What do we know about mass ejection in B Supergiant Stars?

Haucke M.[1,2], Tomić, S.[3,4], Cidale, L.[1,5], Kraus, M.[3,6] & Aret, A.[6]

[1] *Facultad de Ciencias Astronómicas y Geofísicas, UNLP, Argentina*
[2] *Agencia Nacional de Promoción Científica y Tecnológica, Argentina*
[3] *Astronomický ústav, Akademie věd České republiky, Ondřejov, República Checa*
[4] *Matematicko-fyzikální fakulta, Universita Karlova v Praze, Praga, República Checa*
[5] *Instituto de Astrofísica de La Plata, CONICET–UNLP, Argentina*
[6] *Tartu Observatoorium, Tõravere, Estonia*

Contact / mhaucke@fcaglp.unlp.edu.ar

Resumen / En este trabajo presentamos el monitoreo espectroscópico en Hα de una muestra de supergigantes B (BSGs, por sus siglas en inglés) . Entre los resultados preliminares mostramos el modelado del viento de HD 41117 (62 Ori), donde sugerimos un mecanismo pulsacional para el origen de su variabilidad.

Abstract / In this paper we present a Hα spectroscopic monitoring of B supergiants (BSGs). Among the preliminary results, we present the wind properties of HD 41117 (62 Ori) and suggest the pulsation mechanism to describe its variability.

Keywords / stars: early-type, supergiants, mass loss

1. Introduction

Observations show that some B supergiants (BSGs) display photometric and spectroscopic variations with periods ranging from a few hours to tens of days. Recent studies support the scenario that most of the variations could be produced by asteroseismic activity (Saio et al., 2013). In addition, some BSGs present variable stellar winds, which are evident in the behavior of the observed Hα line profile. As the standard theory of line driven wind does not predict the BSG wind properties at all, we can wonder if the observed wind variations are related to pulsations, as was recently found in HD 50064 (Aerts et al., 2010) and in 55 Cyg (Kraus et al., 2015). In this work we present spectroscopic observations of a sample of BSGs which show variations in their Hα profiles and photospheric lines. In order to understand these behaviors we search for correlations between the wind properties, via line fitting procedures using the FASTWIND stellar atmosphere code, and pulsational activities, via moment analysis.

2. Observations

We carried out a spectroscopic campaign of BSG stars on both hemispheres between 2009 and 2015. In the north, single slit spectra covering the region around the Hα line were taken with the Perek 2-m telescope at Ondřejov Observatory (Czech Republic), and with the 1.5-m telescope at Tartu Observatory (Estonia). In the south, the observations were performed with the 2.15-m "J. Sahade" telescope at CASLEO (Complejo Astronómico El Leoncito, Argentina) using the REOSC echelle spectrograph. All these instruments provide a spectral resolution in the Hα region of ∼ 13 000. Here we present a preliminary study of selected BSG stars. The objects and their positions in the Hertzsprung-Russell diagram are shown in Figure 1.

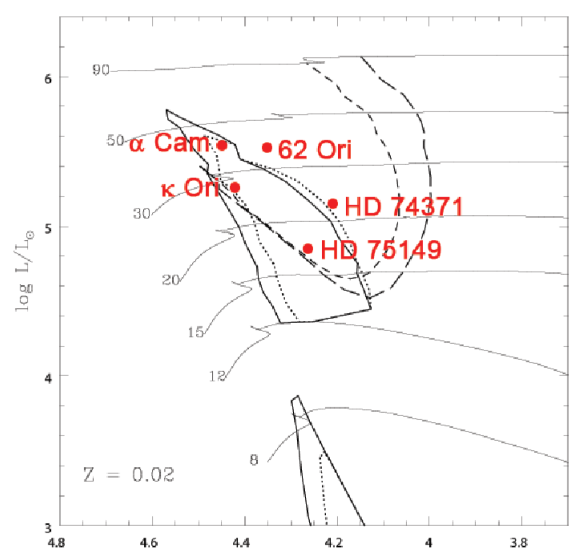

Figure 1: Theoretical instability domain and evolutionary tracks taken from Saio (2011), where we located our star sample. Stellar parameters are from Snow et al. (1994); Crowther et al. (2006); Lefever et al. (2007).

3. Results

Our aim is to analyze the wind variability and possible triggering mechanisms. To this purpose, we calculate the synthetic Hα line using the FASTWIND code (Puls et al., 2005) and compare (by-eye procedure) with the observed one. A moment analysis of the photospheric absorption lines is used to reveal pulsational activity.

In Figures 2 and 3, we show a series of Hα line profile fits of HD 41117 (62 Ori) and its corresponding moment analysis of the HeI $\lambda\,6678$ Å line, respectively.

