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Large HI shells catalogue in the second galactic quadrant

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Abstract. We present the results of a neutral hydrogen shell (GS) catalogue located in the outer part of the Galaxy in a region delimited by the galactic longitudes $88^\circ \leq l \leq 165^\circ$ and galactic latitudes $-50^\circ \leq b \leq +50^\circ$. This catalogue was made using a combination of the traditional technique of visual identification and of an automatic search, resulting in the identification of 382 structures.

Due to that our algorithm is able to detect incomplete structures, we have incremented the number of shells catalogued by other authors. About 80 % of the structures (considered as maximum confidence by other authors) have been identified in our search. The effective radius of the shells increments linearly with respect to the galactic plane height.

Resumen. Presentamos los resultados de un catálogo de supercáscaras (GS, por sus siglas en inglés) de hidrógeno neutro (HI) localizadas en la parte externa de la Galaxia en una zona delimitada por las logitudes galácticas $88^\circ \leq l \leq 165^\circ$ y las latitudes galácticas $-50^\circ \leq b \leq +50^\circ$. Dicho catálogo se realizó mediante una combinación de la tradicional técnica de identificación visual y de un algoritmo automático de búsqueda, resultando en la identificación de 382 estructuras.

Debido a que nuestro algoritmo permite la detección de estructuras incompletas, hemos incrementado el número de cáscaras catalogadas por otros autores en esta misma región del cielo. Aproximadamente el 80 % de las estructuras (consideradas de máxima confiabilidad por otros autores) han sido identificadas en nuestra búsqueda. El radio efectivo de las estructuras crece linealmente con la altura sobre el plano galáctico.

1. Introduction

The interstellar medium (ISM) when observed at 1420 MHz, shows the presence of regions of low emissivity surrounded, completely or partially, by regions of enhanced HI emission. These structures receive the generic name of *shells*. If the energy necessary to create them were greater than 10^{52} erg, they would be called *supershells* (Heiles, 1979).

The HI shells could be originated for the cumulative effects of the stellar winds and/or supernova explosions, from the infall of high velocity clouds interacting with the galactic plane (Tenorio-Tagle 1981) or gamma ray bursts (Loeb & Perna 1998; Perna & Raymond 2000).

Using visual identification methods (Heiles 1979, 1984; McClure-Griffiths 2002) or automatic ones (Ehlerová & Palous 2005, Daigle et al. 2007) several shell catalogues have been elaborated in the Milky Way.

In this work we present a shell catalogue, in the second galactic quadrant ($88^\circ < l < 165^\circ$), using a combination of both the traditional visual method and a supervised automatic algorithm of identification.

2. Observations

HI data were retrieved from the Leiden-Argentine-Bonn (LAB) HI survey (Kalberla et al. 2005). The angular and velocity resolutions are 34′, and 1.3 kms^{-1}, respectively. The survey covers a velocity range from -450 to 400 kms^{-1}. Owing to the angular resolution, this database is well suited for studying large shells structures.

3. Selection criteria

Our automatic algorithm is based on a previous visual search consisting on a reduced set of shell candidates. In general, an HI structure will be considered a shell if it fullfills the following criteria:

1. It presents a local minimum in the HI emission distribution surrounded, partially or completely, by regions of enhanced HI emission.
2. The HI minimum must be detected at least in 5 consecutive velocity channels.
3. Its angular size must be greater than 2°.
4. Its linear size must exceed 200 pc at the kinematic distance of the structure.

4. Automatic search algorithm

Our algorithm implements an automatic search of structures that meet the criteria mentioned above. The algorithm mainly consists on the application of the following steps:
Step 1: To search for local minima: Since we need to find structures observed in at least 5 consecutive velocity channels, instead of working on single slices at a given velocity, we average 5 slices corresponding to adjacent channels. In every averaged channels, we identify those pixels that belong to a relative local minima.
Step 2: To find surrounding walls: For each detected local minimum pixel, the algorithm computes the temperature profile along radial lines, having different position angles, with center at the corresponding local minimum pixel. We define the existence of an HI wall if a clearly identifiable local maximum does exist along the individual temperature profile. In order to avoid weak structures, the temperature at the local

maximum should exceed the temperature at the central minimum by a certain threshold. The value of this threshold depends on the position in the data cube (l, b, v).

