KINEMATICS AND DISTRIBUTION OF INTERSTELLAR HI IN THE REGION $290 \leq \ell \leq 320$, $+3 \leq b \leq +17$

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RESUMEN. Se analizaron los perfiles de la línea de 21 cm del HI correspondientes a la región de Centaurus comprendida por $290° \leq \ell \leq 320°$ y $+3° \leq b \leq +17°$. Casi todos los perfiles muestran una componente angosta ($\sigma \sim 3$ km/s), y de velocidad radial V(LSR) $\sim$ 0, que identificamos con el gas local vinculado al Cinturón de Gould.

Un objeto de aspecto elongado que aparece en la zona con V(LSR) $\sim$ -11 km/s sería, según lo indican las líneas interestelares, una nube muy cercana al Sol ($r \sim 100$ pc). Sugerimos que este filamento podría haber sido expelido desde un subgrupo de la asociación estelar Scorpius-Centaurus.

Otros objetos fueron hallados en la región, entre ellos se destaca uno con forma de arco el cual estaría relacionado con el brazo espiral de Sagittarius-Carina y contendría una gran masa, de alrededor de 5×10^5 $\mathfrak{M}_\odot$. Se propone que este objeto, el cual alcanza una altura del orden de 260 pc sobre el plano galáctico, podría formar parte de una envoltura gigante de 500 pc de diámetro que rodea a una región HII extendida.

ABSTRACT. The analysis of the region $290° \leq \ell \leq 320°$, y $+3° \leq b \leq +17°$ reveals the presence of some HI features with filamentary characteristics and, particularly, the existence of a supershell in the Sagittarius-Carina arm. The region encloses a group of young OB stars known as the Lower Centaurus-Crux association. It is proposed that an elongated shape cloud would be related genetically with such a star association. The close relation of radiocontinuum emission and HI gas at large height above the galactic plane is shown.

I. INTRODUCTION

Gaussian analysis of 21-cm profiles was performed in the region $290° \leq \ell \leq 320°$, $+3° \leq b \leq +17°$. All the observational material was taken from an extensive survey (Poppel *et al.* 1979) that covers the considered region.

Partial analysis of the region under study have been done by previous investigators (Vieira 1971, Strauss *et al.* 1979, Pöppel *et al.* 1982).

To interpret the 21-cm profiles we adopt, as working hypotesis, that the interstellar medium consists of cool *clouds* embedded in a substratum of a warm ubiquitous intercloud

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medium (see, for instance, Mebold 1972, Radhakrishnan 1975, Heiles 1980).

Before analysing the profiles into Gaussian components we must subtract the component due to the intercloud medium (ICM), because this component does not have a Gaussian-shape at low latitudes. Therefore, we had to evaluate the contribution of the diffuse intercloud medium by constructing synthetic HI-profiles.

For that purpose we considered that the ICM is stratified parallel to the galactic plane with a density distribution

$$n(z) = 0.155 \exp(z^2/2(233 \text{ pc})^2) \text{ cm}^{-3} \quad (1),$$

as given by Falgarone and Lequeux (1973). We also consider that the ICM follows Schmidt's (1965) circular rotation law. Assuming low optical depth and no absorption due to clouds, we calculated the ICM profile by means of

$$T(v) \simeq c. \int_0^\infty n(r) \,.\, f(v - U(r))\, dr \qquad \text{(see Mebold 1972 eq. 4.1)},$$

where n(r) and f(v-U(r)) represent the HI-density, which was derived from (1), and the radial velocity distribution of the gas at a distance r. Here, U(r) is the radial velocity component due to galactic differential rotation at position r. For f(v-U(r)), we adopted a Gaussian function whose dispersion velocity was considered constant throughout the Galaxy and equal to 10 km/s.

In general, the theoretical profiles for the ICM are compatible with the observations. We, therefore, conclude that the observations of the region do not contradict the adopted hypothesis.

After subtracting the ICM's emission from the observed profiles, the residual profiles were analysed into Gaussian components. Thus, by decomposing the residual profiles, the parameters of the principal *clouds* of the region were determined.

In the present paper we discuss only the more conspicuous HI features that appear in the region. We call them features A, B, C and D. They have velocities of about 0, -11, -19 and -30 km/s, respectively. In the region there are also other HI features such as a turbulent gas complex with velocities between about -50 and -40 km/s. In section III we will refer to a z-extension of this gas, in connection with a prominent radiocontinuum feature.

Figure 1 illustrates a typical line profile of the region, with the various components indicated. The main results are shown in the contour maps of N_H (the number of hydrogen atoms in a column of 1 cm^2 cross-section along the line of sight) as a function of ℓ and b (Figs. 2, 3, 4 and 5). The N_H's were calculated on the assumption that the gas is optically thin. Table 1 gives the features parameters, namely, the mean velocity ($\bar{v}$) and the mean velocity dispersion ($\bar{\sigma}$), both with their rms deviations, and the mass per unit square distance ($\mathcal{M}/r^2$). Besides, it includes some comments that summarize the discussions in the next section, about the possible identifications, distances and masses of the features.