To calculate the line profiles we fixed the stellar parameters using values found in the literature ($T_{\rm eff}$ = 18 500/19 000 K, $log\,g$ = 2.25 dex, R = 61.7 $R_\odot$ and $v\,sin\,i$ = 35 / 40 km s^{-1}, Kudritzki et al., 1999) and derived the wind parameters. We found that the mass-loss rate ($\dot{M}$) varies from 0.5 10^{-6} $M_\odot$ yr^{-1} to 1.23 10^{-6} $M_\odot$ yr^{-1} and the terminal velocity (v_∞) from 200 km s^{-1} to 800 km s^{-1}. We observe variations in the terminal velocity and mass loss rate above a factor of 2.

Additional parameters to model the line profiles are the photospheric microturbulence ($v_{\rm micro}$), the macroturbulent velocity ($v_{\rm macro}$) and the β index power associated with the velocity field. The uncertainty of these parameters are discussed in Kraus et al. (2015). The best models were obtained with values of $v_{\rm micro}$ ranging from 30 km s^{-1} to 40 km s^{-1} and $v_{\rm macro}$ from 40 km s^{-1} to 70 km s^{-1}. All the models were calculated with β = 2. High values of $v_{\rm macro}$ are consistent with pulsational activity (Aerts et al., 2009).

To look for additional evidence of asteroseismic activity, as the one found in 55 Cyg, we have applied the moment method by Aerts et al. (1992) to the He I $\lambda\,6678$ Å line. Figure 3 shows that the first and third moments vary in phase. This implies that the star is in fact pulsating. We found that the first moment varies from -6 km s^{-1} to 10 km s^{-1} over three years. However, the data are too few to determine a pulsation period.

We also present results for other four BSG stars (see Figure 4, HD 74371, HD 75149, κ Ori, α Cam). All of these objects show variations in Hα and in the photospheric lines, indicating possible mass-loss variability. As all the mentioned stars are located in the instability domain (see Figure 1) the presence of pulsation is expected.

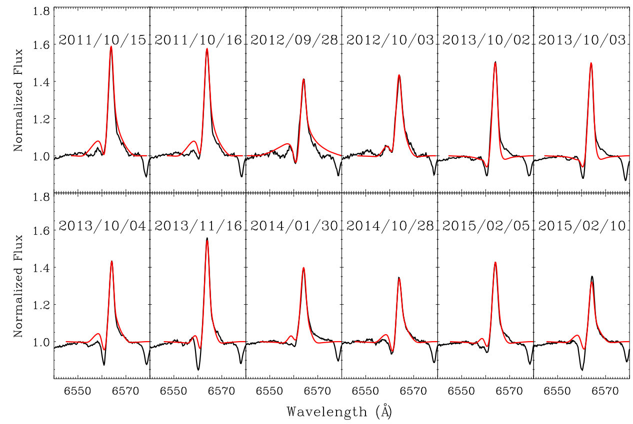

Figure 2: Time-serie of Hα emission line in HD 41117 (in black) compared with profiles modeled using FASTWIND code (in red).

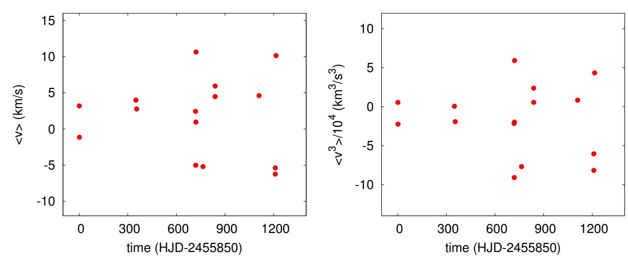

Figure 3: First (left) and third (right) moments of the He I $\lambda\,6678$ Å line of HD 41117.

Acknowledgements: M.H. and L.C acknowledge financial support from the Universidad Nacional de La Plata (Programa de Incentivos G11/137) and CONICET (PIP 0177). S.T. and M.K. acknowledge financial support from GA ČR (grant number 14-21373S). The Astronomical Institute Ondřejov is supported by the project RVO:67985815. M.K. also acknowledges financial support from the European Structural Funds grant for the Centre of Excellence "Dark Matter in (Astro)particle Physics and Cosmology". Financial support for International Cooperation of the Czech Republic (MŠMT, 7AMB14AR017) and Argentina (Mincyt-Meys ARC/13/12 and CONICET-AVCR 14/003) is acknowledged. A.A. acknowledges financial support from Estonian Science Foundation grant ETF8906 and institutional research funding IUT40-1 of the Estonian Ministry of Education and Research. This study is based on observations taken with: a) the J. Sahade Telescope at Complejo Astronómico El Leoncito (CASLEO), operated under an agreement between the Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina, the Secretaría de Ciencia y Tecnología de la Nación and the National Universities of La Plata, Córdoba and San Juan; b) the Perek 2-m telescope at Ondřejov Observatory, Czech Republic; c) the 1.5-m telescope at Tartu Observatory, Estonia.

