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The ISM around WR Stars: WR 152 and WR 153ab

C. E. Cappa,[1,2] J. Vasquez,[2] E. M. Arnal,[1,2] S. Cichowolski,[3,4] and S. Pineault[4]

[1]*Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina*
[2]*Instituto Argentino de Radioastronomía, C.C. 5, 1894 Villa Elisa, Argentina*
[3]*Instituto de Astronomía y Física del Espacio, Argentina*
[4]*Université Laval, Québec, Canada*

Abstract. We analyze the distribution of interstellar matter in the environs of the WR stars WR 152 and WR 153ab, associated with two different ring nebulae in the H II region Sh2-132. We have detected the radio continuum and infrared counterparts of the inner and outer ionized shells related to WR 152. An H I interstellar bubble was also identified surrounding the outer shell. As for WR 153ab, dust and molecular gas was found to be associated with its ring nebula. The emission in MSX band A suggests the presence of a photodissociation region at the interface between the ionized and molecular material.

1. Introduction and Data Sets

With mass loss rates of about 10^{-5} $M_{\odot}\mathrm{yr}^{-1}$ and terminal velocities in the range 1000-3000 $\mathrm{km\,s^{-1}}$Cappa et al. (2004), stellar winds from Wolf-Rayet (WR) stars transfer large amounts of mechanical energy and momentum to the interstellar medium creating hot and rarified regions bounded by outer expanding envelopes. These structures, known as *interstellar bubbles*, can be detected as optical ring shaped nebulae, as shell shaped thermal radio continuum sources, as neutral gas voids and expanding shells in the H I 21 cm line emission distribution and as infrared shells (Cappa 2006).

Here, we analyze the distribution of the interstellar gas and dust in the environs of WR 152 (= HD 211564) van der Hucht (2001) and WR 153 (= HD 211853) , related to the H II region Sh2-132. The WR stars are probable members of Cep OB1. We adopted a distance $d = 3.0$ kpc for both stars (Nugis & Lamers 2000, van der Hucht 2001).

To accomplish this project we have used radio continuum images at 408 and 1420 MHz and H I 21cm-line data from the Canadian Galactic Plane Survey (CGPS), obtained with the Synthesis Telescope of the DRAO, in Canada. The synthesized beams are $3\farcm4$ and $1\farcm0$ at 408 and 1420 MHz, respectively. CO(1-0) line data were obtained from the FCRAO, in the USA, with an angular resolution of about $1\farcm0$. Additional images in the four IRAS bands (with angular resolution $\leq 2\farcm0$) and MSX images (angular resolution = $18\farcs3$) were obtained from IPAC.

2. The Ring Nebula around WR 152

The ring nebula around the star displays a filamentary inner shell of about $17'$ in diameter and a diffuse outer shell of $36'$ in size. Both shells are clearly identifiable at 1420 MHz and are thermal in nature. From the image at 1420 MHz, and adopting a filling factor $f = 0.2$, we derived an electron density and an ionized mass of 16 cm^{-3} and 290 $M_\odot$, respectively, for the inner shell. The corresponding values for the outer nebula are 15 cm^{-3} and 400 $M_\odot$. The large amount of ionized material indicates that the nebula consists mainly of interstellar gas. The ring nebula is detected at 60 and 100 μm. The estimated dust color temperature and dust mass are 25 K and 5 $M_\odot$, respectively.

H I gas having LSR velocities in the range –65 to –45 km s^{-1} delineates the outer ionized shell towards the galactic plane and higher galactic longitudes. Including 10% He abundance, the related neutral atomic gas mass is 310 $M_\odot$.

3. The Ring Nebula around WR 153ab

WR 153ab is buried in the brightest section of the H II region Sh2-132 of about $20'$ in diameter. The LSR velocity of the ionized gas is about –48 km s^{-1}(Esteban & Rosado 1995).

The image at 1420 MHz shows a radio continuum semicircular shell of $4'\times9'$ in diameter, first identified by Harten et al. (1978). Adopting a filling factor $f = 0.2$, we derived an electron density of 65 cm^{-3} and an ionized mass of 100 $M_\odot$. These values are compatible with previous determinations. The IR emission at 60 and 100 μm shows a shell structure in the environs of the WR star. The derived dust color temperature is 25 K. The CO emission distribution within the velocity interval –45 to –39 km s^{-1}closely matches the brightest radio continuum regions. The associated molecular mass amounts to 1800 $M_\odot$.

The emission in MSX band A (which shows emission from PAHs) delineates the bright optical and radio continuum emission region. The comparison of the ionized and molecular gas distributions with that of the PAHs marks the location of a photodissociation region at the interface between the ionized and molecular material.

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