In the next section we will analize features A, B, C and D; and in the last section, we compare the continuum at 408 MHz from Haslam *et al.* (1982) with some of our HI features in order to show probable relations between them.

All velocities in this paper are with respect to the local standard of rest.

II. HI FEATURES

We will first discuss features A and B. The last one which is characterized by its filamentary aspect has a rather constant velocity of about -11 km/s. Instead, feature A presents some velocity details which are shown in Fig. 6.

In Table 2 we have listed the data regarding interstellar lines in the region of the present study, that were used for distance estimation. The insterstellar absorption lines seen on the spectra of some nearby stars (HD 121263, 106490, 124367, 118716, 113791 and 129557) with the same radial velocity as features A and B, seem to indicate that these HI features should be

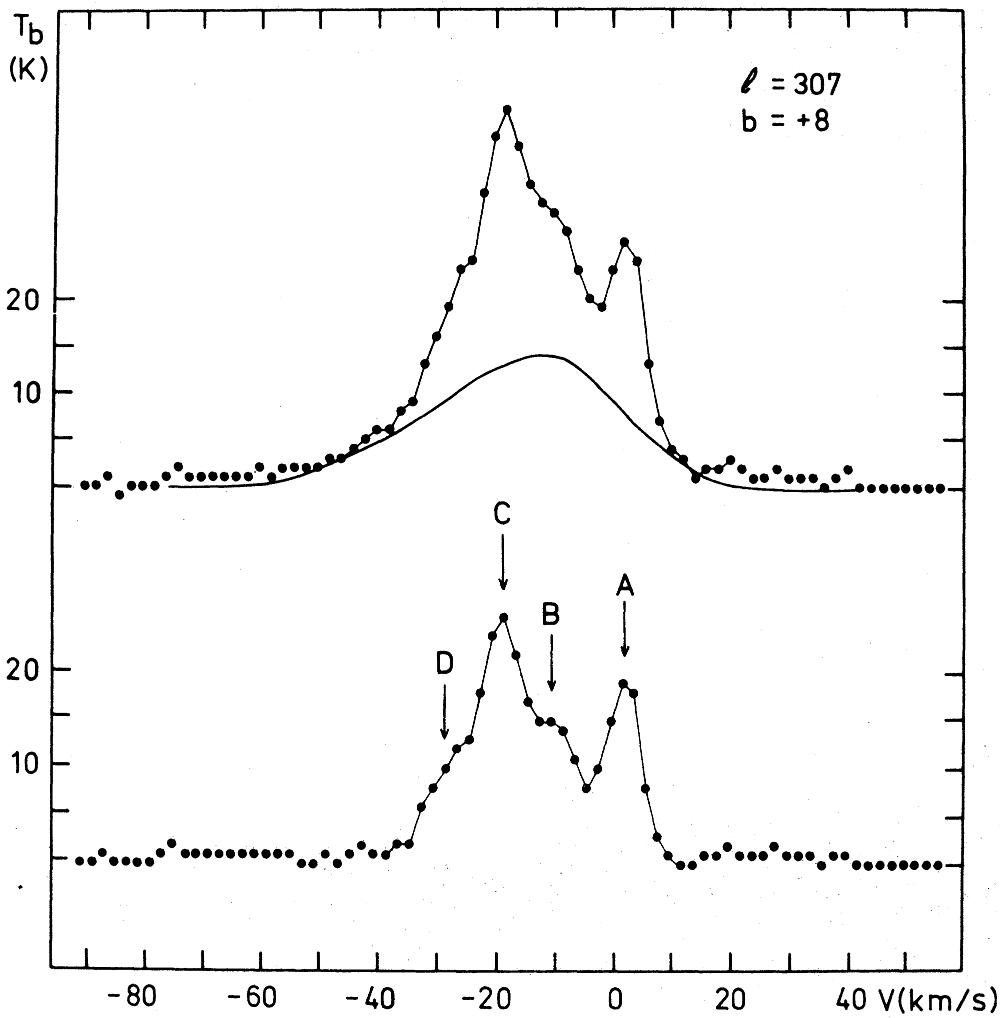

Fig. 1. At the top, 21 cm line profile observed at position ℓ = 307°, b = 8° (dots joined with full lines); and its calculated ICM component (full line). At the bottom, the corresponding residual profile obtained by subtracting the ICM's component from the observed profile. The residual profiles represent the emission of the clouds. Capital letters identify the features.

local objects situated not more than 80-100 pc away. Probably, because of limitations in spectral resolution, these interstellar absorption lines appear as single. For instance, the spectrogram of S II (1259.520 Å) of HD 121263 (Bohlin *et al.* 1982) presents a single minimum whose velocity agrees with that of feature B, and a wing that might correspond to feature A.

