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HD 93129A AT DIFFERENT RADIO SCALES

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RESUMEN

Observaciones recientes hacia la estrella HD 93129A (O2 If*) han revelado emisión no-térmica en radioondas; además, datos del FGS-HST mostraron que tiene una compañera de tipo O temprana, a 140 UA si la distancia estelar es de 2.5 kpc. Ambos resultados son consistentes con la presencia de una región de colisión de vientos entre las dos componentes. En esta región pueden acelerarse los electrones relativistas involucrados en la emisión sincrotrón. Con el objetivo de resolver la fuente no-térmica hemos llevado a cabo observaciones VLBI con el LBA australiano a 2.37 GHz. Presentamos aquí algunos resultados preliminares.

ABSTRACT

Recent observations toward the O2 If* star HD 93129A have revealed important non-thermal radio emission, and that it has an early O companion 140 AU away if at 2.5 kpc (FGS-HST data). These facts strongly support the possibility of a massive stars wind-collision region as the acceleration site of the synchrotron-emitting relativistic electrons. We have carried out LBA VLBI observations at 2.37 GHz to resolve the non-thermal source, and search for a bow-shock shape, typical of a wind-collision region. Preliminary results are presented here.

Key Words: radiation mechanisms: non-thermal — stars: individual (HD 93129A) — stars: winds, outflows

1. INTRODUCTION

Since the first high-resolution radio observations of the earliest stars (OB to WR spectral types) an important fraction revealed as non-thermal emitters (see latest compilations by De Becker 2007; Benaglia 2009). The radiation is believed to be synchrotron emission from relativistic electrons accelerated in shocks, either caused by the instability of the radiative driving mechanism (Owocki et al. 1988), or by colliding winds in a massive binary system — so called colliding wind binaries (Eichler & Usov 1993). WR radio stars present a strong correlation between emission and binarity (Dougherty & Williams 2000). Yet in a number of examples, the wind-collision region (WCR) is resolved into the expected bow shape, e.g. VLBA observations of WR 140, with the arc wrapping around the star with the weakest wind (Dougherty et al. 2005).

For O stars, both instability-related shocks and wind-collision shocks seemed viable explanations, but recent modeling by Van Loo et al. (2005) shows that the instability-related shocks cannot explain the observed non-thermal spectra. Moreover, the relation with binarity is not as clear as in the case of WR stars: there is only one case (Cyg OB 2 No. 5) where binarity/multiplicity can be related to a WCR (see Linder et al. 2009, and references therein).

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2. HD 93129A AT ARCSEC RESOLUTION

HD 93129A is an O2 If* star, the brightest member of the young compact cluster Trumpler 14 in the Carina nebula, that has recently been observed as a strong non-thermal radio emitter (Benaglia & Koribalski 2004; Benaglia et al. 2006), with a 1.4 GHz flux of ≈ 10 mJy (see Figure 1). At the same time, Nelan et al. (2004) used the Fine Guidance Sensor on the HST to demonstrate that this star has an O-star companion 55 mas distant (140 AU in projection at a system distance of 2.5 kpc), with a similar spectral type to HD 93129A. New HST FGS observations (2006), when combined with previous ones (1996 and 2002) showed that the system components, Aa and Ab, are approaching. The data are consistent with a proper motion along the radius vector between Aa and Ab of $<\mu>= 2.08 \pm 0.23$ mas/a, and a total mass, if a circular orbit, of $200 \pm 45\ M_{\odot}$. The change in projected separation suggests that the periastron passage should be ~ 10 yr from now (Maíz Apellániz et al. 2007).

The spectrum of HD 93129A, as measured with ATCA, is plotted in Figure 1. We have computed a the thermal flux at 8.64 GHz using the expression $S = \mathrm{C}\, \nu^{+0.77}$, and subtracted it from the total de-

