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Study of the interstellar medium towards RCW 103

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Abstract. RCW 103 is a shell type supernova remnant (SNR) that, according to near infrared observations, is interacting with a molecular cloud, specially to the south. In this paper we report on the study of the interstellar medium in an extended region towards RCW 103 based on HI λ 21 cm data acquired with the ATCA radiotelescope. Also, we report on the detection of HCO^+ and CO emission in the rotational transition J=1-0 associated with the remnant. These observations were carried out with the millimeter radiotelescope MOPRA (Autralia). Our results reveal the presence of a molecular cloud interacting with the remnant to the south. We also show that the action of the shock front is depleting the HCO^+.

Resumen. RCW 103 es un remanente de supernova (RSN) de tipo cáscara que, según observaciones en el rango infrarrojo cercano, estaría interactuando con el medio circundante, especialmente hacia el sur. En este trabajo se informa sobre el estudio del medio interestelar en una región extendida en dirección a RCW 103 analizando datos obtenidos con el radiotelescopio ATCA en la línea de λ 21 cm del HI. Además en el borde sur, se realizaron observaciones con el radiotelescopio milimétrico MOPRA (Australia) en las líneas J=1-0 del CO y del HCO^+. Nuestros resultados ponen en evidencia la presencia de una nube molecular interactuando con el remanente hacia el sur. Se muestra que el frente de choque está produciendo la destrucción del HCO^+.

1. Introduction

The dynamical interaction of supernova remnants (SNRs) with their surroundings can significantly alter the physical and chemical conditions of the interstellar medium. SNR shocks interacting with molecular clouds can heat and compress the gas causing substantial excitation of the molecules.
RCW 103 (G332.4-0.4) is a Galactic SNR that at radio wavelengths appears as an almost complete, circular, $8'$ diameter shell (Caswell et al. 1980). On the southern side, the remnant appears to be interacting with a molecular cloud, according to observations in the 2.122 μm line of the H_2 and other near infrared lines (Burton & Spyromilio 1993, Oliva et al. 1990).
In this paper we present CO J=1-0 and HCO^+ J=1-0 observations of nine points towards the southern side of RCW 103 and HI λ 21 cm observations of a $1°$ x $1°$ region around the SNR.

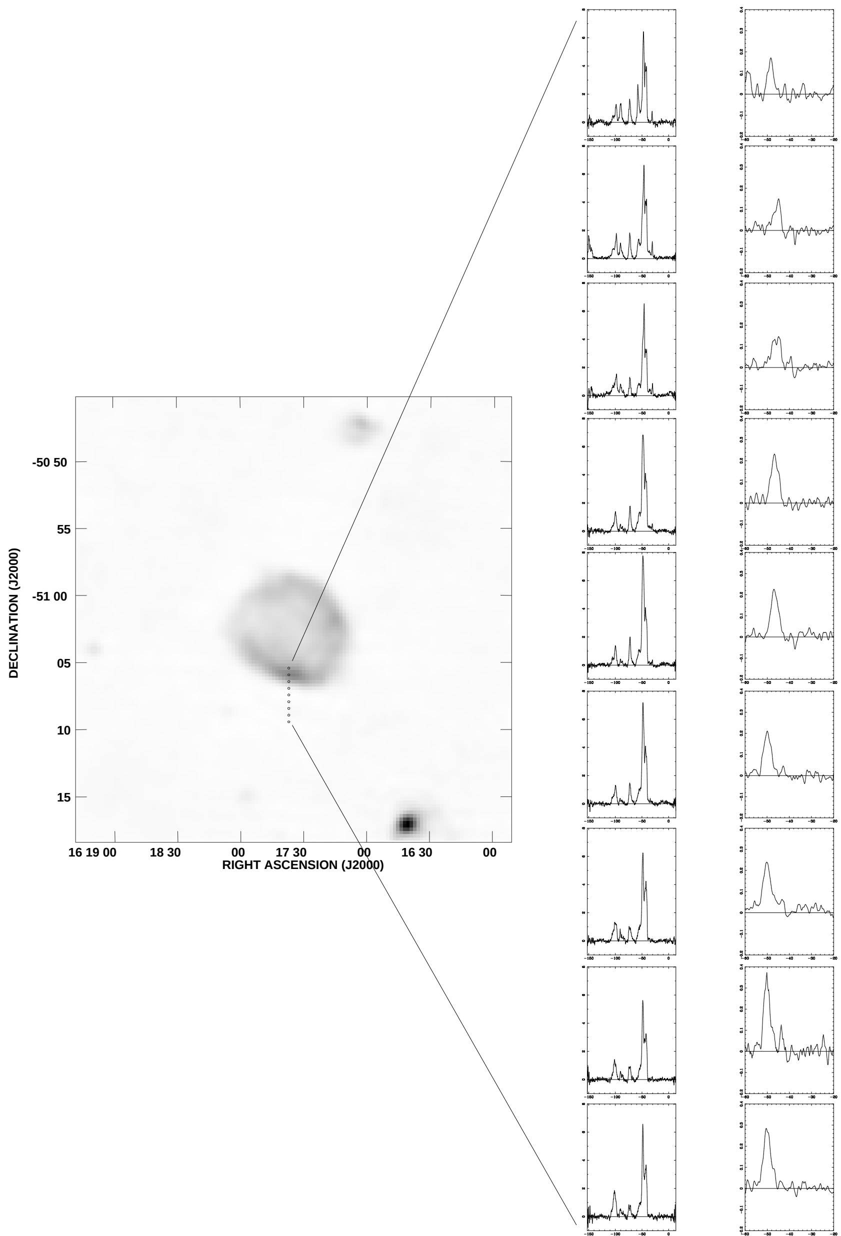

Figure 1. *Left:* Radio continuum emission of RCW 103 at 1.4 GHz. The nine points where the molecular transitions were observed are indicated. *Right:* CO (left column) and HCO^+ spectra (right column) in the J=1-0 transitions. The top spectra correspond to the inner observed points. The plotted velocity ranges are [-150 km s^{-1}, -10 km s^{-1}] for the CO profiles and [-60 km s^{-1}, -20 km s^{-1}] for the HCO^+. Temperature scales range between -1 and 8 K for CO and from -0.2 to 0.4 K for HCO^+.

