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THE KINEMATICS OF THE SUPERBUBBLE SMC 1 IN THE SMALL MAGELLANIC CLOUD

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RESUMEN

En este trabajo reportamos el campo de velocidades radiales de la superburbuja SMC 1 en la Nube Menor de Magallanes, obtenido de observaciones en Hα con un interferómetro de Fabry-Perot de barrido. Las observaciones revelan la presencia de un cascarón esférico de 600 pc de diámetro. Las estimaciones para la velocidad de expansión, edad y energía cinética resultan en 40.8 km s^{-1}, 4.5×10^6 años y 2.0×10^{51} erg respectivamente.

ABSTRACT

In this work we report the radial velocity field of the superbubble SMC 1 in the Small Magellanic Cloud, obtained from scanning Fabry-Perot interferometer observations at Hα. The observations reveal the presence of a complete spherical shell of 600 pc diameter. From these observations the estimate for the expansion velocity, age and kinetic energy yields 40.8 km s^{-1}, 4.5×10^6 yr and 2.0×10^{51} erg respectively.

Key words: **MAGELLANIC CLOUDS — ISM: BUBBLES — ISM: KINEMATICS AND DYNAMICS — ISM: INDIVIDUAL OBJECTS: SMC 1**

1. INTRODUCTION

Several shell-like structures have been detected in many spiral and irregular galaxies. A fundamental problem with these objects is the identification of the energy source. Stellar winds of massive stars in an OB association, supernova explosions or clouds falling into the disk of a galaxy, are the mechanisms that can explain the formation of large dimension structures (hundreds of parsecs or more). The nine supershells observed in the Large Magellanic Cloud have radii between 300 and 700 pc. In almost all the cases a stellar cluster with young stars or a large stellar association is found interior to the shell. Bordering the shells, there are young H II regions, OB associations, young supernova remnants and smaller shells, all of which indicate recent star formation activity (Tenorio–Tagle & Bodenheimer 1988 and references therein). In the Small Magellanic Cloud (SMC), only one superbubble has been detected in the optical (Meaburn 1980). The structure, named SMC 1, has a radius of 300 pc and is located in the wing of the galaxy. Center coordinates (1950) are $\alpha = 1^h 28^m$, $\delta = -73^\circ\ 35'$.

2. DESCRIPTION OF THE INSTRUMENT

The fields used in this work are part of an Hα survey of the Small Magellanic Cloud (Le Coarer et al. 1993). The equipment used was a 36-cm telescope equipped with a focal reducer, a scanning Fabry-Perot interferometer and a photon counting camera. General characteristics of this equipment can be found in Amram et al. (1991) and Le Coarer et al. (1992). Data reduction was performed with a dedicated software. Calibration interferograms, obtained by scanning the diffuse light of both neon and hydrogen lamps, allow the derivation of the phase–map which gives the wavelength origin of each pixel.

