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THE 2008+ OUTBURST OF THE BE STAR 28 CMA

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RESUMEN

La fase precursora de la erupción que comenzó en octubre de 2008 fue intensamente monitoreada por fotometría, alta resolución en óptico e IR cercano e interferometría. Contrario a la esperada erupción monotónica prevista se observó una fase de largo período con pequeñas erupciones cíclicas. Una parte más distante del disco circunestelar, donde el Br γ se forma típicamente, fue afectada perceptiblemente sólo en enero de 2009. Por lo tanto, nuestras observaciones de 2008 en AMBER permiten derivar parámetros geométricos y físicos del disco formado durante erupciones anteriores, pero el nuevo el disco interno visible en líneas metálicas ópticas no pudo ser resuelto espacialmente.

ABSTRACT

The precursor phase of the outburst started in October 2008 was intensively monitored by photometry, high-resolution optical and near-IR spectroscopy and interferometry. Contrary to the expected monotonic outburst a long precursor phase with cyclic smaller outbursts was observed. A more distant part of the circumstellar disk, where Br γ is typically formed was significantly affected only in January 2009. Consequently, our 2008 AMBER observations enable to derive geometrical and physical parameters of the disk formed during previous outbursts, but the new inner disk visible in the optical emission metallic lines could not be spatially resolved.

Key Words: H II regions — ISM: jets and outflows — stars: pre-main sequence — stars: mass loss

1. INTRODUCTION

28 (ω) CMa (HD 56139, HR 2749; B3Ve) belongs to the most observed southern Be stars. Long-term photometric monitoring, shows at least four quasi-cyclic outbursts with an amplitude of about $0.^{m}5$ separated by 6–8 years. This permits to study their evolution in detail. Štefl et al. (2003a,b) described the outbursts in 1994–1997 and beginning of the 2001. Their analysis of rapid photospheric line profile variations confirmed the single period of P=1.371 d. Its phase shows incoherent shifts during the outbursts. Maintz et al. (2003) showed that rapid line profile variations can be well modeled as non-radial pulsations with spherical modes: $m = 2$, $l = 2$. The relatively low $v \sin i = 80\,\mathrm{km\,s^{-1}}$ is the consequence of the almost pole-on view. The model gives the rotational velocity $v_{\rm rot} = 350\,\mathrm{km\,s^{-1}}$.

The above spectroscopic study left many questions without answers. With no interference of non-radial pulsation modes, such as for μ Cen (Rivinius et al. 1998), we have no clue as to what physical mechanism triggers the outbursts and what is the role of pulsation in this process. As for other Be stars, the mechanism transferring the angular momentum to the Kepplerian disk remains unknown.

In order to address the above questions, we decided to monitor the starting 28 CMa outburst by spectro-interferometric observations, which can help resolve the dynamical profile of the disk. After the new outburst was detected photometrically in October 2008 (S. Otero, priv. com.), we executed interferometric observations with the VLTI/AMBER interferometer in the high-resolution mode ($R = 12\,000$, Br-γ) and supporting high-resolution spectroscopy in the optical (La Silla/FEROS and VLT/UVES) and near-infrared (GEMINI/PHOENIX, Br-γ line and SOAR/OSIRIS). Each of about 15 spectral bins over the Br-γ line observed with AMBER represents a projection on the sky in the given RV range. Preliminary results of observations obtained in November 2008–February 2009 are reported here.

2. RESULTS OF OBSERVATIONS

The start-up of the main outburst was confirmed by the follow-up FEROS spectra, showing typical features of the outburst, as e.g. increased emission

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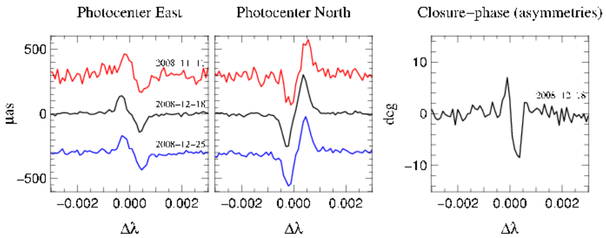

Fig. 1. Interferometric phase transformed into the photocenter shifts and closure phase corresponding to AMBER observations.

in Balmer wings and extra emission peaks in Fe II, Mg II and Ca II. The spectroscopic behaviour resembled the earlier phases of the 1992 and 2001 outbursts as described by Štefl et al. (2003a). Red absorption components seen in Ca II can be interpreted as in evidence of ejected matter falling back to the star.