Let us now estimate roughly the thickness and density of feature B, for which we take the distance of HD 121263, the closest star in whose spectra feature B appears, as the distance to feature B, namely 85±30 pc. Then considering that the boundary of feature B is defined by the contour of 15×10^{19} atoms/cm^2 (Fig. 3), which contains 80% of the feature's mass, and assuming that the feature is a filament with equal dimensions parallel and perpendicular to the

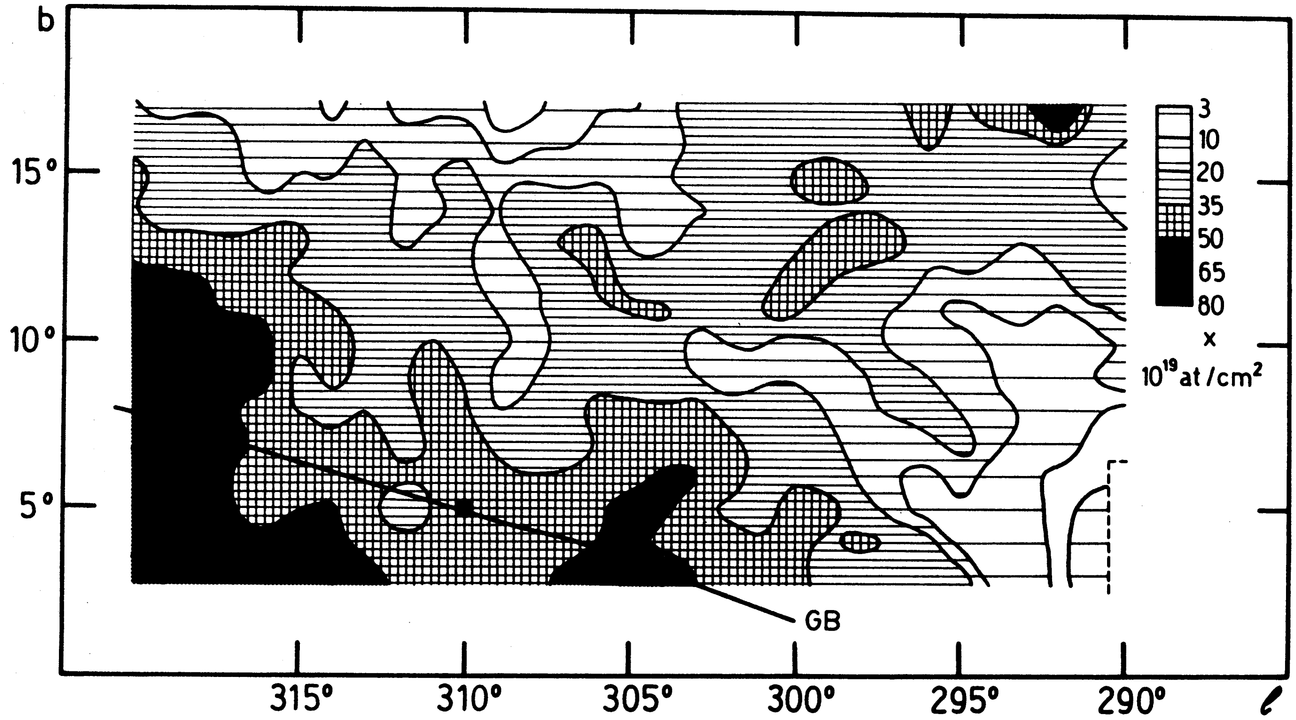

Fig. 2. N_H distribution of feature A. The full line is the optical equator of Gould's Belt (Stothers and Frogel 1974). The broken line at the lower right border limits a small region that was not analysed because of its complexity.