References

Aerts C., de Pauw M., Waelkens C., 1992, A&A, 266, 294
Aerts C., et al., 2009, A&A, 508, 409
Aerts C., et al., 2010, A&A, 513, L11
Crowther P. A., Lennon D. J., Walborn N. R., 2006, A&A, 446, 279
Kraus M., Haucke M., et al. 2015, A&A, 581, A75
Kudritzki R. P., et al., 1999, A&A, 350, 970
Lefever K., Puls J., Aerts C., 2007, A&A, 463, 1093
Puls J., et al., 2005, A&A, 435, 669
Saio H., Georgy C., Meynet G., 2013, MNRAS, 433, 1246
Saio H., 2011, in Neiner C., et al., eds., IAU Symposium Vol. 272, Active OB Stars: Structure, Evolution, Mass Loss, and Critical Limits. pp 468–473
Snow T. P., et al., 1994, ApJS, 95, 163

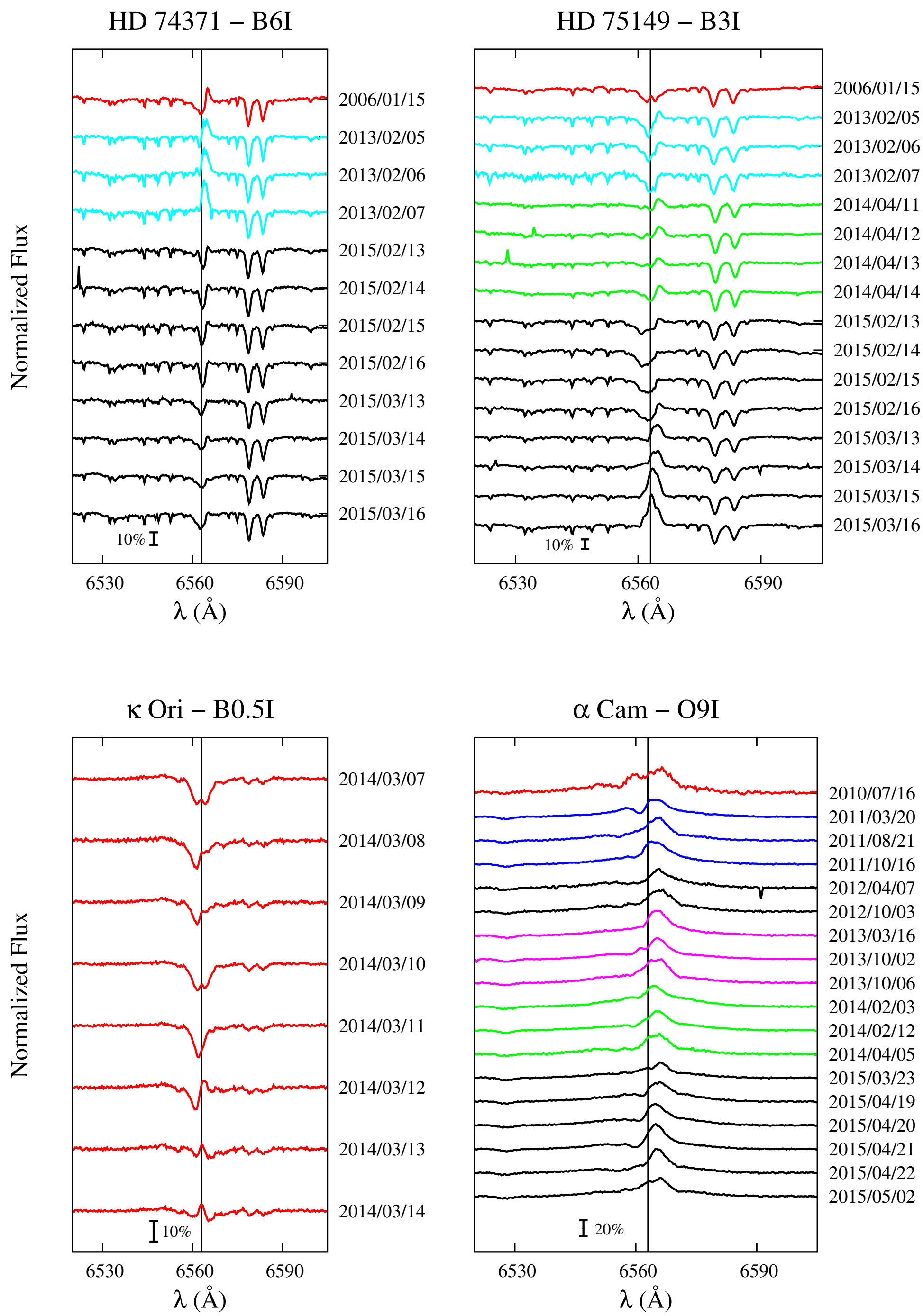

Figure 4: Temporal variations of Hα line profiles in four BSGs indicating wind variability. Different colors refer to observations in different years and the vertical lines mark the Hα rest wavelength position. The bars indicate the scale of the variations.