Asociación Argentina de Astronomía
BAAA, Vol. 54, 2011
J.J. Clariá, P. Benaglia, R. Barba, A.E. Piatti & F.A. Bareilles, eds.

PRESENTACIÓN ORAL

GS 100-02-41: a new HI shell in the outer part of the Galaxy.

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Abstract. GS 100-02-41 is a large neutral hydrogen (HI) shell located in the outer part of the Galaxy, at a distance of 2.8 kpc from the Sun. From an analysis of the HI data several parameters that characterize the structure have been determined. Based in energetic considerations, we estimated that GS 100-02-41 could have been originated for the join action of stellar winds and supernova explosion of the stars members of Cep OB1.

Resumen. GS 100-02-41 es una gran cáscara de hidrógeno neutro (HI) localizada en la parte externa de la Galaxia, a una distancia de 2.8 kpc del Sol. A partir del análisis de los datos de HI varios parámetros que caracterizan a la estructura han sido determinados. En base a consideraciones energéticas, se estima que GS 100-02-41 podría haberse originado por la acción conjunta de los vientos estelares y explosiones de supernova de las estrellas miembros de Cep OB1.

1. Introducción.

The interstellar medium, when viewed in the 21 cm line emission, is far from being homogeneous it present filaments, bubbles, cavities, loops, worms and shells. The HI shells are detected as minimums surrounded totally or partially of enhanced HI emission. They were first detected by Heiles (1979).

The origin of the shells is far from clear. Though the small ones may be created by the join action of stellar winds and supernova explosions, alternative mechanisms like the infall of high velocity clouds (Tenorio-Tagle 1981) or gamma-ray burst (Perna & Raymond 2000), have to be thought for the larger ones. In spite of this, there is an increasing number of HI structures detected in the Milky Way whose origin may be related to OB associations through the stellar winds and supernova explosions of their member stars.

On the other hand, the gas swept up by these expanding shells may be the triggering agent for the formation of new generation of stars (Elmegreen 1998)

In this work we have used the Leiden-Argentine-Bonn (LAB) HI survey (Kalberla et al. 2005), which angular and velocity resolution are $34'$y 1.3 kms^{-1}, respectively. High angular resolution HI data were obtained from the Canadian Galactic Plane Survey (CGPS, Taylor et al. 2003). Radio continuum emission at 2695 MHz were also used in this study (Reich et al. 1990).

2. GS 100-02-41.

To characterize the shell we have fitted the ellipse that best fit it. From this fit we obtained the central longitude and latitude (l_0, b_0), the length of both the semi-major (a) and semi-minor (b) axes of the ellipse, and the inclination angle (positive towards the north galactic pole) (θ) between the major axes and the galactic longitude axis. In Fig. 1 (*left*) the shell and the fitted ellipse are shown, it is an average in the velocity channels where the shell is best detected. Assuming a symmetric expansion of the shell, The expansion velocity is estimated as half of the total velocity range $(V_e = 0{,}5\,(|V_{\rm M} - V_{\rm m}|))$ where the shell is observed. Where $V_{\rm M}$ and $V_{\rm m}$ are extreme velocities. The central velocity where the shell is detected is V_0.

The systemic velocity (V_0) of the shell can be translated to a kinematical distance of 2.8 $\pm$ 0.6 kpc using the observed velocity field given by Brand & Blitz (1993).

The mass was estimated using the procedure described by Pineault (1998): $M_{\rm HI}(M_\odot) = 1{,}3 \times 10^{-3}\, d^2\, \Delta V\, \Delta T_{\rm B}\, \Omega$, where d is the distance in kpc, Ω (square arc-min) is the solid angle subtended by the structure, ΔV is the velocity interval over which the structure is detected, expressed in kms^{-1}, and $\Delta T_{\rm B}$ (K) is the mean brightness temperature defined as $\Delta T_{\rm B} =|\ T_{\rm sh} - T_{\rm bg}\ |$, where $T_{\rm sh}$ refers to the mean brightness temperature of the HI shell, and $T_{\rm bg}$ corresponds to the temperature of the contour level defining the outer border of the HI shell. The latter represents the temperature of the surrounding galactic HI emission gas. The total gaseous gas is $M_{\rm t}(M_\odot) = 1{,}34\, M_{\rm HI}$, adopting solar abundances. We have also estimated the kinetic energy of the shell, which is given by $E_k = 0{,}5\, M_{\rm t}\, V_e^2$. All relevant parameters are given in table 1.

