Multiwavelength Study of the Cas OB5 Supershell

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Abstract

We present the results of a multiwavelength study of a large, expanding shell around the Cas OB5 association. Based on the analysis of HI, CO and infrared data the main parameters of the shell were determined. We estimated the total mass in the shell to be $\approx 7.5 \times 10^5\,\mathrm{M}_\odot$.
KEYWORDS: *ISM:bubbles-ISM:individual(Cas OB5)*

1. Introduction

It is well known that large shell-like structures are relatively common in the disk of spiral galaxies. While the formation of medium size bubbles can be explained by the influence of a single SN event or the stellar wind of massive stars, the size of the largest galactic structures are exceeded by a few orders of magnitude than that created by single event. It is established that these large shells are formed by the energy release of massive stars in OB associations, may be created by impacts of high velocity clouds or its energy input may connect with Gamma-Ray Burst events.

In the last decades several neutral hydrogen shells were investigated apparently related to galactic OB associations (e.g. Cep OB2 (Kun et al., 1987); Orion OB1 (Brown et al., 1995); Perseus OB1 (Cappa & Herbstmeier, 2000)). In our study we investigated the ISM in the vicinity Cas OB5. In this area a large elongated HI shell was found by Fich (1986) with a center position of $\mathrm{l} = 117.5°, \mathrm{b} = 1.5°$. It was suspected that some SN events occured in the pre-rarified medium of the HI shell and these supernovae actively engaged in enlarging the HI shell. Schwartz (1987) found a far infrared ring $(\mathrm{l} = 118°, \mathrm{b} = 2°, \mathrm{diameter} = 5°)$ close to the HI shell defined by Fich. Using the diffuse infrared emission originating from this region Kiss et al. (2003, in prep.) identified a far infrared loop GIRL 117+01 at a position similar to Schwartz's. We used HI, CO and infrared data to determine the important parameters of this shell.

2. HI data analysis

In order to study the distribution of HI gas in the environment of Cas OB5, we analyzed the HI emission in the region $108° \leq b \leq 127°$ and $-7° \leq b \leq 9°$ over the velocity interval from $-100\,\mathrm{kms}^{-1}$ to $+30\,\mathrm{kms}^{-1}$. The data were obtained from the Leiden–Dwingeloo HI survey (Hartmann et al., 1997).

Our investigation revealed a large HI shell in the velocity range $[-60\,\mathrm{kms}^{-1} \leq v \leq +3\,\mathrm{kms}^{-1}]$ surrounding the OB association. The projected image of the loop extends to $\sim 8.5°$ in both directions. In Fig. 1 we display the distribution of the neutral hydrogen emission integrated within the velocity range above.

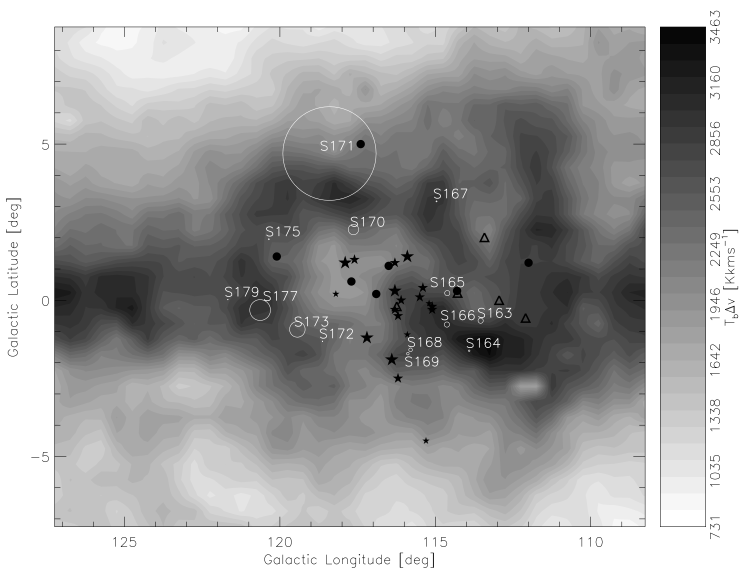

Figure 1: The integrated HI emission map through the velocity range $-60\,\mathrm{kms}^{-1}$ to $+3\,\mathrm{kms}^{-1}$. The displayed Sharpless HII regions are indicated by circles, whose diameter show the mean angular extent of the objects. The star symbols denote the members of the association while the filled circles and triangles mark the SNRs and pulsars respectively

On the basis of the distance to Cas OB5 and HII regions (Sharpless, 1959) encircling the structure we applied a distance of 2.5 kpc for the shell. We assumed that the HI emission is optically thin. After the removal of the background we determined the mass of the HI shell by summing up the column densities of the individual points associated with the shell. This yielded a mass of $M_{sh} \sim 6.3 \times 10^5 M_\odot$. The approaching side of the shell is twice as massive twice as the receding one. This feature sets the true systemic velocity of the center of the expansion to $v_{LSR} \approx -38 kms^{-1}$ and provides a momentum-weighted expansion velocity (Ábrahám et al., 2000) of $v_{eff} \approx 20 kms^{-1}$.

3. Molecular gas in the shell

Heyer et al. (1998) found several large voids of CO emission in the integrated intensity images produced by the FCRAO CO Survey of the Outer Galaxy and demonstrated that there is no extended emission within these voids at a level > 50 mK. One of the most prominent voids is centered at $l = 117.6°, b = 0.0°$ and coincides with the Cas OB5 shell.

In order to estimate the molecular gas mass in the shell we used the Outer Galaxy Survey Cloud Catalog compiled by Heyer et al. (2001). To find the clouds associated with the structure we cut the HI data cube for subsequent $5\, kms^{-1}$ wide slices and searched for clouds in the given velocity range in the shell area. In the velocity interval $v \leq -20\, kms^{-1}$ the CO emission originates from the Local Arm therefore we did not consider these clouds in the following.

Using the parameters of the associated clouds (Heyer et al., 2001) and based on the assumption that these clouds have the same distance as the shell we were able to derive the mass of the molecular shell. We estimate the total molecular gas mass to be $\sim 1.2 \times 10^5 M_\odot$. It should be noted that this method has significant uncertainties since the CO 1-0 line is usually optically thick in molecular clouds.

4. Infrared data

The Cas OB5 shell can be identified in the COBE/DIRBE maps of this region. In order to determine the dust mass in the shell we used the 100 and 240μm COBE/DIRBE data. Assuming ν^2 emissivity law we calculated the dust surface density following the method by Hildebrand (1983). The total cold dust mass of the structure was derived by summing up the surface density values of the appropriate COBE/DIRBE pixels. This resulted in $9.5 \times 10^3 M_\odot$.

5. Summary

We investigated the ISM in the vicinity of the Cas OB5 association based on HI, CO and infrared data, and we identified a large shell at each different wavelength. The whole structure is at a distance of 2.5 kpc and is about 190 pc in radius. The expansion velocity of the shell is $\sim 20\,\mathrm{kms}^{-1}$. The total swept up mass is $\sim 7.5 \times 10^5 \mathrm{M}_\odot$

Acknowledgements

This work has been partly supported by the Hungarian Research Fund (OTKA T-034998).

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