Cirrus as a Probe for the Galactic Bubble Bath

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Abstract. Galactic filaments called *cirrus* are used here to study the froth structure of the interstellar medium. Using the Leiden/Dwingeloo HI survey we observe that a significant fraction of intermediate latitude cirrus are distant clouds ($R_{Gal} < 6$ kpc) and that some cirrus extend far above (or below) the Galactic plane (1 kpc). Among them, a supershell centered at $l = 15°$, $b = -12°$ is studied.

1 Introduction

In the 80s, the IRAS all-sky survey revealed that the infrared (IR) sky is highly structured. Filaments called *IR-cirrus* interwine at all Galactic latitudes. This filamentary picture of the whole sky is corroborated by HI observations. There is indeed a general good spatial correlation between the diffuse far IR emission of dust and the diffuse H I.

Observing this filamentary structure over the whole sky may suggest that it reflects the local environment. Nevertheless filamentary clouds seen near the Galactic plane may be huge structures seen at great distance. Studying these large and distant clouds may help us to understand how the Galactic interstellar matter is organized on large scale, what is its morphology, distribution and dynamics, how the stellar cycle acts on the ISM and what is the nature of the disk-halo interconnection. Having a distant view of large structures may also give strong insights about the structure of the local bubble and the local environment. In that context we propose here to study distant cirrus, or more generally distant filamentary ISM structures.

2 Distant H I

The Leiden/Dwingeloo survey (Burton & Hartmann (1994)) is used as kinematic distance indicator to find distant structures at intermediate latitudes ($|b| \leq 20°$). The H I column density at a given radius is obtained with the velocity information given by the Doppler shift of the 21 cm line assuming that the gas motions are dominated by the global Galactic rotation. Then the H I datacube (l, b, v) can be transposed in the (l, b, R_{Gal}) space using a $v \Rightarrow R_{Gal}$ relation based on the Galactic rotation curve (Burton et al.(1992)).

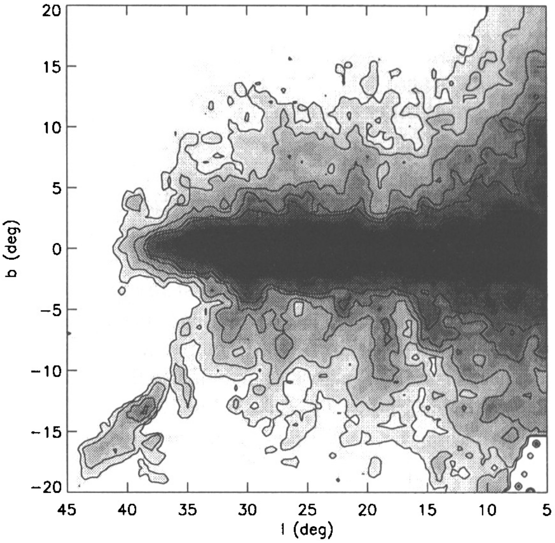

Fig. 1. Distant HI ($2 < R_{Gal} < 6$ kpc); contours are 1.9, 3.8, 9.4, 18.8 and $28.3 \times 10^{19} \mathrm{cm}^{-2}$

We show in figure 1 the H I emission located in the galactocentric radius range $2 \leq R_{Gal} \leq 6$ kpc. There is no significant emission at $l > 40°$; on first approximation, the kinematic of the H I gas located in the inner portion of the Galaxy is well described by the Galactic rotation curve used here. The H I emission is concentrated around the galactic plane ($b = 0°$), but significant emission is observed at all latitudes up to $|b| = 15° - 20°$. There is artificially strong H I emission at intermediate latitudes for $l < 10°$ due to velocity crowding (Burton et al.(1992)).

Elongated structures are apparent in many places , for examples (l,b) = (19°,-8°), (30°,-5°), (14°,-5°), (22°,5°), ... Most of these structures seem to be perpendicular to the galactic plane and look connected to it. Some of them were described as worms by Koo et al.(1992); in particular the (30°,-5°) feature (GW30.5-2.5 in Koo et al.(1992)) could be a Galactic blowout. Besides these filaments, the distant, intermediate-latitude H I emission is also characterized by a faint and diffuse component that extends far above (or below) the Galactic plane. A cloud found at (l,b) = $(20°, -15°)$ and $R_{Gal} =$ 5 kpc is at $z \approx 1.1$ kpc under the plane. This should be compared to the 200 pc scale height of the Galactic H I (Lockman (1984)). Thus this gas is very far from the main H I disk. We should ask ourselves: what put this gas there and what maintains it at this location ? A Galactic fountain (Kahn (1997)) or chimneys (Ikeuchi (1997)) may be invoked to explain the presence of high-z

H I . A study of the physical parameters of individual distant clouds may help us to understand the z distribution and the morphology of the gas, and the importance of dust in a disk-halo circulation scenario.

