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ASTRONOMY AND ASTROPHYSICS

LETTER

Letter to the Editor

Wind fluctuations observed for the [WC9] nucleus of the planetary nebula BD+30^{o}3639*

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Abstract. The CIII and CIV lines in the [WC9] spectrum of BD+30^{o}3639 show variable features, interpreted in terms of radiative acceleration of "blobs" forming in the wind. The variations are like those observed for the WC9 massive stars, and the blobs acceleration appears smaller than for the [WC8] nucleus of NGC 40.

Key words: Planetary nebulae: central stars–Stars: Wolf-Rayet, stellar winds

1. Introduction

Strong stellar winds of Wolf-Rayet stars could be made up of dense clouds flowing out through a rarefied circumstellar medium. Systematic observations of variable subpeaks on the tops of broad stellar emission lines were conducted for massive WR stars (see Moffat & Robert, 1994, and references therein). Recently, a search for similar spectroscopic variations was conducted for [WC] nuclei of planetary nebulae, both by Balick *et al.* (1996) and Grosdidier *et al.* (1996a,b), showing evidence for a clumpy wind in the vicinity of NGC 40's central star.
This letter presents first results of an observational search for wind variability in [WC9] central stars, leading to a detection of wind variations in the spectrum of BD+30^{o}3639.

2. Observations

BD+30^{o}3639 is the brightest northern [WC] star, and appears in a large amount of publications (534 references were found in SIMBAD). The star was included in Balick's study, but no variation was detected at the chosen resolution (0.15 nm).

We conducted our observations at the 1.52 m telescope at the Observatoire de Haute-Provence (OHP, France) equipped with the Aurélie spectrograph (see Gillet *et al.*, 1994). The detector is a linear array CCD-like of 2048 pixels. We used the grating of 600 l/mm, leading to a resolution of 11000 (0.05 nm spectral resolution at 550 nm). The spectral range, centered on 575 nm, covers the 550 to 595 nm domain. A first prospective study was done in 1996 March 1-6 (3 spectra). On 1996 May 15-21, we obtained 27 spectra with exposure times of 25 min, the mean S/N ratio being 24 (May 15: 6 spectra; May 17: 8 spectra; May 20: 9 spectra; May 21: 4 spectra of bad quality). The spectra were reduced in the usual way (bias subtraction, flat field correction, wavelength calibration by using a Argon-Thorium lamp, and flux calibration by using the standard stars HR 3454 and HR 5511).

3. Results and discussion

The CIII-569.6 nm line and the emission feature at 581 nm (CIV-580.1 and -581.2; CIII-582.6 nm) show variable features. The width of the CIII line is about 2 times narrower than for the nucleus of NGC 40, and is comparable to the width of the CIII line of WC9 massive stars (in particular WR 103 = HD 164270), as pointed out by Méndez *et al.*, 1991. The variations of the features occur with a smaller amplitude than in the case of NGC 40. Therefore, Balick *et al.* (1996) were not able to detect them at their relatively low resolution (0.15 nm).
Figure 1 shows the differences from the mean profile of the CIII-569.6 nm line as a function of time for 2 nights of the May run. Subpeaks' variations in intensity appear on a time-scale of a few hours. However, only small accelerations are noticed (about 0.005 km.s^{-2}), as in WR 103 and other massive WC 9 stars, the WC 5-8 stars all showing higher accelerations (up to 0.015 km.s^{-2}, see Robert, 1992).
In order to identify more clearly the variations and their statistical significance relatively to the S/N values, we calculated the Temporal Variance Spectrum (TVS) as defined by Fullerton

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* Based on observations taken at the *Observatoire de Haute-Provence* (France)