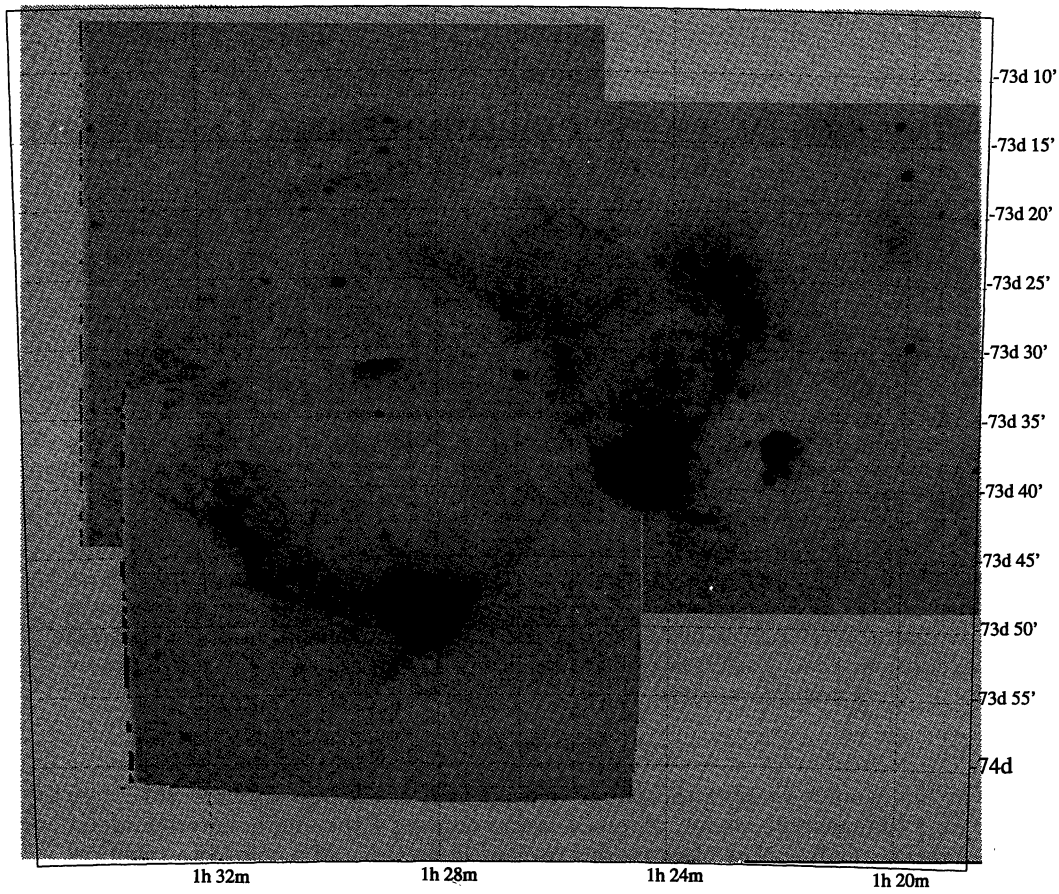

Fig. 1. Monochromatic map of the superbubble SMC 1 in the Hα line.

3. RESULTS

3.1. Velocity Field

Figure 1 shows the monochromatic map of the superbubble SMC 1. It has a filamentary and almost circular appearance and there is an irregular region to the North–West apparently associated. The angular size is about 31 arcmin, equivalent to 600 pc at the SMC distance of 65 kpc. In Figure 2 (Plate 3) the velocity field of the superbubble SMC 1, obtained from the velocity profiles of each pixel in the field, is shown. The colors give an indication of the velocity: blue, 150 km s^{-1}, green, 160 km s^{-1}, yellow, 170 km s^{-1}, and red 180 km s^{-1}. From this map it can be seen that the region to the North–West does not follow the same distribution of velocity as the circular structure and it is likely a structure not belonging to the superbubble. From the analysis of the velocity field we found three velocity components: an almost uniform velocity component (identified as the H II region associated), which is the brightest and has large broad radial velocity profiles, a red or receding component and a blue or approaching component. The average velocity for these components respectivley are 173 km s^{-1}, 203.8 km s^{-1} and 133.9 km s^{-1}. The pattern does not follow the usual law for the expansion of a spherical shell, in order to estimate the expansion velocity of the supershell we take half of the maximum velocity difference between the red and blue components, this is 40.8 km s^{-1}.

3.2. Derived Parameters

From an expansion velocity of 40 km s^{-1} and a radius of 300 pc we derive an age corresponding to 4.5×10^6 yr. From our photometric calibration we estimated a shell Hα surface brightness

$$S(H\alpha) = 7 \times 10^{-7} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1} ,$$

from which we derive the emission measure

$$EM = 7.9 \text{ cm}^{-6} \text{ pc} .$$

Assuming that most of the swept interstellar mater is concentrated in the shell we estimated its electronic density $n_e = 1.1$ cm^{-3}, and the preshock density for the medium $n_o = 0.07$ cm^{-3}. This implies a kinetic energy of expansion $E = 2.0 \times 10^{51}$ erg. On the basis of the comparison with theoretical models of superbubble formation, the most likely explanation for the formation of this supershell is the combined action of the stellar winds and supernova explosions of approximately 200 massive stars (McCray & Kafatos 1987).

4. CONCLUSIONS

From scanning Fabry-Perot interferometer observations at Hα we have analized the velocity field of the superbubble SMC 1, the single superbubble detected in optical wavelengths in the Small Magellanic Cloud. We have estimated the main parameters and found that those agree with a model of combined action of stellar winds and supernova explosions of about 200 massive stars.