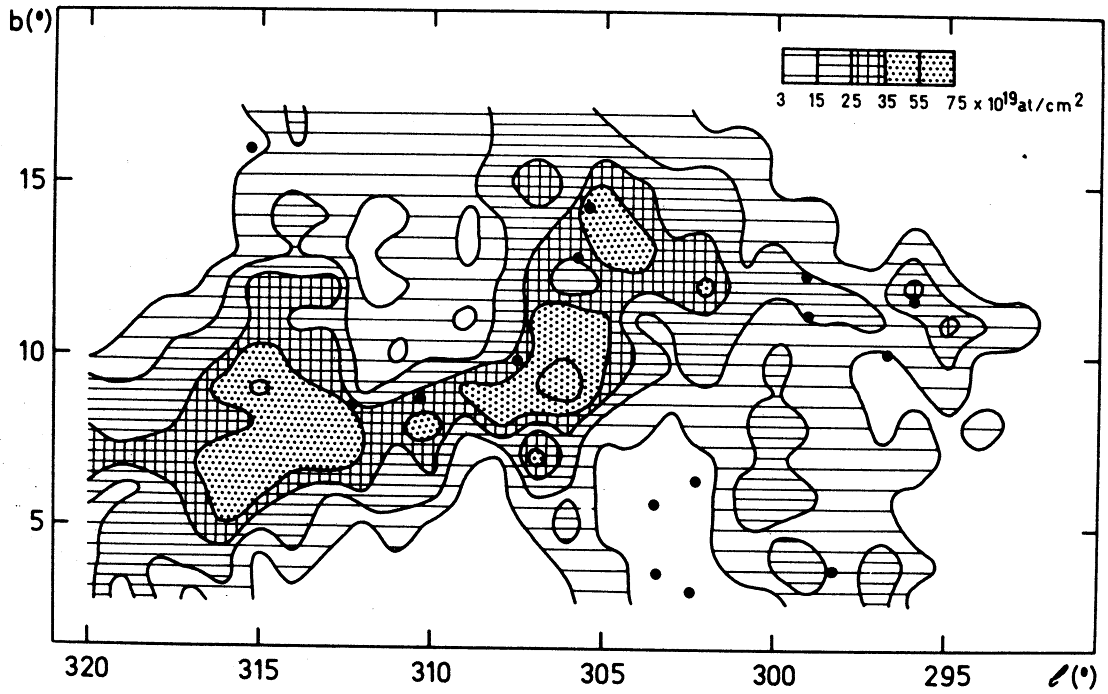

Fig. 3. N_H distribution of feature B. The filled circles represent, as given by Bertiau (1958), member stars of Scorpius Centaurus association which include a five star chain that follows the same arc-shaped structure as that of feature B.

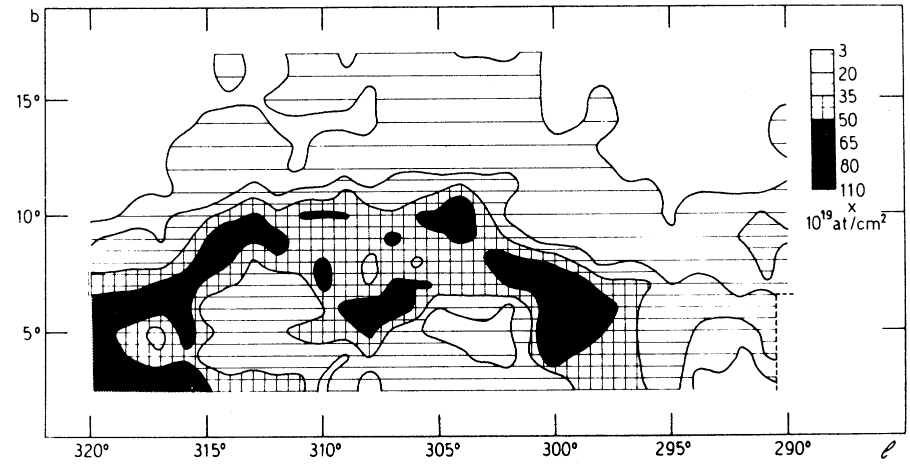

Fig. 4. N_H distribution of feature C.

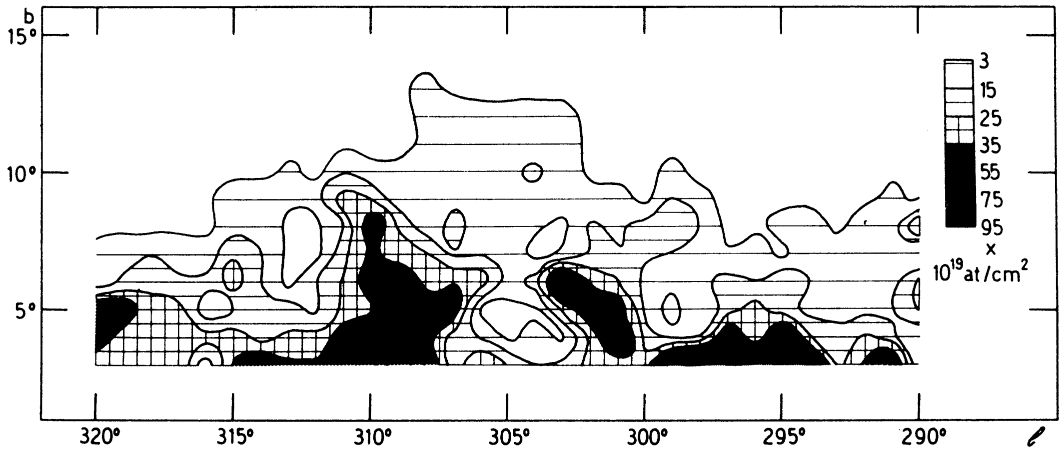

Fig. 5. N_H distribution of feature D.