3 Sagittarius Supershell

We will now focus on a pair of elongated filaments: (19°, −8°) and (14°, −5°). We show in figure 2 a) a sum of selected velocity channels ($20 < v_{LSR} < 69$ km s^{-1}) of that region. Each row of this image has been divided by sin(b) to highlight fainter structures at higher $|b|$. Two bright north-south filaments are evident. Both seem to have a common origin in the Galactic plane at ($l = 17°$) where Myers et al. (1986) found 4 active H II regions and 2 molecular clouds ($M > 10^6 M_\odot$). There are also fainter H I clouds at higher $|b|$ that seem to be kinematically associated with the brighter filaments, forming a cone-like structure as a whole. This large structure has been partly identified by Heiles (1979) as GS 016-06+43 (it goes up to $b \approx -10°$ - see figure 2 a)). From an analysis of the velocity field, no net expansion of the supershell is detected. All the individual substructures have a velocity peak near 45 km s^{-1} and a kinematical distance of $d_\odot = 3.9$ kpc ($R_{Gal} = 4.8$ kpc) is adopted. The total H I mass of the walls of the supershell (for $b < -4°$) is $M_{HI} \approx 10^6 M_\odot$ and the maximum extent under the Galactic plane is $z_{max} \approx 1.1$ kpc. In spite its larger size, this supershell can be qualitatively compared to other supershells recently discovered (Normandeau & Dewdney (1996) and Maciejewski et al. (1996)) and to the theoretical description of Ikeuchi (1997).

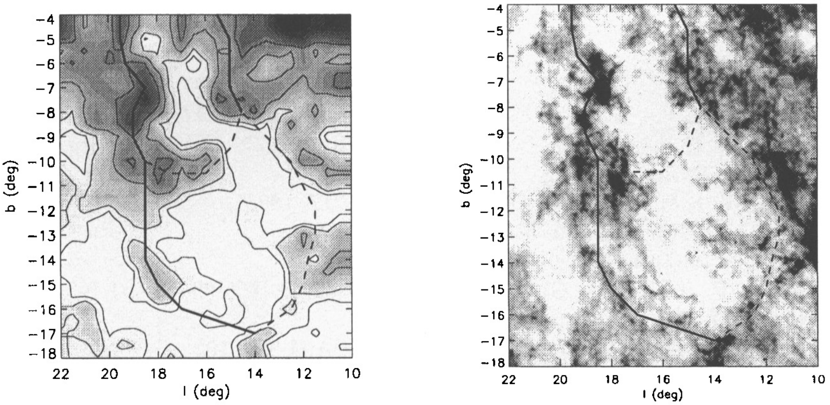

Fig. 2. The Sagittarius Supershell: **a)** Integrated HI emission divided by sin(b) ($20 < v_{LSR} < 69$ km s^{-1}). The contours are 1.5, 1.9, 2.8, and 3.8×10^{19}. **b)** IRAS 100 μm emission (each row is divided by the median of the row)

The IRAS 100 μm emission (each row has been divided by the median of the row) of the same region is shown in figure 2 b). The walls of the supershell are apparent, especially the one at $(19°, -9°)$. The higher angular resolution of IRAS allows us to observe the fragmentation of the walls; the filaments are composed of smaller filaments and nodes.

The emission at 60 and 100 μm is highly correlated all over the walls of the supershell with $I_{60\mu m}/I_{100\mu m} = 0.33$. This value reflects a small excess of very small grains that may be attributed to energetic processes associated with the creation of the supershell that grind down large grains into smaller ones (Jones et al. (1996)). The average 100 μm emissivity of the H I walls is in accordance with the mean value at $R_{Gal} = 5$ kpc (Bloemen et al. (1990)).

We also looked at the ROSAT all sky survey and found an X-ray emission pattern corresponding to a background source shadowed by the supershell. The X-ray shadowing and IR observations confirm that the walls at $b < -5°$ are mostly composed of neutral gas. A more detailed physical analysis of the sagittarius supershell will be the subject of a forthcoming paper.

4 Conclusion

The filamentary structure of the ISM may reveal two realities: 1) large gas structures blown away from the plane by successive supernova, stellar winds and HII regions and 2) a perturbed and complex medium that could, in certain cases, be the small scale structure of the first one. Thus, local cirrus should be considered as small scale structures of larger complex like the local bubble or Loop I. It is also possible that some of the local cirrus may be high-z clouds. Therefore cirrus may reveal the ISM all-scale froth built up by more-less violent dynamical processes that forge the Galactic bubble bath.

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