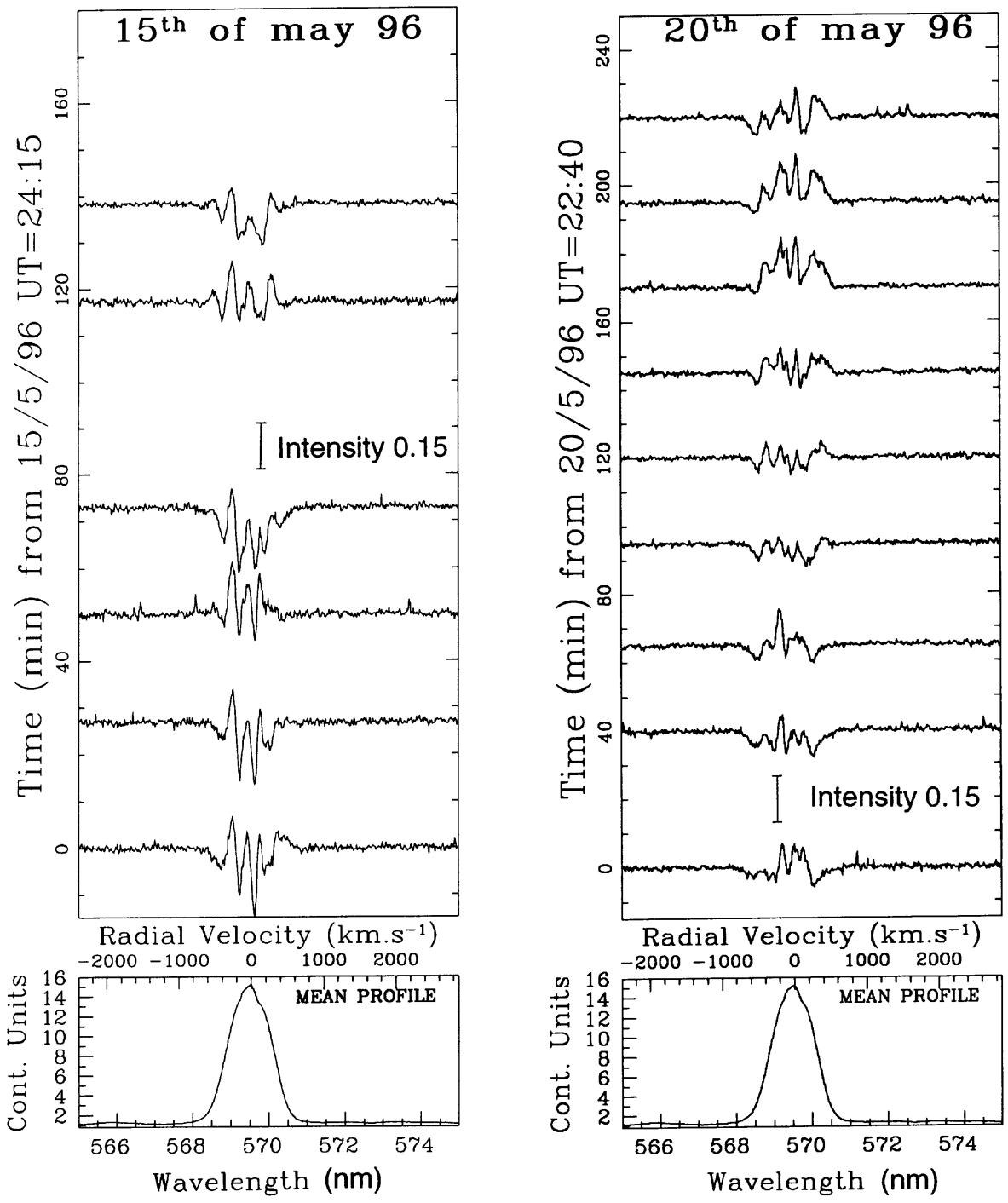

Fig. 1. CIII-569.6 nm residuals (individual minus mean profile) in two nights of OHP data (resolution 11000).

et al. (1996). Figure 2 presents the mean profile of CIII, CIV and HeI with the computed TVS: the observed lines appear statistically variable at the 1 % confidence level. Note the strong variation in the P-Cygni profiles of the OV-559, CIV-580 and HeI-587 nm lines, especially at the blue edge of the absorption lines defining the terminal wind velocity.

