A Massive Star Odyssey, from Main Sequence to Supernova
Proceedings IAU Symposium No. 212, © 2003 IAU
K.A. van der Hucht, A. Herrero & C. Esteban, eds.

Shocked CO and ^{13}CO around Wolf-Rayet ring nebulae

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Abstract. We show CO and ^{13}CO maps toward the WR nebulae NGC 2359, NGC 6888 and Anon (WR 134). We determine global parameters and discuss the probable origin of this gas. Nowadays it is becoming clear that molecule formation and survival is be possible around massive evolved stars.

1. Background

Ring nebulae are the most evident sign of the interaction of massive star evolution with its surroundings. A deep knowledge of the physical state and chemical composition of these objects is of great interest, because they are the typical sites where SN explosions occur, and because they might contain clues about the dominant processes during star evolution.

In recent years, a few authors have detected and studied the molecular gas around WR nebulae, both in H_2 (St-Louis *et al.* 1998) and in rotational CO lines (Marston *et al.* 1999; Rizzo *et al.* 2001a; Cappa *et al.* 2001). Recent discovery of warm and abundant NH_3 (Rizzo *et al.* 2001b) might indicate the presence of shocks as dominant signatures of the molecular gas affected by WR stars.

2. Observations and results

We have performed several maps of the CO (1 - 0), CO (2 - 1) and ^{13}CO lines, using the Kitt Peak 12m and the IRAM 30m radio telescopes. Figure 1 discloses some of the maps, overlaid with optical images of the nebulae.

Excitation studies show that there are high density (10^4 cm^{-3}) and rather hot (30 - 80 K) regions. The computed masses show that most of the gas has an interstellar origin, probably excited by shocks produced by the predecessors of the Wolf-Rayet. The kinematics shows velocity components of different line widths, and gives support to the idea of multiple shocks in the gas.

3. Prospects

It is becoming clear that molecules can survive in the surroundings of massive evolved stars. So far, these scenarios might contain complex molecules which will tell us about the role of the dominant processes (photo-ionization and shocks) in the interplay between massive stars and the ISM.

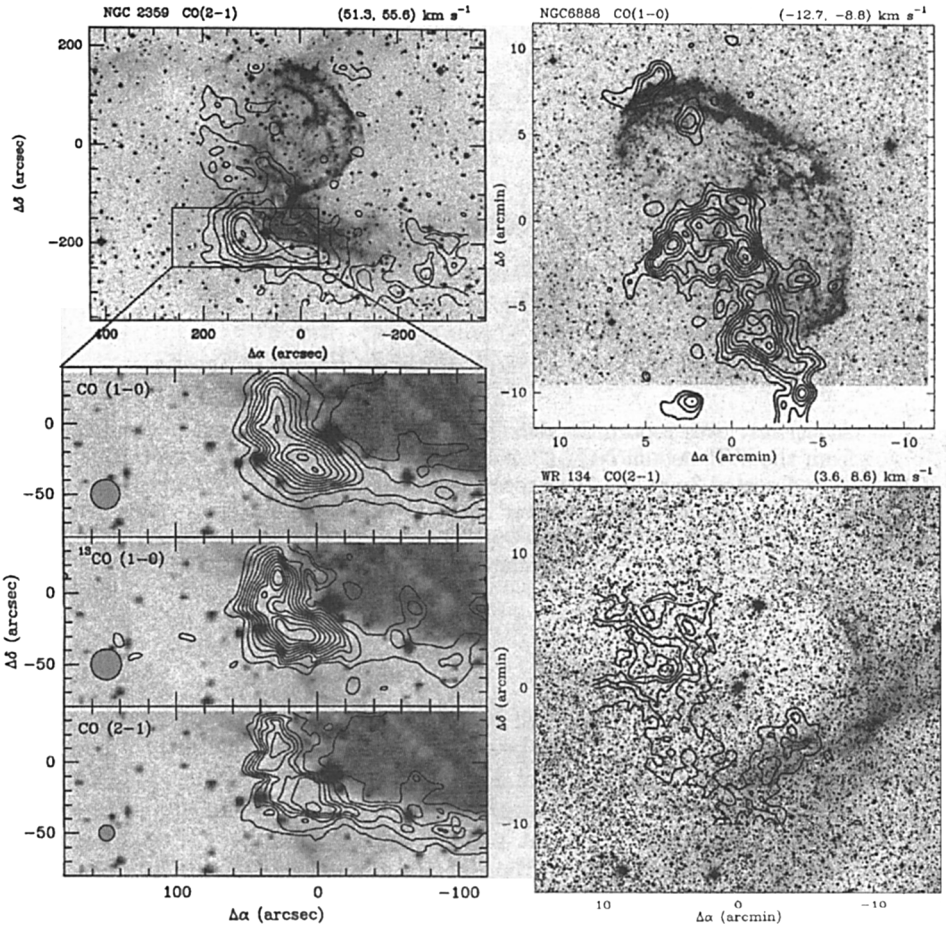

Figure 1. The CO and ^{13}CO distribution around the WR ring nebulae NGC 2359, NGC 6888 and Anon (WR 134). Molecular transitions and velocity intervals are indicated.

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https://doi.org/10.1017/S0074180900213302 Published online by Cambridge University Press