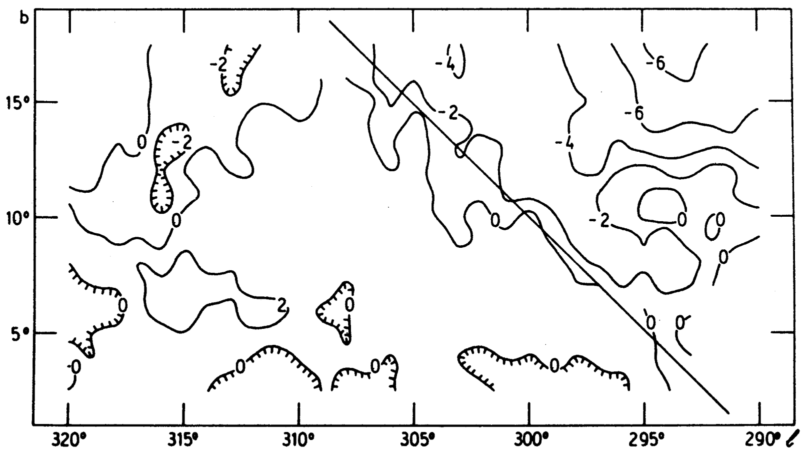

Fig. 6. Velocity distribution, in km/s, of feature A. The diagonal full line divides the perturbed (on the right) from the not perturbed feature A (on the left).

TABLE 1

PARAMETERS OF SEVERAL HI FEATURES DESCRIBED IN THE PAPER

Feature	Mean Velocity $\overline{V} \pm \Delta V$ (km/s)	Mean Velocity Dispersion $\overline{\sigma} \pm \Delta\sigma$ (km/s)	Masses per unit square distance r $\mathcal{M}/r^2$ ($_\odot$/pc^2)		Comments and Identifications
A	- 0.6 ± 2	3.2 ± 0.6	0.33	They would be local objects located very near the Sun.	A portion of the ring of gas associated with Gould's Belt. If the distance is 85 pc, the mass is 2400 $\mathcal{M}_\odot$.
B	-10.8 ± 2	3.6 ± 0.5	0.13		Object of filamentary aspect and peculiar velocity. If its distance to the Sun is 85 pc, its mass is 900 $\mathcal{M}_\odot$.
C	-19.1 ± 2	3.4 ± 0.5	0.23	They woul be related to the Sagittarius-Carina arm	Arc-shaped feature centered at $\ell \sim 308°$ with a radius of 10°. If its mean distance is 1500 pc, then the linear radius and mass are 260 pc and $5 \times 10^5 \mathcal{M}_\odot$, respectively.
D	-29.6 ± 2	3.7 ± 0.3	0.11		
					the distance and mass would be 2500 pc and $7 \times 10^5 \mathcal{M}_\odot$.

TABLE 2

INTERSTELLAR LINE DATA

HD	Galactic Coordinate ℓ (degrees)	b	Distance (pc)	V_{LSR} from optical interstellar absorption lines (km/s)	V_{LSR} from ultraviolet interstellar absorption lines* (km/s)	references
121263	314.1	+14.2	85		-10.8	(1)
106490	298.3	+ 3.8	145		-10.7	(1)
124367	314.1	+ 4.0	150	- 8.2		(2)
118716	310.3	+ 8.7	189		+ 1.4	(1)
113791	305.5	+12.9	240	-12.5:		(2)
129557	318.6	+ 3.8	530	- 2.8		(2)
115842	307.1	+ 6.8	1330	-15.0		(2)
112244	303.6	+ 6.0	1340	-18.1, - 0.1		(2)
120521	310.7	+ 3.4	4710	-42 , -18		(3)
122324	312.8	+ 5.5	5070	-48 , -14		(3)
114340	305.4	+ 3.0	5600	-44 , -11		(3)
114024	305.1	+ 3.1	6240	-21 , + 3		(3)

* The velocities given correspond to the average of the values derived from lines of different elements.

(1) Bohlin *et al.* (1983), (2) Buscombe and Kennedy (1968), (3) Chu-Kit (1973), and corrections from Rickard (1974).

line of sight, we obtain that its mean width along the line of sight is about 10 pc and that the mean density is 10 atoms/cm^3.

The small range of distance in which features A and B seem to lie, favors the possibility that they are physically associated. In view of this it is of interest to enquire whether feature B is behind feature A and hence approaching it or in front of feature A and receding from it. The author favors the first possibility because it would provide a plausible explanation for the following facts. If we compare Figs. 3 and 6 we find that there is a correspondence between the upper right border of feature B and the configuration of the velocity field of feature A. From this border to the right, where feature B is not present, feature A shows the velocity shift. This behaviour could be interpreted as if in this region, feature B has merged into feature A, perturbing its velocity.

Since features A and B, in our view, are supposed to be colliding, we will consider that their distances are similar and close to 85 pc. By multiplying the values of column 4 of Table 1, by the square of the distance in pc, we obtain a HI mass of 2400 $\mathfrak{M}_\odot$ for feature A, and 900 $\mathfrak{M}_\odot$ for feature B. These figures are included in Table 1, where we also give similar values for the other features as well.

Their proximity to us and the anomalous velocities, not explicable by galactic rotation, make these features very special. We have wondered about their nature and origin. One of them, our feature A, is interpreted as a part of the Gould's Belt gas ring, as it has been done by previous investigators (Vieira 1971, Strauss *et al.* 1979, Pöppel *et al.* 1982). On the other hand, the origin of feature B remains more uncertain.