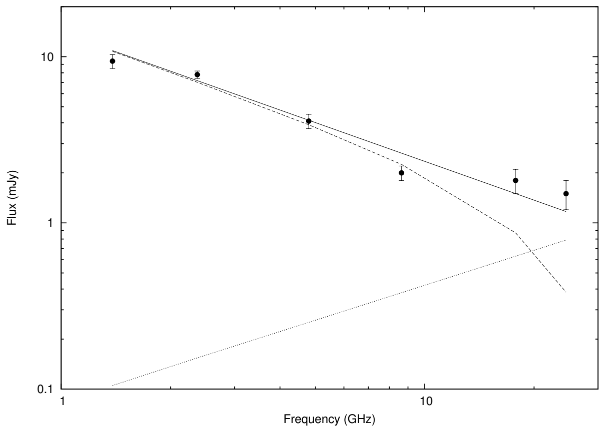

Fig. 1. Radio spectrum of HD 93129A, measured with ATCA (points), and a weighted least-square power-law fit with index 0.77 ± 0.05. The thermal flux estimated from an assumed wind density for the O stars is shown (dotted), along with the implied intrinsic synchrotron spectrum (dashed) determined by subtracting the thermal model from the observed power-law spectrum.

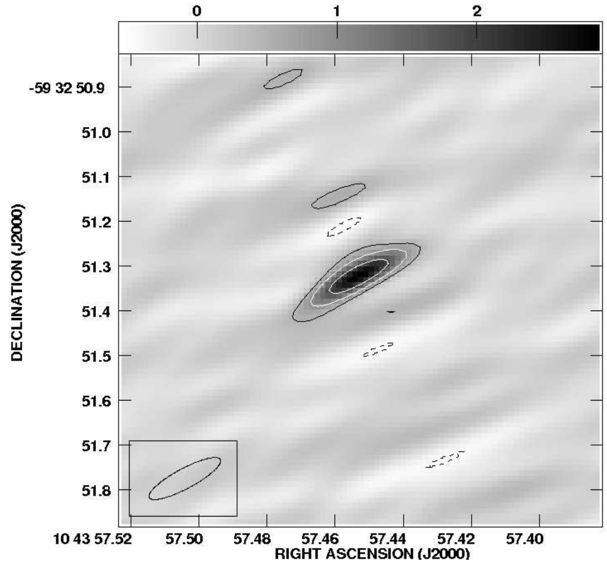

Fig. 2. LBA image of HD93129A at 2.37 GHz, obtained with ATCA, Mopra and Parkes telescopes on 22 June 2007 as part of programme VT11D3. Contour levels are -1, 1, 2, 4, 8, and 16 in units of 0.45 mJy beam^{-1}.

tected flux. The residuals represent the non-thermal –synchrotron– emission.

In seeking for conclusive evidence of a WCR, we have carried out Long Baseline Array (VLBI) observations to attempt to resolve the source of the non-thermal emission in HD 93129A and look for a bow shock print.

3. OBSERVATIONS AND PROSPECTS

The LBA is made up of 6 antennae, named ATCA, Parkes, Mopra, Ceduna, Hobart and Tidbinbilla, with diameters from 22 to 70m. The baselines range from 100 to 1700 km, and at 2.3 GHz the angular resolution attained is 18 mas (50 AU at 2.5 kpc). The project included a 4-h initial campaign in 2006 with three dishes to search for suitable phase calibrators: eighteen were found within 10 degrees of HD 93129A. The target system HD 93129A was detected at about 2 mJy (4–5σ level), on the ATCA-Parkes baseline. On June 22, 2007 we were favored with 8 h of eVLBI test time of the Parkes-Mopra-ATCA baselines. The LST range covered was 03:00–14:00. The sources 0607-752 and J1047-6217 were used as flux and phase calibrators. Figure 2 displays the detected source, with a total flux of ~ 3 mJy. The resulting beam was $0.2 \times 0.05''$. The observation became the second eVLBI-LBA experiment (C. Phillips, private communication).

Additional 12hr of data using the whole LBA array are under reduction. The detection of a bow-shock morphology will allow, as in Pittard & Dougherty (2006), to estimate the winds momentum ratio, re-estimate the mass loss rates of both components and finally derive the energy distribution of the accelerated electrons.

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DISCUSSION

M. De Becker: *You have shown interesting intensity images of the synchrotron radiation associated to colliding winds in massive binaries. I am looking forward to see the results of future observations of colliding wind binaries with interferometric instruments working in the near infrared, but able to produce images, like the next generation instruments for the VLTI such as VSI. This is important because near infrared is a good density tracer, so it can be used as a proxy for the matter distribution in the wind-wind interaction region. However, synchrotron radiation is not a tracer of density, as it depends on a lot of parameters, including the distribution of the magnetic field and the distribution of the properties of the relativistic particles. It would be interesting to see how such IR intensity maps would compare to those you have shown in the radio domain.*

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