However, the outburst stopped about halfway to the previously observed maximum brightness, the spectroscopic features started weakening and the star showed cyclic light variations on a time scale of 45–55 days. The photometric behaviour resembles the beginning of the 1991 outburst observed by Hipparcos, but unfortunately the Hipparcos data do not cover the entire precursor phase and we cannot know whether the oscillation observed in this outburst was also present then.

We could resolve the circumstelar disk in AMBER high resolution observations of the Br-γ emission. Photocenter shifts and the closure phase derived from differential phases are shown in Figure 1. The data suggests the presence of a symmetric (i.e. circularized) circumstellar disk around 28 CMa. Furthermore, within the given errors the interferometric characteristics are constant between the three observations. Both facts suggests that only the external part of the circumstellar disk was probed by the AMBER observations.

The absence of variations in Br-γ was confirmed by high resolution (R=45000) Phoenix spectra.Both the equivalent with of about -11 Å and the line profiles did not change significantly till the beginning of January 2009. In January, the equivalent width increased by 30%, mainly due to increasing core emission. Unfortunately, no AMBER observations at the longest baselines were obtained in January and February.

3. MODELING OF THE CIRCUMSTELLAR DISK

Fitting of the interferometric parameters is a work in progress, and only a brief preliminary report is presented here. The modeling was carried out with the radiative transfer code HDUST (Carciofi & Bjorkman 2006). We have tested two models against observations. The first is a steady-state Keplerian disk model (Bjorkman & Carciofi 2005) and the second the time-dependend disk model of Okazaki (2007), which can take into account the clearing of the inner disk expected to occur during the quiescent (i.e., with no mass loss) phase. The comparison between both models, shown in Fig. 2, is very convincing: the interferometric data is much better described by the dynamical model, which has a more tenuous inner disk due to matter re-accrettion onto the star.

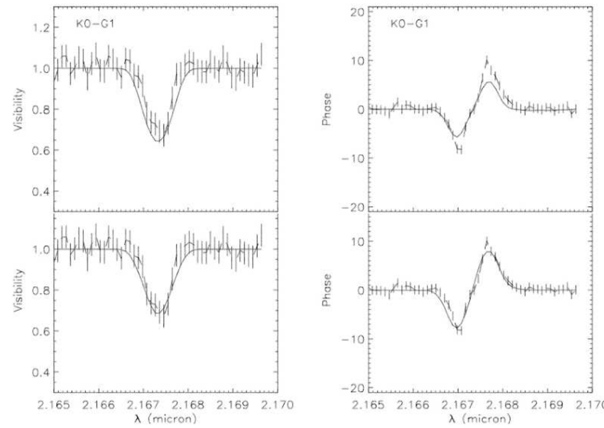

Fig. 2. Preliminary modeling of the AMBER observations. *Top:* Best-fit model with a standard Keplerian disk model. *Bottom:* Best-fit model with the dynamical model of Okazaki (2007), in which the inner disk has been allowed to partially reaccrete to the star.

4. CONCLUSIONS

Although the steep brightening of 28 CMa stopped in a phase with cyclic light variation, a new disk was seen in increased Balmer line wings and extra emission and absorption components of single ionized metalic lines in the optical region. However, the outer area of the disk where Br-γ is typically formed, was not affected during the first 2–3 months after the outburst was detected photometrically and spectroscopically.

Our 2008 AMBER observations resolve the old disk, formed during previous outbursts. Our preliminary modeling shows that the AMBER observations are more consistent with a dynamical disk model, in which the inner disk is more tenuous due to dynamical dissipation, than with a simple steady-state disk model.

REFERENCES

Bjorkman, J. E., & Carciofi, A. C. 2005, ASP Conf. Ser. 337, The Nature and Evolution of Disks Around Hot Stars, ed. R. Ignace & K. G. Gayley (San Francisco: ASP), 75

Carciofi, A. C., & Bjorkman, J. E. 2006, ApJ, 639, 1081

Maintz, M., Rivinius, Th., Štefl, S., Baade, D., Wolf, B., & Townsend, R. H. D. 2003, A&A, 411, 181

Okazaki, A. T. 2007, ASP Conf. Ser. 361, Active OB-Stars: Laboratories for Stellar and Circumstellar Physics,ed. S. Štefl, S. P. Owocki, & A. T. Okazaki (San Francisco: ASP), 230

Rivinius, Th., Baade, D., Štefl, S., Stahl, O., Wolf, B., & Kaufer, A. 1998, A&A, 333, 125

Štefl, S., et al. 2003a, A&A, 402, 253

Štefl, S., et al. 2003b, A&A, 411, 167