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PRESENTACIÓN MURAL

Near-infrared spectroscopic survey of galactic B[e] stars

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Abstract. We study the circumstellar CO emission in a sample of galactic B[e] stars using high spectral resolution data taken with the near-infrared spectrograph VLT/CRIRES. The presence or absence of the first overtone CO band emission can help us characterize the environment around stars in different evolutionary phases, while the modeling of the first CO bandhead in our high resolution spectroscopic data can provide information about the kinematics of the circumstellar material at several AU from the star. This study will help to assess the validity of the latitude dependent B[e] wind paradigm in particular, and our understanding of the final phases of massive star evolution in general. In this contribution we present preliminary results on the modeling of the CO emission for some of the objects of the sample.

Resumen. Estudiamos la emisión de CO en una muestra de estrellas B[e] galácticas usando observaciones de alta resolución espectral obtenidas con el espectrógrafo infrarrojo VLT/CRIRES. La presencia o ausencia de la emisión de CO puede ayudarnos a caracterizar el medio circunestelar alrededor de estrellas en distintos estados evolutivos. Además, el modelado de la primera cabeza de banda de esta molécula en nuestros espectros de alta resolución puede aportar información acerca de la cinemática del material a varias UA de la estrella. Este estudio contribuirá a evaluar la validez del paradigma de los vientos dependientes de la latitud en las estrellas B[e] en particular, y nuestro entendimiento de las fases finales de la evolución de las estrellas masivas en general. En esta contribución presentamos resultados preliminares del modelado de la emisión de CO para algunos de los objetos de la muestra.

1. Introduction

B[e] stars are characterized by the presence of permitted and forbidden emission lines in their optical spectra, and a strong infrared excess emission due to circumstellar dust (e.g. Zickgraf et al. 1985). Some of these stars also show molecular bands in emission, such as TiO and/or CO bands (McGregor et al. 1988). All this points to the existence of a large amount of circumstellar ma-

terial, but the kinematics and physical conditions in these extended envelopes (winds and/or disks) are still unknown. The model proposed by Zickgraf et al. (1985), consisting of a fast, low density polar wind, and a much denser, slowly expanding equatorial wind, is currently under debate. However, the existence of an equatorial density enhancement is supported by observations performed with different techniques, such as spectroscopy, spectropolarimetry and interferometry, and explains the formation and survival of molecules and dust around hot stars. On the other hand, analyses of atomic and molecular emission have provided evidence not only of outflow but also of Keplerian rotation. In order to gain insight into the structure and kinematics of the circumstellar environments around these stars, it is important to study the emission from the different components of the circumstellar medium, because they trace regions at different distances from the star. Here we concentrate on the first overtone CO band emission observable in the near-infrared. This particular disk tracer provides information about the kinematics of the circumstellar material at several AU from the star.

2. Observations

We obtained high-resolution near-infrared spectra (R∼50000) for a sample of galactic B[e] stars using CRIRES, an echelle spectrograph attached to one of the 8m VLT unit telescopes at the European Southern Observatory (ESO) site in Paranal (Chile). The observations were carried out on several nights during November and December, 2009, and during April, June and July, 2010. A standard nodding on-slit strategy was applied to remove sky and detector glow, and telluric standard stars were observed in order to remove telluric lines from the spectra of the target stars. The reduction of these observations was performed with the CRIRES pipeline provided by ESO, while the telluric correction was performed using IRAF software package routines. The final spectra extend approximately from 2.276 to 2.326 μm.

3. Results

The sample consists of 16 objects (see Table 1), 8 of which clearly display the first bandhead of CO in emission. The spectra of these 8 stars, together with 2 of the objects that show no evidence of CO emission, are presented in Fig. 1 (black line). The wavelength range shown, extending from 2.292 to 2.3005 μm, includes the first CO bandhead. The shape of the bandhead implies that either rotation or equatorial outflow broadens the CO band. We use the model of Kraus et al. (2000) to determine the (rotation or outflow) velocity of the CO gas projected to the line-of-sight, $v \sin i$. The values obtained for the 6 objects we have modeled so far are included in Table 1, and the preliminary fits are shown in Fig. 1 (green line). We are currently working to refine these fits and model the remaining 2 stars. The final values of $v \sin i$ will then be used to determine the distance from the star at which the CO gas is located. Combining these distance estimates with those obtained from other tracers, such as the optical forbidden lines [OI] and [CaII] (Kraus et al. 2007, 2010; Aret et al. 2012), we will be able to distinguish between Keplerian rotation and outflow.

Interestingly, all stars displaying CO band emission are either confirmed or suspected supergiants. For 2 of them (HD 327083, Wheelwright et al. 2012; GG Car, Kraus et al. 2013) the CO gas is located in a circumbinary disk. Whether such a scenario holds for more stars in this sample still needs to be studied.