A group of young OB stars known as Lower Centaurus-Crux association (LCC) (Blaauw 1964), is located in the proximity of these two features. The distance of the stars (160 pc) would be a little larger than those of features A and B. It seems likely, therefore, that feature B comes from this group of stars. There is a curious coincidence that might not be a casual fact. A group of five stars of LCC is along feature B (see Fig. 3). This circumstance could suggest that those stars and our feature B are connected genetically. We propose that this filament could have been expelled from LCC and would constitute a vestige of the original cloud out of which the stars of LCC were formed.

This phenomenon could be interpreted within the framework presented by Olano (1982) about the relation of some neighbouring OB-associations with the Gould's Belt HI ring. First, the protostellar material and then the stars left the less dense gas behind. Subsequently stellar winds from the stars have pushed back the fragments of the protostellar material that was not condensed into stars, returning this material to the Gould's Belt HI ring.

Now let us comment about the other two HI features which we called C and D. From the interstellar line data of the region (Table 2) and from studies, on nearby regions, by Rickard (1974) and by Ardeberg and Maurice (1981), I consider that features C and D are related to the spiral structure of the Galaxy and belong to the Sagittarius-Carina arm. The velocities of both features are almost constant and would be mainly due to their circular galactic rotation. Fig. 7 shows the position of features C and D in the Galaxy. It is interesting to note that they are, respectively, located at the external and internal border of the Sagittarius-Carina arm as traced by HII regions.

As Fig. 4 shows, feature C presents the remarkable shape of an arc. We suggest that it might be a part of a supershell surrounding an extended HII region. The existence of a circular diffuse HII region of large angular diameter (at least of 10°) centered about $\ell \sim 305°$, $b \sim 0°$, as seen in Sivan's (1974) Hα Atlas of the Milky Way would support this hypothesis. Besides, there are observations of H166α recombination line at the same longitudes and $b = 0°$ with velocities close to that of feature C (Azcárate and Cersósimo 1983).

The collective action of early type stars presumably located around and along the direction $\ell \sim 305°$ and $b \sim 0°$ would have been responsible for both, the formation of the extended HII region and the expansion of the gas that has originated the circular HI arc.

III. RADIOCONTINUUM SPURS AND RISING HI GAS

As shown in Figs. 8 and 9, enhancements of the background radiocontinuum (RC) emission exist in spatial coincidence with the HI gas located high above the galactic plane.

In Fig. 8., we show a portion of our HI feature D (see preceding section) superposed to a RC feature detaching from the background. Here, feature D presents a cavity with an opening at the top, like a crater in a volcano. Just above it, there are the mentioned RC feature and also a small HI cloud. The RC feature looks as ejected from the HI cavity through the opening,

