THE W28 SUPERNOVA AND THE SURROUNDING INTERSTELLAR MEDIUM

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A large shell, 1.5 degrees in diameter, outlined by nebulosity and dust clouds has been found centred on the W28 supernova remnant. Obscuration has been studied over a 2 degree square area centred on W28. The W28 SNR is coincident with a region of reduced obscuration. The densest parts of the obscuration $A_B \geq 4^m$ is coincident with the molecular clouds associated with M20 and the OH maser to the south of M20.

The observed absorption is interpreted as being the result of the expansion of the W28 SNR into an older pre-existing SNR or stellar wind bubble.

1. INTRODUCTION

The young clusters NGC 6530, NGC 6514 and Bo 14 (10^6 yrs) the HII regions M8 and M20 and the W28 supernova remnant (6×10^4 yrs) all lie at distances of about 1.5kpc near l = 6.0°; b = 0.0°. The apparent proximity of these young objects has led to the suggestion that a physical link exists between them (Goudis, 1976; Stalibovskii and Shevchenko, 1981).

In 1979 a large, 1.5 degree diameter, low surface brightness, arc of nebulosity and dust clouds was found linking M8 and M20 (Figure 1) (Zealey et al. 1982, Hartl et al. 1981). This arc is centred on the W28 radio SNR and appears to pass across the face of M20. Here it is seen as the E-W dust lane of the Trifid. This extensive nebulosity is therefore foreground to M20, and possibly passes behind M8.

2. THE OBSCURATION

In order to further study the link between this large shell, W28, M8 and M20 we have carried out star counting procedures in their neighbourhood. A deep blue ESO/SERC Sky Survey plate of Field 521 was

J. Danziger and P. Gorenstein (eds.), Supernova Remnants and their X-Ray Emission, 267–272.

https://doi.org/10.1017/S0074180900033982 Published online by Cambridge University Press

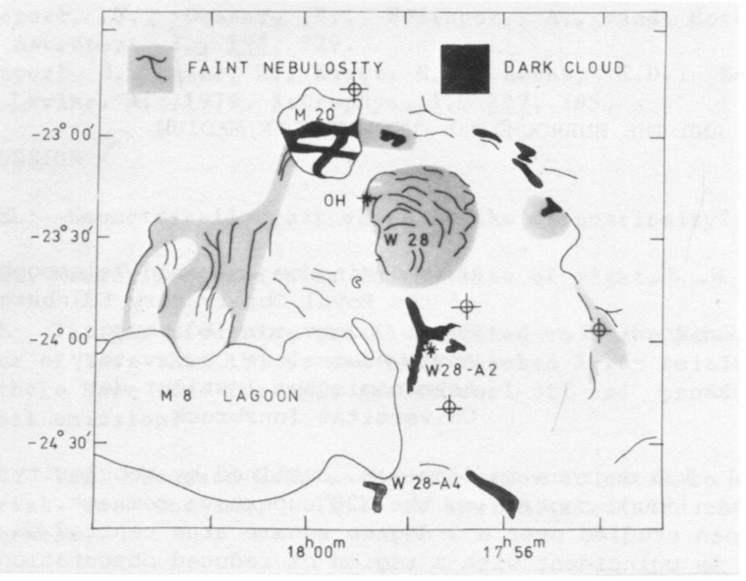

Fig. 1. A diagram of salient features in the M8, M20, W28 region. Indicated are the W28 SNR, the M8, M20 HII regions, the W28-A2 compact HII region and the OH maser source.

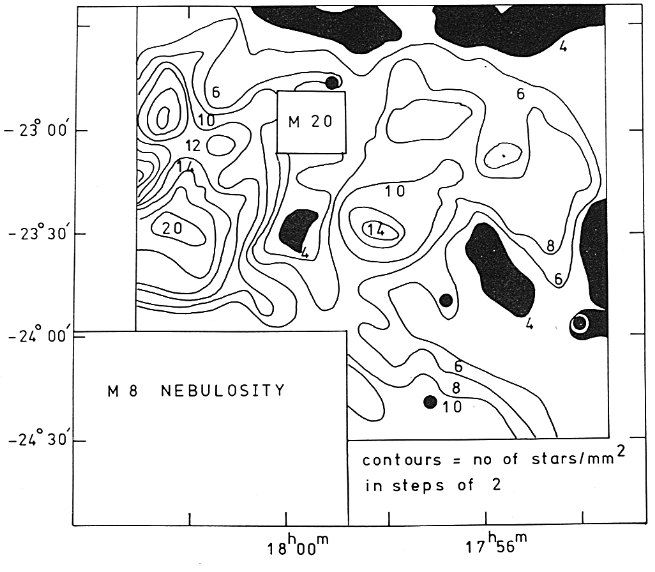

Fig. 2. A star density map of the M8, M20, W28 region.

measured using the fast, automated, measuring, machine COSMOS, operated by the Royal Observatory Edinburgh. (Pratt et al. 1975; MacGillivray 1981). The data was analysed to provide star positions and magnitude. The magnitudes were derived by using a standard photoelectric sequence

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in NGC 6494 in a neighbouring field. The sequence was transferred to the region of W28 using an iris photometer and working via intermediate sequences in the overlap regions of the two fields. The NGC 6530 sequence (Walker 1957) was used to check the accuracy of the transfer process. The data is displayed as a star density map (Figure 2). The resolved elements are 3 millimetres by 3 millimetres.

