Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies
Proceedings IAU Symposium No. 193, ©1999 IAU
K.A. van der Hucht, G. Koenigsberger & P.R.J. Eenens, eds.

Radio light-curve for WR 146 (HM19-3, WC6+O8.5), a colliding wind binary*

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

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

Abstract. We report preliminary results of monitoring the flux from the Wolf-Rayet object WR 146 with the *Westerbork Synthesis Radio Telescope* at 21 cm since 1989. We find the average flux density slowly rising in the period 1989–1997, with evidence of shorter time-scale variability.

WR 146 (HM19-3, WC6+O8.5) is the brightest among the radio WR stars. With *WSRT* data, van der Hucht *et al.* (1995) and Setia Gunawan *et al.* (1996) showed the flux density of WR 146 to be varying at both 6 cm and 21 cm, with a time-averaged spectral index $\alpha_{6-21\text{cm}} \approx -0.7$, in accordance with $\alpha_{6-18\text{cm}} = -0.6$ found from *MERLIN* data (Dougherty *et al.* 1996). The spectral indices clearly point to a non-thermal source, since, in practice, $\alpha \approx +0.8$ is expected from a free-free stellar wind (see *e.g.*, Williams 1996). A *MERLIN* 6-cm image of WR 146 (Dougherty *et al.* (1996) resolved the system in two components: a bright non-thermal northern and a weaker thermal southern component separated by 116 ± 14 mas.

We have been monitoring the system with the *WSRT* since 1989 at 21 cm. The radio components of WR 146 resolved by *MERLIN* can not be resolved by the *WSRT* and thus we observed the total flux densities of the system. Some of the data were obtained in full 12-hr observing runs, but most of them in filler time of a few hours. The reduction of the data, which includes calibration and mapping, was carried out with the *WSRT*-NEWSTAR software package. The data were flux-calibrated with one of the major calibrators, observed immediately before and/or after WR 146. Some of them were combined to make an as complete as possible 4×12^h map, which was subsequently CLEAN-ed. From this map we obtained a model of the field, which includes discrete and extended sources. We used a least-squares technique to fit the model to the observed visibilities, using the NEWSTAR-UPDATE procedure.

We plot the flux densities obtained with UPDATE as a function of time in Fig. 1. The error bars are a combination of the thermal noise and the error

*Based on observations made with the *Westerbork Synthesis Radio Telescope*. The *WSRT* is operated by the Netherlands Foundation for Research in Astronomy (NFRA) which is financially supported by the Netherlands Organization for Scientific Research (NWO).

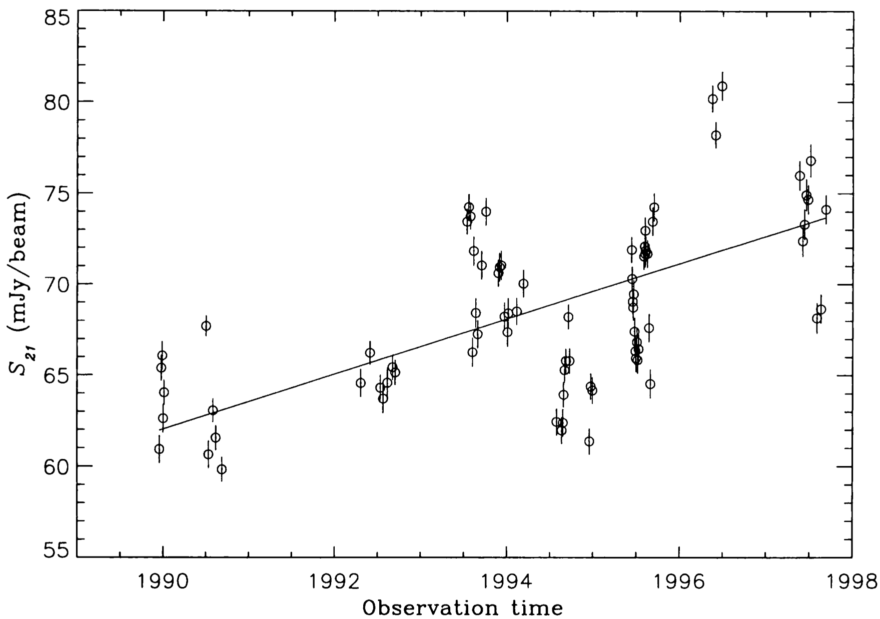

Figure 1. *WSRT* 21-cm monitoring of WR 146

introduced by using different calibrators (less than 1.5% of the flux density). The thermal noise for a typical 2^h filler observation of the galactic plane area is about 0.25 mJy.

It is evident that there are variations on time-scales of weeks to years, of up to ± 8 mJy, superimposed on a slowly rising flux density from ~ 62 mJy to ~ 73 mJy over the period 1989–1997. We show a linear model fitted to the light-curve, using the robust least-squares absolute deviation method. A full analysis of the WR 146 21-cm light-curve will be submitted shortly to A&A.

References

Dougherty, S.M., Williams, P.M., van der Hucht, K.A., Bode, M.F., Davis, R.J. 1996, MNRAS 280, 963

van der Hucht, K.A., Williams, P.M., Spoelstra, T.A.Th., Swaanenvelt, J.P. 1995, in: K.A. van der Hucht & P.M. Williams (eds.), Wolf-Rayet Stars, Binaries, Colliding Winds, Evolution, Proc. IAU Symp. No. 163 (Dordrecht: Kluwer), p. 559

Setia Gunawan, D.Y.A., van der Hucht, K.A., de Bruyn, A.G., Williams, P.M. 1996, in: J.-M. Vreux, A. Detal, D. Fraipont-Caro, E. Gosset & G. Rauw (eds.), Wolf-Rayet Stars in the Framework of Stellar Evolution, *Proc. 33rd Liège Int. Astroph. Coll.* (Liège: Univ. of Liège), p. 327

Williams, P.M. 1996, in: A.R. Taylor & J.M. Paredes (eds.), Radio Emission from the Stars and the Sun, ASP-CS 93, 15