A Massive Star Odyssey, from Main Sequence to Supernova
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Molecular Gas Around the Wolf-Rayet Star WR18

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Abstract. Optically observed ring nebulae and HI cavities around Wolf-Rayet (WR) stars have enabled us to obtain information on the history of mass-loss associated with these massive evolved stars. However, such studies have left a number of unanswered questions regarding the amount of mass-loss and the conditions of the stars during a sequence of mass-loss phases. Here we discuss the molecular gas environments of the Wolf-Rayet star WR18, which has an associated optical ring nebula NGC3199. Our observations show that significant amounts of molecular gas appear close to and associated with the star. Mapping of molecular CO near the star shows that molecular materials appear to substantially avoid areas of optical emission and, instead, form a distorted clumpy shell interior to NGC3199. Molecular emission lines are broader than lines seen in the interstellar medium and suggest the shell is composed of ejecta. This is further corroborated by the enhanced abundances of molecules containing C, N and O. Implications of the observations for the evolution of WR18 are discussed.

1. Introduction

WR18 (HD89358) is a WN4 star that shows no signs of binarity. It is situated near the projected center of an optically bright ring nebula arc, NGC3199. The main portion of the ring nebula is situated approximately $5'$ to the west of the star. On a larger scale, NGC3199 appears to be associated with a large ($>20'$ across) kidney-shaped shell, visible with HIRES IRAS images. Both HIPPARCOS and Tycho data indicate that the star is moving to the north west at around 5mas/yr. For a distance of 2.2kpc (van der Hucht 2001) this equates to a tangential velocity of 60kms^{-1}.

As part of a continuing investigation of the gaseous environment of Wolf-Rayet stars, we have mapped the surroundings of WR18 in the ^{12}CO J=1$\rightarrow$0 emission line and searched for further molecular emission-line species in the direction of WR18. Earlier observations of the region, including the area of NGC3199 were reported in Marston (2001).

2. Observations

The molecular emission-line observations were made at the Swedish-ESO Submillimeter Telescope (SEST), La Silla, Chile, in April 2000. An undersampled map with pointings every $1'$ in RA and Dec was obtained for the emission-lines

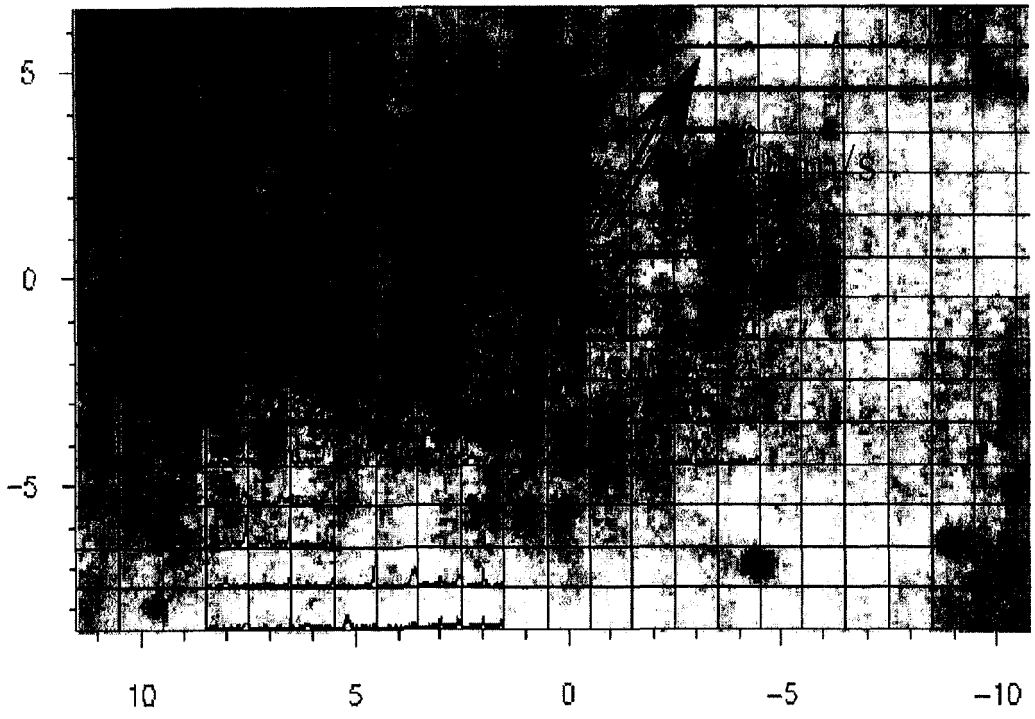

Figure 1. Grid of ^{12}CO J=1→0 emission-line profiles overlaid on the MSX 8.28μm image of the WR18 region. The velocity range of the profiles is -12 to +12 kms^{-1} (LSR). The proper motion of WR18 is shown. Distance of the profiles from WR18 is given in arc minutes along each edge of the figure.

of ^{12}CO J=1→0 and ^{12}CO J=2→1 (beam sizes of 45″ and 23″ respectively). The emisison-lines of HCN, HNC, HCO$^+$ and CN were also observed. A grid of the profiles obtained is shown as an overlay on the MSX 8.28μm image in Fig.1. Profiles of the other observed emission-lines are presented in Marston (2001).

3. Discussion

WR18 appears to lie on the edge of a slowly expanding, ~5kms^{-1}, cocoon of clumpy molecular material that is approximately 5′ across. The existence of HCN emission suggests high densities (>10^{4}cm^{-3}). Abundances of HCN and CN are substantially higher than the interstellar medium and suggest processed material, probably from the surface of the star, is in the molecular gas. The most likely origin of this material is a slow, cool wind phase in an earlier evolutionary phase of the star such as a red supergiant.

4. References

Marston, A. P., 2001, ApJ 563, 875.
van der Hucht, K. A., 2001, New Astronomy Reviews 45, 135.