HI AND CO OBSERVATIONS TOWARDS THE SNR PUPPIS A

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Abstract: The presence of interstellar clouds along the northern and eastern edges of Puppis A is revealed by our HI and CO observations.

Introduction:

The wealth of observational data in the X-ray, optical and radio domains available for Puppis A, can be understood as the result of the SN blast wave interacting with nearby clouds placed towards the northern and eastern directions (e.g. Petre et al. 1982, Milne et al. 1983, Danziger 1983, etc.).

Based on the previous data, the presence of clouds with n_{HI} = 10 to 14 cm^{-3} was postulated. However, up to now, no study of the gas distribution in the environs of the supernova has been undertaken in order to confirm this contention.

Here, we report HI and CO observations carried out in the direction of the Puppis A SNR. Our data disclose the presence of clouds along both the eastern and northern borders of the radio remnant. These features were also detected in the CO J:1-0 transition.

Observations and Results:

Neutral Hydrogen: The HI observations have been performed with the 30 m radiotelescope of the Instituto Argentino de Radioastronomia. The instrumental parameters are: Beam size: 30', velocity resolution: 2.1 km/s, system temperature: 85 K, rms noise: 0.1 K.

Figure 1 (left panel) displays the HI column density distribution (in units of 10^{19} cm^{-2}) for three different radial velocities (throughout this paper all radial velocities are referred to the LSR). THe lowest contour of the 408 MHz emission (Green 1971) is included in all the maps as a dashed line.

Carbon Monoxide: The CO data were obtained using the 1.2 m Columbia Southern Millimeter Wave Facility at Cerro Tololo (Chile), in two observing runs during 1985. The instrumental parameters can be summarized as follows:
Beam size: 8', velocity resolution: 0.2 km/s, system temperature: 195 K (excluding atmospherical radiation losses), rms noise: 0.2 K.

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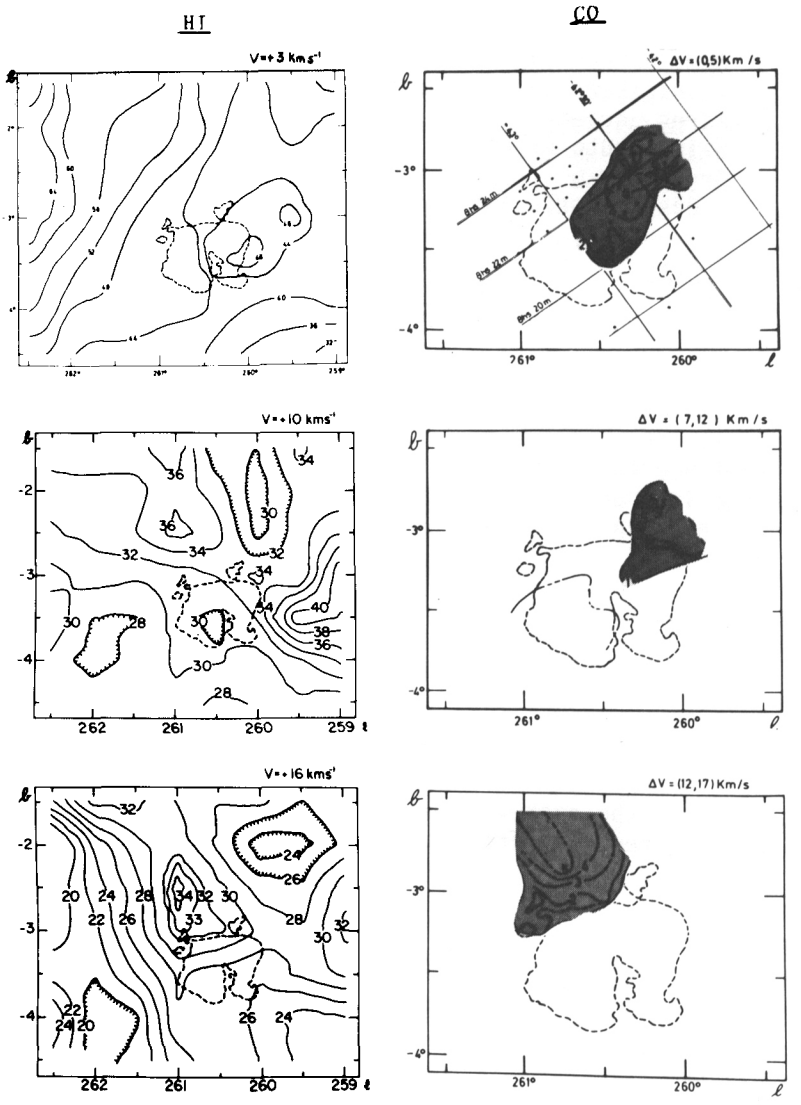

Figure 1: Contours of HI column density in units of 10^{19} cm^{-2} (left panels) and of CO integrated intensity over 5 km/s ranges in radial velocity (right panels).