In Fig. 1 (*right*) is shown the radio continuum emission at 2695 MHz towards the region where GS 100-02-41 is observed. There is no large scale counterpart of the HI shell. The strong source observed at $(l, b) \simeq (102.^\circ8, -0.^\circ7)$ is the cataloged region Sh2-132, studied by (Vasquez et al. 2010). Towards the south area of Sh2-132 a ring nebula related to the Wolf-Rayet star WR 152 is also observed (Cappa et al. 2010). Three continuum sources are seen projected in the borders of the HI shell, they are labelled G98, G100, and G103. From the spectral index calculation we infer that they are thermal in nature. An inspection of the $1'$ CGPS HI data reveals HI minima having a good morphological correlation with the HII regions at velocity ranges compatible with the velocity spanning by GS 100-02-41. This leads to the conclusion that G98, G100, and G103 are located at the same distance than GS 100-02-41.

2.1. Shell's origin.

From the *Galactic OB Associations in the Northern Milky Way Galaxy* (Garmany & Stencel 1992) we see that several stars belonging to Cep OB1 are pro-

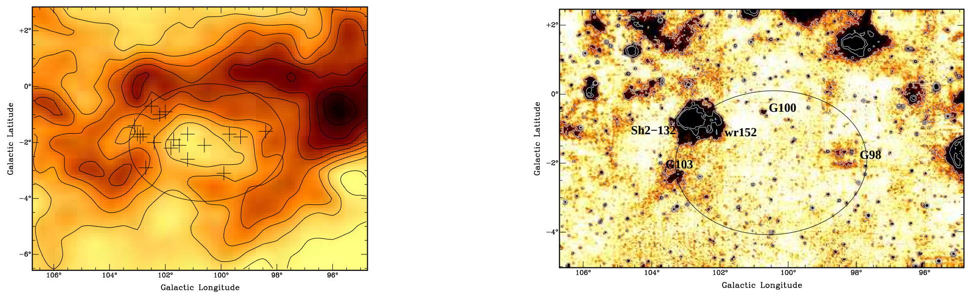

Figura 1. *Left:* LAB HI emission averaged in the velocity rage from -46.3 to -34.0 kms^{-1}. Contour levels are from 10 to 90 in steps of 10 K. The cross symbols indicate the location of the members of Cep OB1 lying inside the ellipse. *Right:* 2695 MHz emission distribution in the region of GS 100-02-41, contour levels are 65, 250 and 400 mK. The fitted ellipse is shown in both panels.

Parameter	Value
Distance (kpc)	2.8 ± 0.6
$(l_0,\ b_0)$	$(100\overset{\circ}{.}6,\ -2\overset{\circ}{.}04)$
a	$2\overset{\circ}{.}56$
b	$1\overset{\circ}{.}69$
θ	$-5\overset{\circ}{.}7$
a (pc)	125± 25
b (pc)	83 ± 17
V_0 (kms^{-1})	−41 ± 2
V_e (kms^{-1})	11 ± 2
M_t ($M_\odot$)	(1.5± 0.7) $\times 10^5$
E_k (erg)	$(1{,}8 \pm 0{,}8) \times 10^{50}$

Tabla 1. Main parameters of GS 100-02-41

jected inside GS 100-02-41. In Fig. 1 (*left*) they are indicated by cross symbols. The distance estimated by Garmany & Stencel (1992) for the OB association is in agreement with the kinematical distance estimated for GS 100-02-41. To answer if the stars belonging to Cep OB1 are the responsible of creating the shell, we have calculated the total wind energy released by the stars of Cep OB1 lying inside the shell during its main sequence phase, $E_w = 0{,}5\,\dot{M}\,V_w^2\,t(\mathrm{MS})$, where $\dot{M}$ is the mass loss rates, V_w the wind velocities and t(MS) is the time during the mains sequence phase of each star.

