

Non-thermal radio emission from Wolf-Rayet stars

Jessica M. Chapman^{1,2}, Claus Leitherer³, and Bärbel Koribalski²

¹*Anglo-Australian Observatory,
 PO Box 296, Epping, NSW 2121, Australia*

²*Australia Telescope National Facility,
 PO Box 76, Epping, NSW 2121, Australia*

³*Space Telescope Science Institute,
 3700 San Martin Drive, Baltimore, MD 21218, USA*

We have used the *Australia Telescope Compact Array* to search for radio continuum emission at λ 3, 6, 13 and 20 cm from a distance-limited sample of 36 southern Wolf-Rayet stars within 3 kpc of the Sun. The observations were taken between 1994 and 1997. Radio continuum emission has been detected from 16 sources at 3 cm. Of these 11 sources were detected at 6 cm, seven sources were detected at 13 cm and 2 sources were detected at 20 cm (Chapman *et al.* 1999).

From the *ATCA* data we have identified six WR stars, WR 14, WR 39, WR 48, WR 90, WR 105 and WR 112 which have non-thermal radio continuum emission. From the detection rate we estimate that *at least* 40 % of the WR stars have non-thermal emission at cm wavelengths. Table 1 lists the six non-thermal sources. Columns 1 and 2 gives the source identifications and spectral types. Column 3 gives the best available distances. Columns 4 and 5 give the radio spectral indices and the wavelength ranges for which the indices have been calculated. Column 6 gives their 5 GHz radio luminosities.

Table 1. Wolf Rayet stars with confirmed non-thermal radio emission

WR	spectral type	d (kpc)	α	λ (cm)	$L_{5\text{ GHz}}$ ($10^{19}\text{ erg s}^{-1}\text{ Hz}^{-1}$)
14	WC7	2.9	-1.0	3-6	0.5
39	WC7+WC7	5.7	0.0	3-20	3.4
48	WC6+O9.5	2.4	-0.4	3-13	1.4
90	WC7	2.0	0.0	3-6	0.5
105	WN8	1.6	-0.3	3-6	1.4
112	WC9	1.2	< 0	3-20	<0.1

In all cases the non-thermal radio emission almost certainly originates from an interaction between the WR stellar wind with the wind from a massive companion star. The radio luminosities and spectral indices are in good agreement with theoretical models where synchrotron emission is generated from relativistic electrons which are accelerated in strong shocks (Eichler & Usov 1993). For WR 90, WR 105 and WR 112 no binary companions have been identified. However the

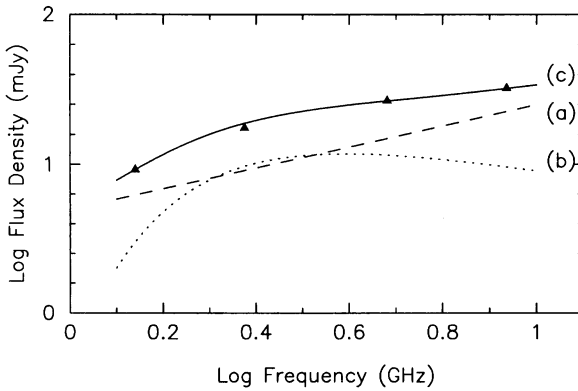


Figure 1. Model spectra for WR 11 (γ^2 Velorum, WC8+O9I)

radio emission is variable on a timescale of years indicating that orbital motions are likely. The radio variability is likely to be due to a variable amount of absorption through the ionized winds of the WR stars. WR 14 may also have a binary companion, indicated by variability in optical polarisation data (Drissen *et al.* 1992).

WR 39 is of particular interest as it is the first known example of a possible wind-wind interaction occurring between two WR stars. We propose that the non-thermal emission occurs from an interaction with the wind of the WR star WR38B which is offset by approximately $3''$. The small angular separation between the two stars and similarities in their optical spectra show that they are likely to have been formed as a pair (Shara *et al.* 1991).

Another source of interest is WR 11 (γ^2 Velorum) which has an O9 companion star with an orbital period of 78.53 days. The spectral index of WR 11 decreases with frequency between 1.4 and 8.6 GHz. This is interpreted as evidence for a strongly attenuated non-thermal component to the observed emission. This is illustrated by the model shown in Fig. 1. The dashed line (a) shows the thermal emission from an ionized wind with a spectral index of +0.7. The dotted line (b) shows non-thermal emission with a spectral index of -0.5 which is attenuated by free-free absorption. The solid line shows the sum of the two components. The triangles show the measured ATCA flux densities which were used to determine the model parameters.

References

- Chapman, J.M., Leitherer, C., Koribalski, B., Bouter, R., Storey, M. 1999 ApJ in press
 Drissen, L., Robert, C., Moffat, A.F.J. 1992, ApJ 386, 288
 Eichler, D., Usov, V. 1993, ApJ 402, 271
 Shara, M.M., Moffat, A.F.J., Smith, L.F., Potter, M. 1991, AJ 102, 716