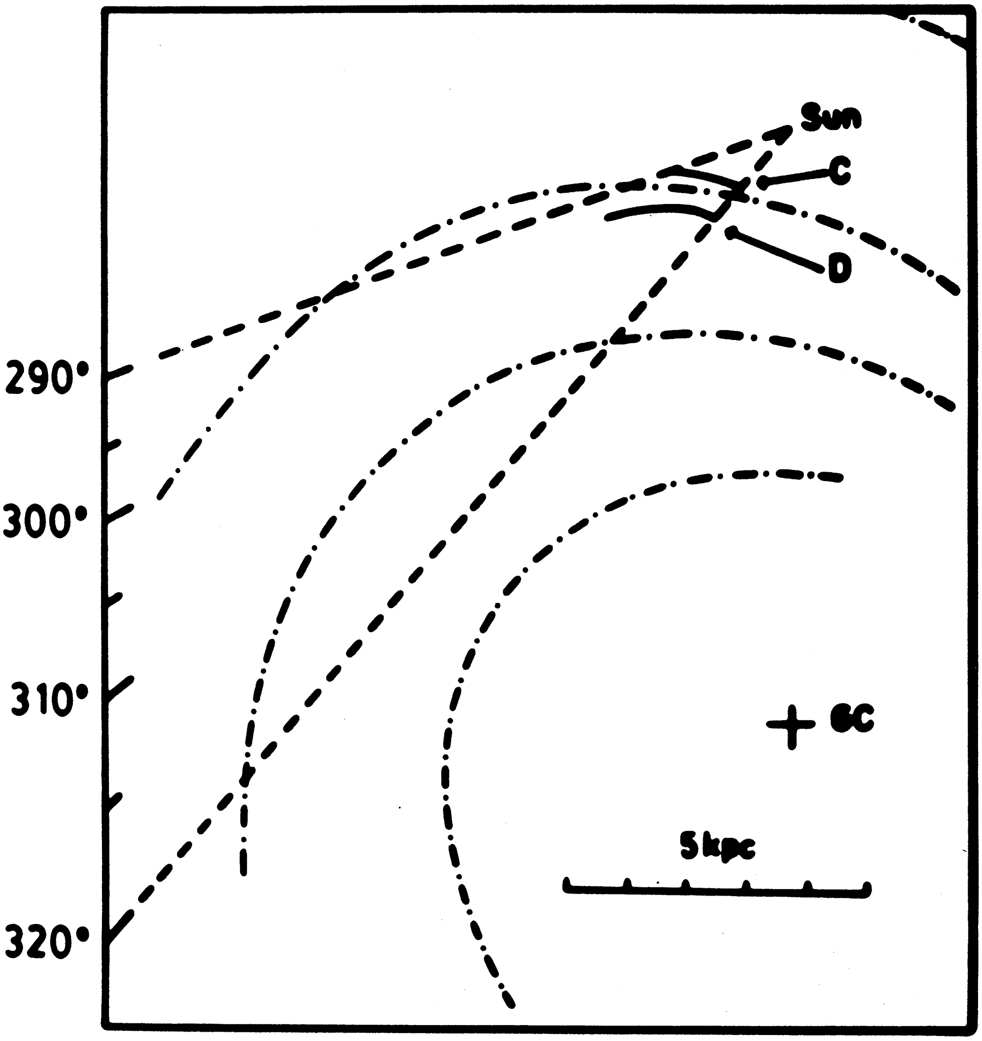

Fig. 7. Location of features C and D in the Galaxy as derived from the kinematical distances that were computed by means of Schmidt's rotation law. The broken line indicates the spiral arms traced by HII regions according to Georgelin (1976).

like smoke is poured out through a chimney. It is probable that the HI cavity would have been produced by a supernova explosion. The upper part of the HI shell opened and, then, the plasma with a frozen magnetic field (responsible for the RC emission by synchroton radiation) has escaped from inside the cavity flowing out of the galactic disk.

Fig. 9 shows the probable connection of a RC spur with a turbulent HI component having a velocity dispersion of 9.6 km/s and a mean velocity of -49 km/s. This gas complex would be related to a structure in the disk whose lower and upper limits of distance, as given by interstellar lines, would roughly be 3 and 6 kpc, respectively (see Fig. 8 in Rickard 1974).

The velocities of the gas observed at these heights show a distinct clustering around the velocity that corresponds to that of the gas on the plane. This is due to the fact that only the clouds expelled in directions perpendicular to the galactic plane can manage to leave the disk.

