

## STAR FORMATION AND SUPERNOVAE

T. N. Rengarajan, R. P. Verma and K. V. K. Iyengar  
Tata Institute of Fundamental Research  
Homi Bhabha Road, Bombay-400 005, India

We have searched for associations between supernova remnants (SNR) and IRAS sources. For this purpose we used 117 SNRs from the catalogue of van den Bergh and searched the IRAS Point Source Catalogue for sources associated with SNRs and having a flux density spectrum increasing with wavelength beyond 25  $\mu$ m. For each SNR a square box of area  $2 \text{ deg}^2$  was searched for sources. The difference between the observed number within the SNR (with 10% radial extension) and the number expected on the basis of source density in the box excluding the SNR itself, was termed the excess. The results are shown in Table 1. There are a few SNRs which show significant excess on an individual basis. The cumulative excess of the rest has a 4  $\sigma$  significance. For 58 SNRs with well defined maps, the data in Table 1 show that the significance of excess increases in the shell area. Figure 1 shows the excess as a function of distance to SNR. Also plotted are average excesses for different distance intervals. The increase in excess as distance decreases, strengthens the hypothesis of association with SNR, since at shorter distances, more IRAS sources will be above the threshold of detection.

Figures 2-4, show radio/X-ray maps of Cygnus loop, Pup A, and HB21 with the positions of IRAS sources shown as crosses. The association of IRAS sources with the shell is clearly seen. This is most marked in Cygnus loop. Most of the SNRs having high excess also have ages in excess of 10,000 years.

The associated sources are most likely to be (a) dusty knots heated by the X-ray emitting plasma or (b) young protostars whose formation was triggered by the SN shock. Further observations in the near-infrared and in molecular lines are needed to elucidate the nature of these sources.

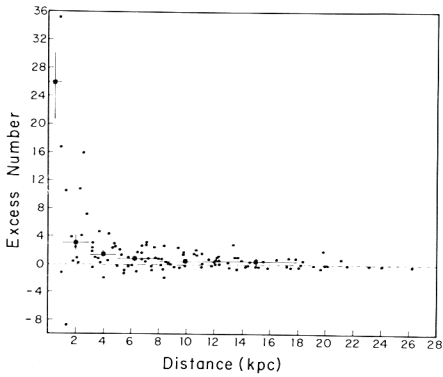


Fig. 1

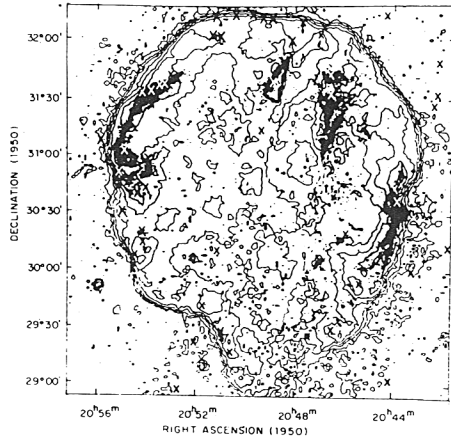


Fig. 2 Cygnus Loop  
X-ray map ; X IRAS Source

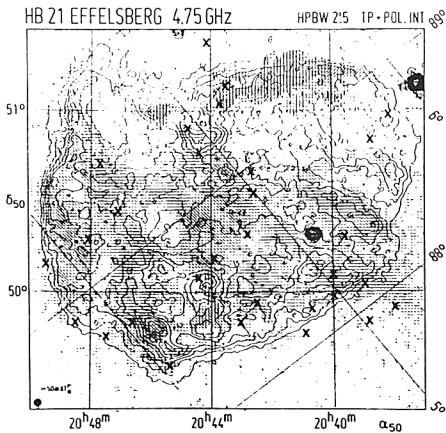


Fig. 3

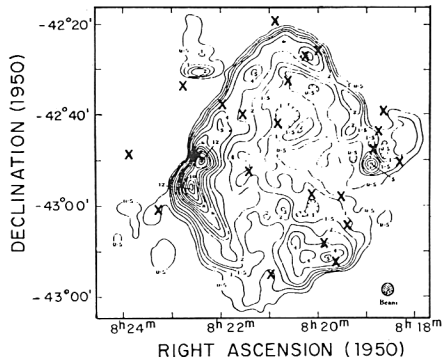


Fig. 4 Pup A (408 MHz)

| Object                         | No. of IRAS Sources |          |             |
|--------------------------------|---------------------|----------|-------------|
|                                | Observed            | Expected | Excess      |
| Cygnus loop                    | 51                  | 15.9     | 35.1 ± 7.2  |
| IC 443                         | 14                  | 6.9      | 7.1 ± 3.8   |
| Pup A                          | 20                  | 4.1      | 15.9 ± 4.5  |
| W 28                           | 22                  | 11.2     | 10.8 ± 4.7  |
| HB 21                          | 28                  | 17.6     | 10.4 ± 5.3  |
| S 147                          | 63                  | 45.3     | 17.7 ± 9    |
| 111 SNRs                       | 347                 | 283.8    | 63.2 ± 18.6 |
| 58 SNRs*                       | 222                 | 172      | 50 ± 15     |
| Shells <sup>†</sup> of 58 SNRs | 109                 | 55       | 54 ± 11     |

\* SNRs with well defined peripheries

† 0.85 < R/θ < 1.05