4. Conclusions

Evidence for clumping in the wind of the [WC9] spectrum of BD+30^{o}3639 is shown for the first time. In a forthcoming paper based on new observations of BD+30^{o}3639 and southern late-[WC] nuclei, Grosdidier *et al.* (1996b) will determine the velocity field for different radial distances, deriving kinematical parameters which give constraints on the stratification of

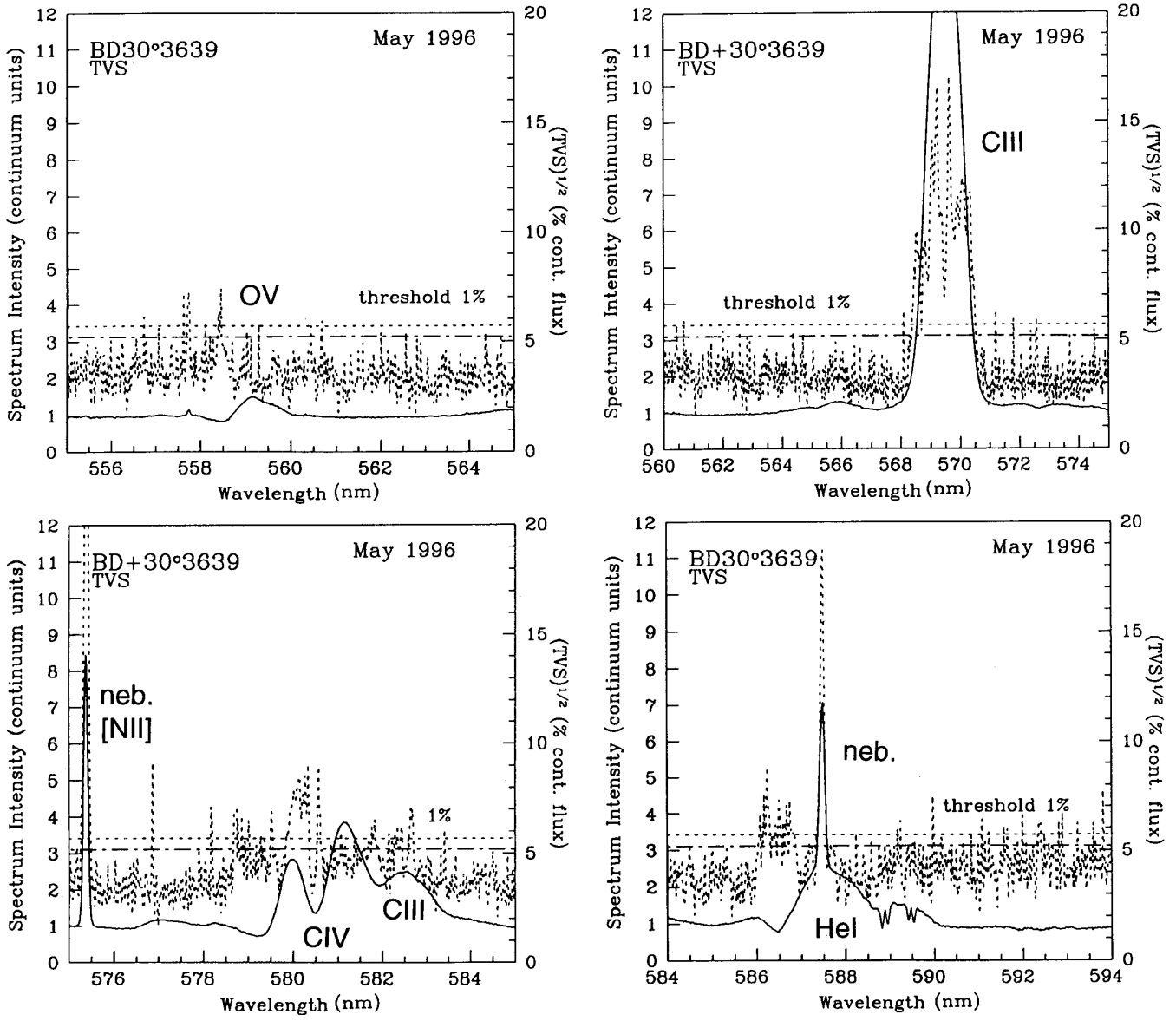

Fig. 2. BD+30^{o}3639 mean spectrum (solid line) and the computed square root of the TVS, both calculated with 20 individual spectra. Contours of statistical significance for 1% *and* 5% levels are indicated by dotted *and* dot-dashed lines, respectively. Our calculations account for pixel-to-pixel and spectrum-to-spectrum differences in the noise distribution.

ionization, on the effective mass loss rates and the radius of the stars.

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