According to theoretical models, only 20 % of the wind energy is converted into mechanical energy of the shell (Weaver et al. 1977), therefore for creating GS 100-02-41, a wind energy greater than 9 $\times 10^{50}$ erg would be required. However, observed HI shells show that the conversion efficiency is about 2-5 % (Cappa et al. 2003). We obtained that the energy released by the stellar wind of the Cep OB1 stars is $\sim 29{,}7 \times 10^{50}$ erg, which is enough to create GS 100-02-41 if the energy conversion efficiency were ~ 6 %.

3. Conclusions.

GS 100-02-41 is a large shell of radius 200 pc located at 2.8 $\pm$ kpc from the Sun. The mass of the shell is (1,5 $\pm$ 0,7) $\times 10^5$ $M_\odot$. The shell is expanding at a velocity of 11 $\pm$ 2 kms^{-1} and its kinetic energy is (1,8 $\pm$ 0,8) $\times 10^{50}$ erg.

From the 2695 MHz radio continuum image, we found three sources, labelled G98, G100, and G103 projected onto the borders of GS 100-02-41. From their spectral indexes we infer that they are thermal in nature. From the analysis from the CGPS HI data we infer that G98, G100, and G103 are located at the same distance than GS 100-02-41. The fact that they are located at the same distance as GS 100-02-41 and that they are projected into the borders of the HI shell, leads us to the conclusion that G98, G100, and G103 may have been created as a consequence of the action of a strong shock produced by the expansion of GS 100-02-41 into the surrounding gas.

Several evolved massive stars members of Cep OB1 are projected inside the large shell. The distance to the OB association is compatible with the kinematical distance of the HI shell. An energetic analysis suggests that the wind energy provided during the main sequence phase of the stars could explain the origin of the shell. However, taking into account the SN rate in OB associations, the energy contribution of a SN explosion as well as of its massive progenitor can not be discarded.

Referencias

Brand, J. & Blitz, L. 1993, A&A, 275, 67.

Cappa, C. E., Arnal, E. M., Cichowolski, S., Goss, W. M., & Pineault, S. 2003, in IAU Symposium, Vol. 212, AMassive Star Odyssey: FromMain Sequence to Supernova, ed. K. van der Hucht, A. Herrero, & C. Esteban, 596+

Cappa, C. E., Vasquez, J., Pineault, S., & Cichowolski, S. 2010, MNRAS, 403, 387.

Elmegreen, B. G. 1998, in Astronomical Society of the Pacific Conference Series, Vol. 148, Origins, ed. C. E.Woodward, J.M. Shull, & H. A. Thronson, Jr., 150+.

Garmany, C. D. & Stencel, R. E. 1992, A&AS, 94, 211.

Heiles, C. 1979, ApJ, 229, 533.

Kalberla, P. M. W., Burton, W. B., Hartmann, D., et al. 2005, A&A, 440, 775.

Perna, R. & Raymond, J. 2000, ApJ, 539, 706.

Pineault, S. 1998, AJ, 115, 2483.

Reich, W., Fuerst, E., Reich, P., & Reif, K. 1990, A&AS, 85, 633

Taylor, A. R., et., & al,. 2003, AJ, 125, 3145

Tenorio-Tagle, G. 1981, A&A, 94, 338.

Vasquez, J., Cappa, C. E., Pineault, S., & Duronea, N. U. 2010, MNRAS, 405, 1976.

Weaver, R., McCray, R., Castor, J., Shapiro, P., & Moore, R. 1977, ApJ, 218, 377.