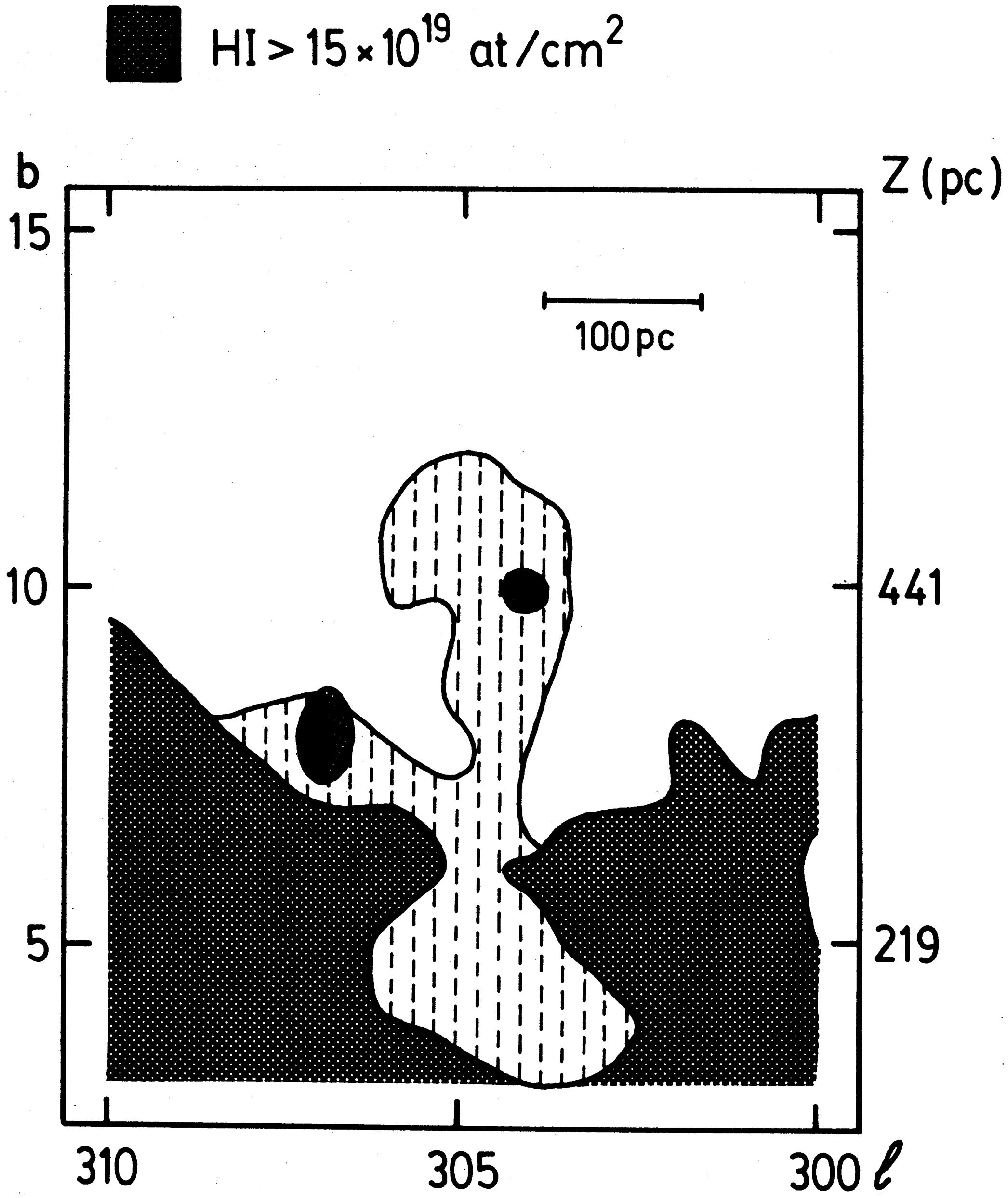

Fig. 8. A portion of feature D, represented to show a possible relation between a HI cavity and the radiocontinuum feature (hatched area). It seems to emerge vertically from the cavity in the galactic disk. This configuration looks like that of a volcano in eruption.

This gas outflow reaches a height of 800 pc above the galactic plane (see Fig. 9) and involves $10^5 \mathcal{M}_\odot$. Very energetic processes, of at least 10^{51} erg, must have taken place to carry such a huge mass at those heights. Perhaps very gigantic explosions in the disk have pushed up gas from the disk.

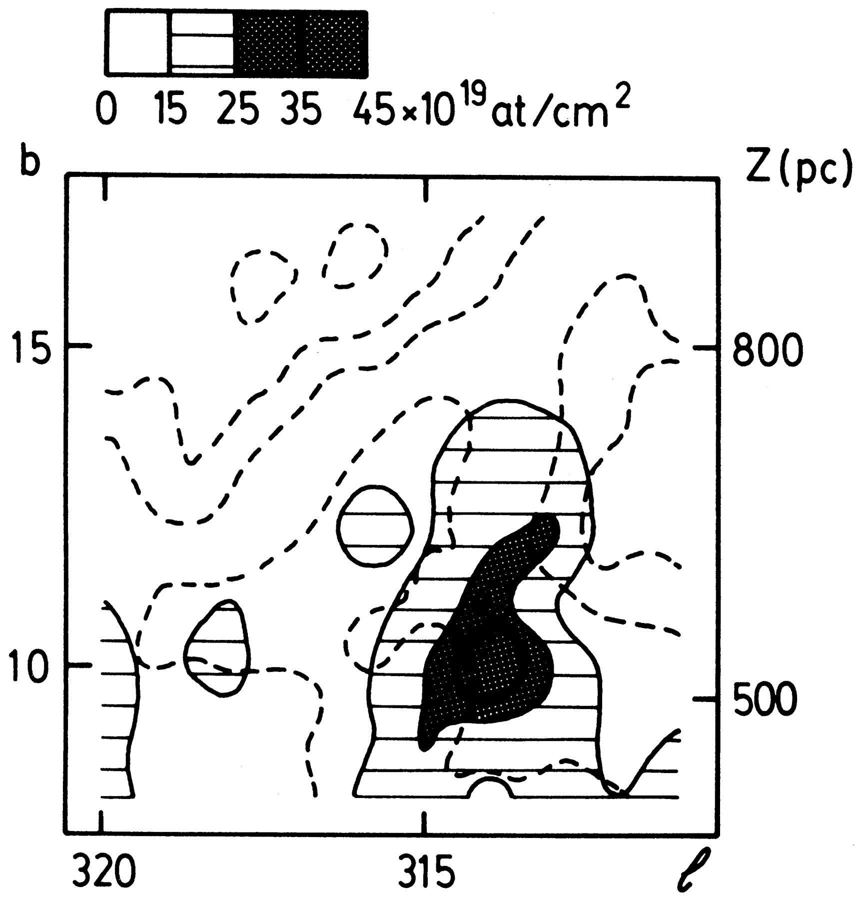

Fig. 9. N_H distribution for the z-extensions of a gas complex. The integration was performed within the velocity range -70 km/s < V < -30 km/s after subtracting the other components. The superimposed broken lines show the prominent radiocontinuum spur which seems to be associated to the HI complex at great height above the galactic plane. The vertical scale correponds to z, the height (in pc) above the galactic plane. The vertical scale corresponds to z, the height (in pc) above the plane, was calculated by adopting the lower limit of 3000 pc as the distance.

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