Several regions were selected as being typical of heavily obscured areas and lightly obscured or unobscured areas. A comparison of the regions is shown in Figure 3, in the form of log N_m versus M

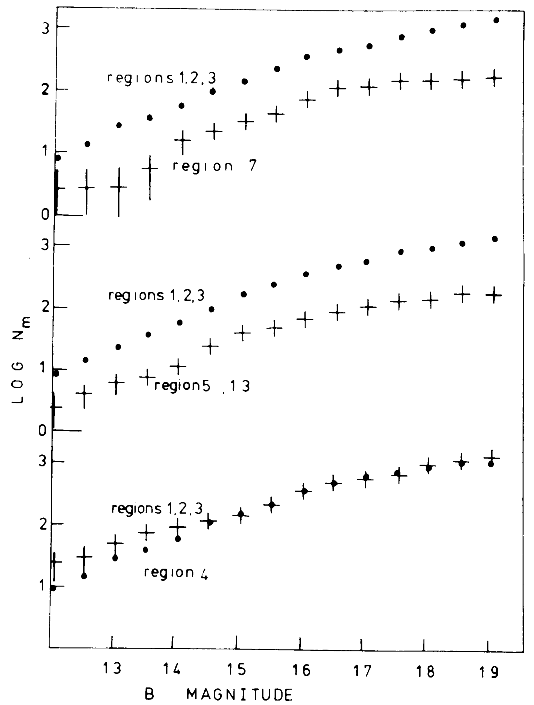

Fig. 3. Log N_m versus M diagrams for regions of heavy and intermediate obscuration. Crosses are for the obscured region, dots for the unobscured comparison region.
Top diagram W28-A2 compact HII region
Middle diagram CO/OH molecular cloud
Bottom diagram W28 + comparison

plots (where N_m is the number of stars per square millimetre brighter than magnitude m).

The star density map shows three main features

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(i) A maximum in density coincident with the centre of the W28 radio SNR (RA $17^H 57^M 35^S$: DEC -23° 28' 30"). Half density points coincide with the remnants edges.

(ii) High densities are also found at the eastern edge of the area measured.

(iii) Low densities exist between M8 and M20, near the molecular clouds found in CO and OH by Wootten (1981) and Pastichenke and Slysh (1974), and to the northern and western edge of the region.

3. DISCUSSION

In view of the lack of known star clusters, coincident with the observed positions of peak star density, and the similarity in peak densities at well separated positions, it seems that the density map is best interpreted as being due to varying absorption. The coincidence between the position of maximum star density and the W28 SNR can be interpreted as the SNR having made a cavity in an extensive sheet of obscuration ($A_B \geq 4^m$). The similarity of the star density near W28 and in other unobscured regions measured indicates that the W28 SNR has almost totally penetrated the obscuring sheet. The sheet must therefore be less than L = 20pc thick (dimension of W28 SNR at 1.5kpc). The density of the sheet is therefore $N_H \geq 120$ cm^{-3} using $N_H = 630\ A_B/L$ cm^{-3} (Jenkins and Savage 1974).

An upper limit to the distance of the sheet can be estimated by assuming that it is totally opaque and all of the stars are foreground objects (Armandroff and Herbst, 1981). Using $d = 320\ N_{CT}^{0.57}$, where N_{CT} is the number of stars in a 5' diameter area, they found an upper limit of 2200 pc for the CO molecular cloud region. Star densities show that the densest parts of the obscuring sheet have similar upper limits to their distances.

4. INTERPRETATION

If we discount the possibility of a chance alignment of two SNR we conclude that the W28 SNR, the large 1.5 degree diameter shell and the obscuration are coincident and lie in the immediate neighbourhood of the M8, M20 HII regions. Two possible scenarios of the evolution of this complex are:

(i) <u>A single event</u>

The large 1.5° diameter shell and the W28 SNR result from a single event which occurred about 6 x 10^4 years ago. This event occurred at the edge of a dense sheet of material, perhaps associated with the Sagittarius spiral arm. Expansion occurred more rapidly in the less dense material than into the dense sheet. The rapid expansion produced

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the large shell. The slower expansion into the sheet produced the smaller, more intense W28 SNR. Star formation, as evidenced by the OH maser sources and W28 - A2 region has occurred at the edge of the W28 SNR. The HII regions M8, M20 and the young clusters are not a direct result of the W28 event's expansion.

(ii) Events of different periods

More than 10^6 years ago, star formation occurred in an expanding SNR or stellar wind shell. The M8 and M20 regions are a result of this epoch of star formation. More recently a high mass star, in or near this shell, evolved to become a supernova, producing the W28 SNR. This young, rapidly expanding remnant, has tunneled into the old fossil remnant, rejuvenating it. The old remnant is now seen as a 1.5 degree diameter shell. Star formation has been triggered in the old shell by W28.

In order to distinguish between the models, further molecular observations are required covering a large area. However, perhaps the existence of a pulsar PSR 1754-24 near the edge of the large shell, provides evidence for an old supernova event. The pulsar has a period of 0.234 seconds, indicating that the associated event is older than 10^6 years(Large 1970). It is possible for the pulsar to have travelled the projected distance of 29pc from the event centre in that time.

Acknowledgments

One of us (HH) wishes to thank the Austrian "Fonds zup Forderung der Wissenschaftlichen Forschung (project 3487) for financial report.

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https://doi.org/10.1017/S0074180900033982 Published online by Cambridge University Press