Object	Classification	CO emission	$v \sin i$ (km s^{-1})
Hen 3-298	sgB[e]	yes	19
GG Car	B0-B2, sgB[e]	yes	80
CPD-52 9243	B3Ia, sgB[e]	yes	26
3 Pup	A2Iab[e]	yes	42
MWC 137	Be, sgB[e] candidate	yes	85
HD 87643	sgB[e] candidate	yes	
HD 327083	sgB[e]	yes	
CD-57 3107	sgB[e]	yes	65
MWC 300	B1Ia+, sgB[e]	no	
V921 Sco	Bpe, sgB[e] candidate	no	
MWC 314	LBV candidate, sgB[e] candidate	no	
Hen 3-1398	O9/B0[e]	no	
Hen 3-140	unclB[e]	no	
HD 45677	B2V[e], unclB[e], extreme Be?	no	
HD 50138	B6III-IV[e], unclB[e], extreme Be?	no	
AS 381	B1e+, sgB[e] candidate	absorption	

Table 1. Sample of galactic B[e] stars observed with CRIRES.

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References

Aret, A. et al., 2012, MNRAS, 423, 284
Kraus, M. et al., 2000, A&A, 362, 158
Kraus, M. et al., 2007, A&A, 463, 627
Kraus, M. et al., 2010, A&A, 517, A30
Kraus, M. et al., 2013, A&A, 549, A28
McGregor, P. J. et al., 1988, ApJ, 324, 1071
Wheelwright, H. E. et al., 2012, A&A, 543, A77
Zickgraf, F. -J. et al., 1985, A&A, 143, 421

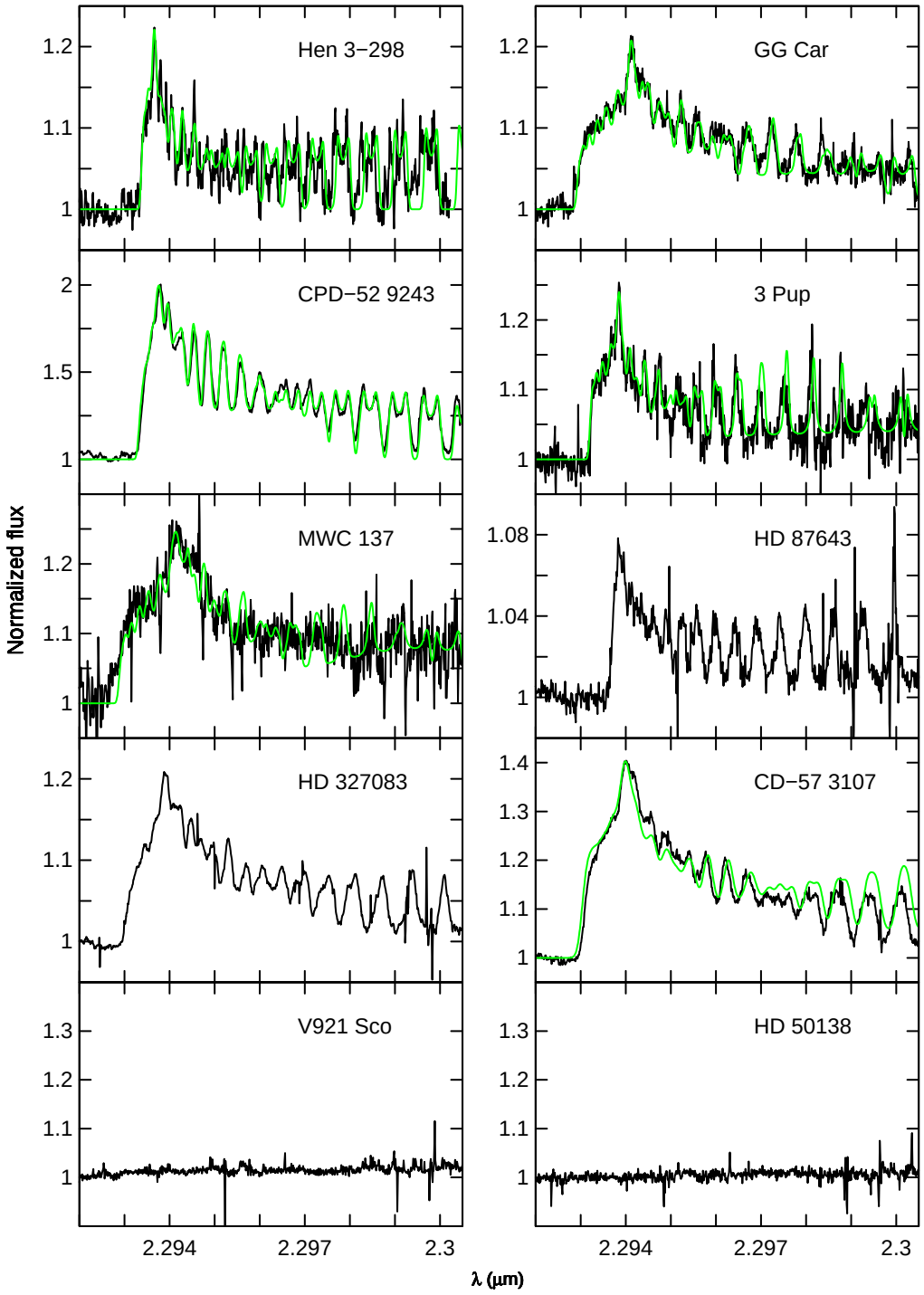

Figure 1. Normalized CRIRES spectra (black) of the stars that display CO in emission. For 6 of the 8 stars we show preliminary fittings (green). We also include for comparison 2 of the objects that do not show CO in their spectra.