RevMexAA (Serie de Conferencias), **35**, 48–49 (2009)

THE MOLECULAR COMPLEX ASSOCIATED WITH RCW 121 AND RCW 122

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RESUMEN

Mediante el uso de datos de ^{12}CO obtenidos con el telescopio NANTEN, se estudia la distribución del gas molecular en una región que contiene al cúmulo abierto HM 1, a las estrellas Wolf-Rayet WR 87, WR 89, y WR 91, y a las regiones de formación estelar RCW 121 y RCW 122 con la finalidad de encontrar una posible conexión física entre los objetos mencionados. Adoptando una distancia de 5 kpc para RCW 121 y RCW 122, se ha encontrado que una nube molecular gigante (NMG) se encuentra asociada con las mismas. La dimensión de dicha estructura es de $\sim$100$\times$20 pc, posee una masa de 1.2×10^6 $M_\odot$, y sela detecta a una velocidad radial de -15 km s^{-1}.

ABSTRACT

The distribution of the molecular gas towards the region containing the open cluster HM 1, the Wolf-Rayet stars WR 87, WR 89, and WR 91, and the star forming regions RCW 121 and RCW 122 is analyzed with the aim of looking for a possible physical relationship among these objects. Using ^{12}CO observations carried out at λ $\sim$2.6 mm with the 4 m NANTEN radiotelescope, and adopting a distance of 5 kpc for RCW 121 and RCW 122, a giant molecular cloud (GMC) having a lineal extent of $\sim$100$\times$20 pc is found to be associated with these galactic star-forming regions. The total mass of this GMC is of the order of 1.2$\times$10^6 solar masses and its mean radial velocity is about -15 km s^{-1}.

Key Words: H II regions — ISM: clouds

1. INTRODUCTION

RCW 121 (l,b)=(348$^\circ\!\!.$24,−0$^\circ\!\!.$98) and RCW 122 (l,b)=(348$^\circ\!\!.$73,−1$^\circ\!\!.$04) were first noticed in the catalogue of Hα-emission regions in the Southern Milky Way (Rodgers et al. 1960). Both sources are almost point-like strong thermal continuum sources (Shaver & Goss 1970), with strong infrared counterparts (Ghosh et al. 1989).

About 20$'$ northwards of RCW 122 the open cluster Havlen-Moffat 1 (hereafter HM 1) is located. This cluster harbours a very compact group of O_f stars (Sanduleak 1974) and is placed at a distance of 2900 pc (Mermilliod 1999). The Wolf-Rayet (WR) stars WR 87 and WR 89 are members of this cluster (van der Hucht 2001). Another WR star present in this area is WR 91. This star does not belong to HM 1 and is seen projected onto RCW 122.

Radio recombination line observations of RCW 122 and RCW 121 (e.g., Caswell & Haynes 1987) and observations of several molecular line transitions in both sources indicate that the ionized and the molecular gas has a radial velocity of about −12 to −13 km s^{-1} (RCW 122) and about −18 km s^{-1} (RCW 121), respectively. All radial velocities are quoted with respect to the LSR.

Gillespie et al. (1979) surveyed at (CO(J=1→0) an area of 0.5 square degrees towards RCW 122. They found a peak of CO emission coincident with the radio continuum peak of RCW 122 as observed by Shaver & Goss (1970).

The distance to RCW 121 and RCW 122 is a matter of some debate (see Walsh et al. 1997; Radhakrishnan et al. 1972). In this paper we shall adopt the distance of 5 kpc derived by Radhakrishnan et al. (1972).

In this paper we present the results of a large scale CO study aimed at finding the characteristics of the molecular gas associated with RCW 122 and RCW 121.

2. DATABASES

This research was carried out using ^{12}CO (J=1→0) data obtained with the 4 m NANTEN telescope. The half-power beamwidth and the system temperature, including the atmospheric contribution towards the zenith, were 2$'\!\!.$6 and $\sim$ 220 K (SSB) at 115 GHz, respectively. The data were gathered using the position switching mode, with a velocity resolu-

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tion of ~ 0.055 km s^{-1}. The data were calibrated in intensity by observing Orion KL and ρ Oph East.

