B stars.

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