The right panel of Figure 1, depicts the maps of CO integrated intensity, evaluated over the three velocity ranges (indicated in the upper right corner of each map) where the molecular emission is detected. The dots in the first map mark the observed positions, and a RA-DEC (1950) grid is also shown. Unfortunately, the CO features were only partially mapped due to a very tight observing schedule. As a consequence, only lower limits for the total masses can be derived.

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Table 1

	VELOCITY RANGE (km/s)	HI	CO
NORTHERN FEATURES	N1 (0-5)	$(l,b)_{CENT}$ = (259.7,-3.2) V_{CENT} ≅ 3 km/s M^*_{HI} = (747 ± 110) $M_\odot$ n_{HI} = (1.05 ± o.20)cm^{-3}	V_{CENT} =(3.2 ± 0.4) km/s V_{FWHM} = 1.2 to 2.6 km/s $N^{**}_{H_2}$(max)= 1.8 x 10^{21} m cm^{-2} M_{H_2} ⩾ 3810 $M_\odot$ n_{H_2} = 30 m cm^{-3}
	N2 (7-12)	$(l,b)_{CENT}$= (258.0,-2.0) V_{CENT} ≅ 10 km/s M_{HI} = (6170 ± 920) $M_\odot$ n_{HI} =(1.32 ±0.25) cm^{-3}	V_{CENT} =(10.0 ± 0.1) km/s V_{FWHM} =(2.5 ± 0.7) km/s N_{H_2}(max)= 7.8 x 10^{20} m cm^{-2} M_{H_2} ⩾ 2850 $M_\odot$ n_{H_2} = 12 m cm^{-3}
EASTERN FEATURE	(12-18)	$(l,b)_{CENT}$= (261.0,-2.5) V_{CENT} ≅ 15 km/s M_{HI} = (3565 ± 530) $M_\odot$ n_{HI} = (12 ± 2.5)cm^{-3}	V_{CENT} =(13.8 ± 0.7) km/s V_{FWHM} =(4.67 ± 1.15) km/s N_{H_2}(max)= 1.2 x 10^{21} m cm^{-2} M_{H_2} ⩾ 3430 $M_\odot$ n_{H_2} = 13 m cm^{-3}

(*) Assuming d=2 kpc
(**) $N_{H_2} = 2.3 \times 10^{20} \int T_A \, dv$ (Murphy, Cohen & May,1986)

Conclusions: The most relevant results from our observations are: i) neutral hydrogen emission at three different radial velocities, namely: v=+3, +10 and +15 km/s, respectively, has been observed possibly associated with Puppis A; ii) every HI feature has a counterpart, in the same velocity interval, in the molecular gas.

The observed and derived parameters for the three features are summarized in Table 1.

Eastern feature: The existence of a dense HI cloud at v=+15 km/s, adjacent to the eastern edge of Puppis A, and at the same kinematical distance as the remnant, is clearly demonstrated. To the extent of our observations the spatial distribution of the CO emission within this velocity range, correlates with the HI cloud.

The coincidence between the derived HI volume density (n_{HI} = 12 cm^{-3}) and that predicted from X-ray data (n_{HI} = 10 to 14 cm^{-3}), is remarkable.

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Northern features: Two different concentrations are observed both in HI and CO lines in direction to the northern edge of Puppis A. In both cases, the cold gas clouds are seen in projection against part of the radio remnant.

Unlike the eastern feature, for the northern clouds the derived kinematical distances do not agree with that of Puppis A, and the volume densities derived for these concentrations are much lower than the predicted ones. However, bearing in mind the effects of interaction with surrounding clouds evidenced in other wavelength ranges, we feel that a chance alignment of these clouds with the SNR is highly improbable, and that they are actually associated with Puppis A. Indeed, the HI map of a very large field containing the SNR Puppis A (Dubner 1987, in preparation) shows clear evidence of the SN evolving in the periphery of a large swept-up shell (centered around ℓ=260°, b=-2°). Therefore, the kinematics of the ambient gas interacting with Puppis A might be reflecting non-circular motions.

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