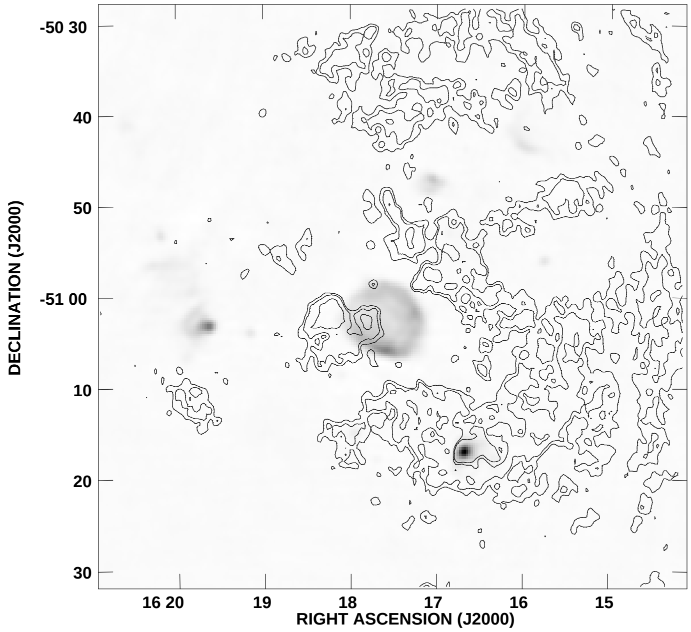

Figure 2. HI emission integrated between -52 and -43 km s^{-1} (contours) superimposed onto the radio continuum image (greyscale) of RCW 103 at 1.4 GHz. The HI levels are 850, 900 and 1000 K km s^{-1}.

2. Observations

The HI λ 21 cm observations were carried out with the Australia Telescope Compact Array towards a 1° x 1° region around RCW 103. The resolution is 50″. Single dish data from the Southern Galactic Plane Survey were added to recover the contribution from lower spatial frequencies.
The rotational transition J=1-0 of ^{12}CO (115.27 GHz) and HCO^{+} (89.18 GHz) were observed using the 22 meter telescope MOPRA (Australia) in July 2003. Nine points with constant Right Ascension (16^h 17^m 37.06^s) were observed towards the southern side of RCW 103 with resolutions of 25″ and 34″ respectively for each molecular transition. The pointings were made each 30″ in declination from δ=-51° 5′ 30″ to δ=-51° 9′ 30″ (J2000).

3. Results

A grayscale map of RCW 103 with the nine points observed in the molecular transitions is shown in Figure 1.
Also in Figure 1 we present the profiles in the J=1-0 transitions of CO and HCO^{+} respectively. Within the plotted velocity range, the CO profiles show three strong emission peaks at $\sim$ -43, -48 and -55 km s^{-1} and three weaker peaks at $\sim$ -70, -90 and -100 km s^{-1}, while the HCO^{+} emission presents only one peak at $\sim$ -48 km s^{-1} in coincidence with the most intense CO peak. All velocities are referred to the LSR. Oliva et al. (1990) detected shocked Fe II and

H_2 at $\sim$ -60 km s^{-1} using IR observations, however the poor spectral resolution at such wavelengths does not allow us to make a reliable comparison with our radio data.
The molecule HCO^+ is observed only between -52 and -43 km s^{-1}. Figure 2 displays the HI λ 21 cm emission integrated in this velocity range. This figure shows a shell of atomic gas open to the West of the SNR, and a structure presumably in contact with the remnant towards the East.

4. Discussion

These new observations have revealed that the velocities at which the HCO^+ emission is produced coincide with those of the most intense CO peaks. The HCO^+ intensity decreases towards the interior of the SNR shell (see the three upper HCO^+ profiles in Figure 1). This is a strong proof of the SNR/molecular cloud interaction. The observed molecule depletion is compatible with the shock model by Iglesias & Silk (1978).
Taking into account the velocities corresponding to the CO and HCO^+ peaks, we assigned to RCW 103 a systemic velocity of $\sim$ -48 km s^{-1}. Using the Galactic rotation model of Fich, Blitz and Stark (1989), we determined a distance of $\sim$ 3.3 kpc for the remnant. This distance is in agreement with that suggested by HI absorption measurements at 21 cm (Caswell et al. 1975, Reynoso et al. 2004).
The SNR radio continuum can be described as two bright lobes extending one of them from West to North and the other from West to South, being the remnant intensity lower to the East. This morphology coincides with that of the open HI shell (see Figure 2). However, the HI shell is not in contact with the SNR shock front. In particular on the southern side, where we have shown that a molecular cloud exists and is interacting with the SNR, we do not observe HI emission. We suggest that this is due to self absorption processes rather than to an absence of neutral gas. The same occurs in Tycho's SNR, where the HI emission decreases in regions where it has been shown that the shock front is encountering a denser medium (Reynoso el al. 1999, Lee, Koo & Tatematsu 2004).

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