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WSRT 21-cm continuum field in Cygnus OB2: in search of more Wolf-Rayet stars*

Diah Y.A. Setia Gunawan[1,2], Karel A. van der Hucht[2], A. Ger de Bruyn[1,3], and Peredur M. Williams[4]

[1]*Kapteyn Astronomical Institute, RU Groningen, the Netherlands*
[2]*Space Research Organization Netherlands, Utrecht, the Netherlands*
[3]*Netherlands Foundation for Research in Astronomy, Dwingeloo, the Netherlands*
[4]*Royal Observatory, Edinburgh, United Kingdom*

Abstract. We present a deep look into the Cygnus OB2 region using the *WSRT*. A $2° \times 2°$ map of the optically highly-obscured region was obtained at 1400 MHz, with a noise level down to 0.2 mJy and an angular resolution of $1''$. We will compare the resulting radio point source list with optical and near-IR catalogues, in order to identify stellar wind sources like WR and OB stars.

1. Introduction

The direction towards the Cygnus OB2 association is known to have strong and varying extinction ($E_{B-V} \simeq 1.4$–2.3). WR 146 (WC6) has a visual extinction of A_v=9.5, while WR 147 (WN8) has A_v=12.6. Placing them at the 1.7 kpc distance of the Cyg OB2 association would make these WR stars too luminous. Similarly, placed at the distance of Cyg OB2, Cyg OB2 #12 would have $M_v = -10$ and $M_{bol} = -11$ which would make it one of the most luminous objects in the Galaxy. However, this star may be a foreground object like WR 146 and WR 147: recently accepted distances for WR 146 and WR 147 (1.2 kpc and 0.63 kpc, respectively) bring their X-ray, optical and IR luminosities closer to those of other WR stars of their respective subclasses. Recent studies also show both WR 146 and WR 147 to be WR+OB binary systems with colliding stellar winds, generating excess non-thermal radio fluxes (Dougherty *et al.* 1996; Williams *et al.* 1997; Niemela *et al.* 1998), and making them bright radio stars.

In our 21-cm *WSRT* observations of the WR 146 field, we note a number of additional point sources which are not present in, *e.g.*, *DSS* and *IRAS* maps of the same area. Comparison with our 6-cm maps indicates inverted spectral indices, suggesting a galactic (thermal) origin of those possibly stellar wind sources like OB and WR stars.

Encouraged by those examples, we have started a project to search for more of such point sources in the line-of-sight to the Cyg OB2 association, which is veiled by the thick IS clouds. At radio wavelengths one can see through the huge

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and varying extinction, and expose sources which are more difficult to discover at optical and infrared wavelengths. Therefore, we have mapped the Cyg OB2 region at 21-cm continuum with the *WSRT*.

2. Observations and data reduction

Our mosaic observation, a $2^\circ \times 2^\circ$ field centered at $\alpha(1950) = 20^h 31^m 17^s.30$ and $\delta(1950) = 40^\circ\, 39'\, 0''$, was divided into 6×6 pointings with a grid of about 0.4 degrees. The *WSRT* East-West-array of 14 antennas, with a maximum baseline of 2.8 km, observed each grid point cyclically with an integration time of 50 seconds. The total observing time was 6×12 hours spanning two observing periods: 2×12^h in 1996 and 4×12^h in 1997. The continuum back-end used had a frequency bandwidth of 1360-1420 MHz.

The reduction was carried out using the *WSRT*-NEWSTAR reduction package. The data were first calibrated for antenna corrections using standard calibrators observed directly before and after each 12^h run. Thereafter, they were SELF-CAL-ed. The resulting maps, with a $13'' \times 19''$ beam, were subsequently CLEAN-ed and the restored maps were combined into one mosaic. The noise level across the map is 0.2–0.6 mJy per beam, allowing us to detect 2 mJy sources at a 5σ level.

3. Preliminary result and future work

We have made use of the SIMBAD data base to identify the point sources in the field. Several point sources remain unidentified. Comparison with the *WSRT* 92-cm survey including the same field (Vasisht & de Bruyn, unpublished) and 6-cm observations would yield the spectral indices α ($S_\nu \propto \nu^\alpha$) of these sources. WR stars are expected to have thermal spectral indices, $\alpha \simeq 0.6$–0.8. At the distance of Cyg OB2, new WR stars would be rather weak sources, but less weak if they are foreground objects. In addition, if they are non-thermal colliding wind sources like WR 146 ($\alpha_{6-21} \simeq -0.7$) and WR 147 ($\alpha_{6-21} \simeq -1$), they could be relatively bright radio stars.

Follow-up deep optical and infrared photometry and spectroscopy has to determine interstellar extinction and distance towards the individual point sources and thus to assess their classification and luminosity properly.

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