Step 3: Ellipse fit: The algorithm, also finds the best ellipse that fits the local maximum points for each detected structure by using a classical Minimum Least Squared technique. Then, ellipses are characterized by the following parameters: centroid (l_0, b_0), major and minor semi-axes and the position angle of the major semi-axis with respect to the galactic plane.

As a further check, every structure detected by the blind search was visually inspected in order to analyze their behavior along the velocity dimension. Only those features showing the expected trend were included in the final catalogue.

5. Results

We compare our algorithm against the one implemented by Ehlerová & Palous (2005) because both use the same database. However our algorithm is not only able to detect structures that are totally surrounded by walls of enhanced HI emission but also the ones that are partially surrounded by these walls (open structures). From this perspective our algorithm has incremented the number of discovered structures in comparison with the one developed by Ehlerová & Palous (2005) that fails at detecting open structures.

The number of structures detected by our algorithm is 382 which is larger than the one found by Ehlerová & Palous (2005) (79). In this comparison we have only taken into account the structures detected by these authors which dimensions are greater than 200 pc and that are located in the same area where we are doing the search. Using only the shells classified by Ehlerová & Palous (2005) as having maximum confidence level (15 in total), we find that 80% of them were identified in our search.

Taking into account the morphology of the detected structures, 200 out of the 382 are completely surrounded by walls of enhanced HI emission; 128 are surrounded in almost 75 % ($\sim 270°$) of their perimeter by walls of enhanced HI emission; 36 structures show HI emission along an extension of almost 180°, and only 18 show HI emission in an arc-like feature having an angular extension smaller than 90°.

In Fig. 1 (*left panel*) a linear increment of the effective radius (R $= \sqrt{a_1 * a_2}$, where a_1 and a_2 are the major and minor semi-axes, respectively) versus the galactic plane height ($z = sin(b) * d$, where b is the galactic latitude of the geometric center and d is the kinematic distance) of the structures. Figure 1 (*left panel*) shows that the effective radius increases linearly (R(z)= k_1 * z + k_2, where k_1=1.153 $\pm$ 0.012 and k_2=5.682 $\pm$ 3.249.) with z.

Figure 1 (*right panel*) shows the effective radius distribution of a subset of 260 structures whose distances are lower than 10 kpc. Almost 50 % of them have effective radius greater than 200 pc.

6. Conclusions

The catalogue of HI shells found using a supervised automatic algorithm reveals the existence of 382 structures, tripling the number of structures found by Ehlerová & Palous (2005). Around 65 % of the structures that have 75% of their perimeters surrounded by enhanced HI emission are open towards the galactic halo. The effective radius of the structures increments linearly with respect to the galactic plane height and the distri-

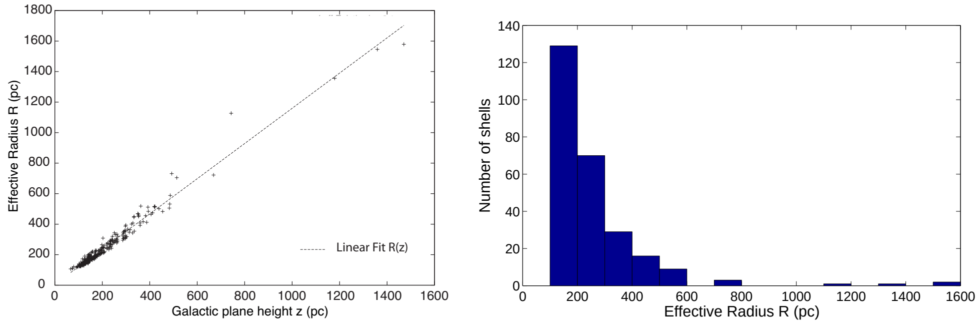

Figure 1. *left panel:* distribution function of the effective radius versus z in pc. *Right panel:* distribution function of the effective radius of shells whose distances are lower than 10 kpc, expressed in parsecs.

bution of the effective radius shows that $\sim$ 50 % of the structures have effective radius larger than 200 pc.

We are currently working on a extended catalogue that includes the 3^{rd} galactic quadrant.

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