Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies
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A high resolution H I study of the ISM local to WR 132 and WR 140

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Abstract. The neutral matter distribution from the interstellar medium located in the vicinity of the galactic WR stars WR 132 and WR 140 has been examined by means of the H I 21-cm line observations obtained with high angular resolution observations. The most interesting discoveries are the presence of huge ovoidal H I minimum spanning the velocity range +13 to +21 $\mathrm{km\,s^{-1}}$ (WR 132) and –18 to –7 $\mathrm{km\,s^{-1}}$ (WR 140). These minima were created, very likely, by the joint action of the progenitor of both WR stars and the WR star itself. Inside each cavity, two minima are clearly discernible. The WR star is offset with respect to either the geometrical centre of the main H I void or the inner H I minima. The dual H I minimum geometry observed inside the main H I cavity, a feature also seen in the H I distribution of the ISM located close to other galactic WR stars, may be a consequence of the interaction process itself.

1. Introduction

Wolf-Rayet stars, believed to be descendants of massive stars (van der Hucht 1992) have a high mass-loss rate ($\dot{M} = 2\text{–}5 \times 10^{-5}\,\mathrm{M_\odot\,yr^{-1}}$) and a high wind terminal velocity ($v_\infty = 1650\text{–}3500\,\mathrm{km\,s^{-1}}$) , and radiate an enormous amount of Lyman continuum photons ($N_{\rm Lyc} \simeq 1.7 \times 10^{48}\,\mathrm{s^{-1}}$ for a WN4 star: Barlow *et al.* 1981). As a result of the *combined* action of copious Lyman continuum emission and high mass-loss rates, massive stars have a significant impact on their environments, and play a significant role in defining its topology and evolution.

After the pioneering work by Avedisova (1972) and Dyson & de Vries (1972), several theoretical groups have modelled the interaction of a strong stellar wind with its surrounding ISM (see Koo & McKee 1992 and references therein). These models predict the creation around the massive star of a highly evacuated cavity ($n \simeq 10^{-2,-3}\,\mathrm{cm^{-3}}$) and hot ($T \simeq 10^{6-7}\,\mathrm{K}$) region surrounded by an expanding outer shell. This shell may be fully ionized by the Lyman continuum stellar flux but, if the ionization front gets trapped within it, its outer portions may recombine and eventually *become observable* in the line radiation emitted by atoms and/or molecules. This overall structure is usually referred to as an *interstellar bubble* (IB).

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Since a given IB is characterized by a quite low volume density, when observed in 21-cm H I line radiation, its *fingerprint* should be a *cavity* in the observed H I distribution. This cavity should be visible in the velocity range centred at *a radial velocity that is characteristic of the ISM local to the WR star.*

In this paper we would like to report on 21-cm high angular-resolution line observations of a $\sim 2^\circ$ field centred at the optical position of the stars WR 132 (HD 190002) and WR 140 (HD 193793). The observations were carried out with the *DRAO* interferometer.

2. Parameters derived from the H I observations

In order to investigate the presence of cavities and/or shells possibly related to WR stars, the entire data cube ($\mathbf{T}_b(l,b,v)$) of the observed brightness temperature distribution was used to construct a series of *position vs position (l,b)* maps at constant radial velocity, showing the overall H I emission distribution. Under the assumption that a WR star will inexorably alter its local ISM, the main results of our study are the following:

(a) The presence of a large ovoid H I minimum close to the optical position of each of the stars was detected. This minimum spans the velocity range $+11 \leq v \leq +23\,\mathrm{km\,s^{-1}}$ towards WR 132, and $-7 \leq v \leq -18\,\mathrm{km\,s^{-1}}$ towards WR 140, respectively;

(b) inside the main H I cavity, two minima are clearly apparent. A similar structure has already been noticed for the IB related to WR 3 (Arnal & Roger 1997) and WR 6 (Arnal & Cappa 1996);

(c) the location of both stars is offset from both the symmetry centre of the main H I cavity and the central position of the inner H I minima;

d) as in the cases of WR 3 and WR 6, no early type stars other than WR 132 and WR 140 (and their progenitors!) seem to have played a role in creating the observed H I distribution. Thus, the double-lobe minimum feature structure observed inside the main cavity may be a characteristic intrinsic to the interaction process between the stellar wind of a massive star and its local ISM; and

e) the shape and main features observed inside the H I depression cannot be explained with the standard hydrodynamic IB theory, even by relaxing the assumptions of isotropic stellar wind and homogeneous ISM.

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