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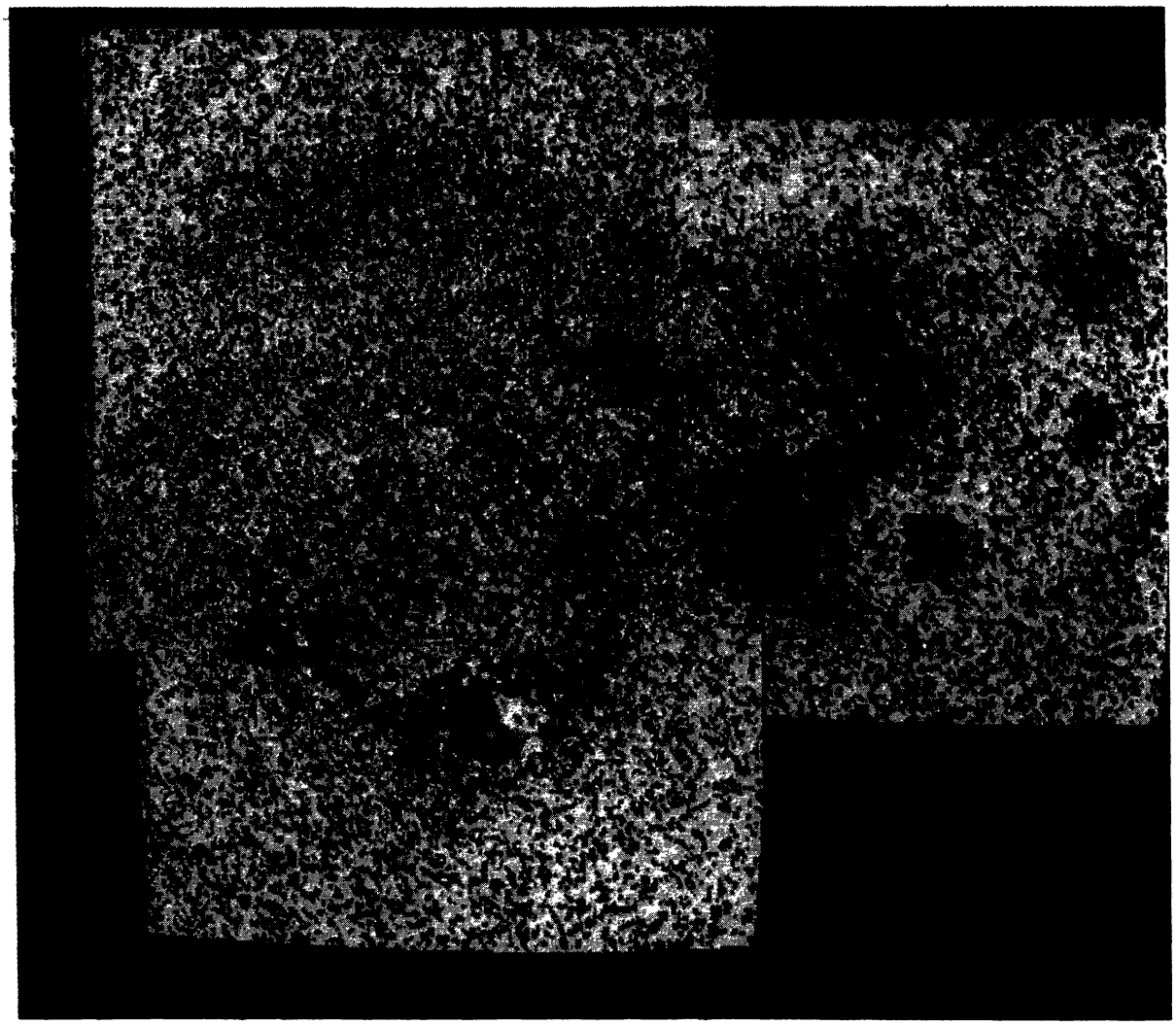

Fig 2. Velocity field of the superbubble SMC 1 in the Small Magellanic Cloud. The colors give an idea of the value of the velocity: *blue*, 150 km s^{-1}, *green*, 160 km s^{-1}, *yellow*, 170 km s^{-1}, and *red*, 180 km s^{-1}.