The CO observations covered a region ($\triangle l \times \triangle b$) of 101$'$.5 × 79$'$.8 centred at (l,b)=(348°.625, −1°.115). An inner area of 31$'$.2 × 32$'$.4 centred at (l,b)=(348°.76, −1°.06) was sampled one beam apart, while the remaining area was sampled every 5$'$.4 (two beamwidth). The typical rms noise per point is ∼0.3 K.

3. OBSERVATIONAL RESULTS

Our results show a striking correlation among the infrared counterparts of RCW 121, RCW 122 and the CO distribution, in the sense that each major IR feature has its own CO counterpart. A southern extension of RCW 122 at 8.1 μm is closely delineated by a CO feature that potrudes from the main body of CO emission observed towards RCW 122.

The CO features mentioned above are projected onto a much more extended CO structure that has a low level of emission. From here onwards, this structure will be referred to as the *plateau.* The deconvolved cloud size (to the 6.3 K level) of the CO structure related to RCW 121 is ∼ 0°.3 × 0°.16. For RCW 122 (to the 7.0 K level) the CO features have an angular size of ∼0°.34 × 0°.34.

The mass of the molecular gas traced by CO can be estimated using the empirical relationship between the molecular hydrogen column density, N(H_2), and the integrated molecular emission, W(CO)($\equiv \int T_R^*$ dv), over a given velocity range, given by Murphy & May (1991). The mass of the molecular concentration, M(H_2), was calculated by using the equation

$$M(H_2) = \mu m_H \sum \Omega N(H_2) d^2 (M_\odot)\,, \qquad (1)$$

where μ is the mean molecular weight, assumed to be equal to 2.76 after allowance of a relative helium abundance of 25% by mass, m_H is the hydrogen atom mass, Ω is the solid angle subtended by the CO feature, and d is its distance, expressed in kpc. The summation was performed over those pixels having a $T_R^* \geq 7.0$ K for RCW 122, and $T_R^* \geq 6.3$ K for RCW 121.

4. CONCLUSIONS

The ^{12}CO molecular gas distribution within a square region 1°.47 × 1°.45 in size centred at (l,b)=(348°.52, −1°.055) has been analyzed to investigate the relationship among the Wolf-Rayet stars WR 87, WR 89, WR 91, the open cluster HM 1 and the star forming regions RCW 122 and RCW 121.

Relying on the morphological correlation between the infrared emission depicted by the MSX Band A image and the CO molecular emission in the velocity range from −18 to −5 km s^{-1}, a giant molecular complex (GMC) is revealed for the first time associated with the star forming regions RCW 121 and RCW 122. Adopting a distance of 5 kpc, the GMC has a mean lineal size ($\triangle l \times \triangle b$) of $\sim 100 \times 20$ pc.

The total amount of molecular gas is $\sim 1.2 \times 10^6\ M_\odot$, and its mean volume molecular hydrogen density is about 120 cm^{-3}. In the same velocity range (−18 to −5 km s^{-1}) there is no noticeable CO emission towards the area where WR 87, WR 89 and HM 1 are located. This lack of CO emission north of the GMC associated with the three RCW star forming regions may imply that the northern part of the IR ring-like feature whose geometric centre falls in the vicinity of the stellar objects, is unrelated to the GMC.

Within the GMC, the regions RCW 122 and RCW 121 are related to well defined CO concentrations. The individual mass of these concentrations are from $2.2 \times 10^5\ M_\odot$ (RCW 122) to $\sim 5.7 \times 10^4\ M_\odot$ (RCW 121). The lineal dimensions of these concentrations range from 30×21 pc (RCW 122) to 25×14 pc (RCW 121).

Based on both the correlation between the IR emission and the CO distribution, and the similarity of the radial velocity among the three main molecular concentrations, it is concluded that RCW 121, RCW 122 (A & B), and RCW 122C are *different* star forming regions within the *same* molecular complex.

This work was partially supported by the Agencia Nacional de Promoción Científica y Tecnológica (ANPCyT) under project PICT 14018/03.

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