N93-26776

IRAS Studies of Galactic Supershells

Jon M. Saken (Univ. of Colorado, CASA), J. Michael Shull (Univ. of Colorado, CASA & JILA), Robert A. Fesen (Dartmouth College)

Using IRAS Skyflux images and a new catalog of OB stars in the Cygnus region, we have identified a complete infrared supershell surrounding the Cyg OB1 Association (Saken *et al.* 1992). This supershell is seen as a conspicuous, well-defined $2° \times 5°$ region deficient of IR emission, with a limb-brightened edge and dimensions of about 50×130 pc at 1.5 kpc. The shell's elongated morphology is consistent with OB-star subclustering over the $\sim 10^6$ yr age of the bubble. With a parent star cluster still visible (10 O stars between 25 and 45 $M_\odot$, 3 – 4 Wolf-Rayet stars, and the possibility of 3 – 5 more massive stars that died as supernovae) the Cyg OB1 supershell is an excellent object for studying the formation and evolution of Galactic supershells. A discrepancy between the ≤ 1 Myr bubble age estimated from its size and the 5 Myr cluster turnoff age (45 $M_\odot$) may require non-coeval massive star formation to explain the number of post-main-sequence stars and limit the number of past supernovae.

The bubble appears too small for the 5 Myr age inferred from the main-sequence turnoff, particularly if 3 – 5 supernovae had occurred from stars of initial mass $45-80$ $M_\odot$. If we assume that the cavity was produced by winds and supernovae from spatially distributed massive stars, we can model the dynamics as a set of ~ 3 overlapping bubbles, each of radius approximately equal to the minimum lateral size (25-30 pc). In spherical geometry, the radius and velocity of a bubble (Weaver et al. 1977) driven by a constant wind luminosity $L_o = (10^{38}\ \mathrm{ergs\ s^{-1}})L_{38}$ into a medium of constant ambient density $\rho_o = 1.4 m_H n_o$ yields a shell age of $t = (2.2 \times 10^5\ \mathrm{yrs})(n_o/L_{38})^{1/3} D_{1.5}^{5/3}$, for $R_s = R_{\min} = (26.2\ \mathrm{pc})D_{1.5}$, far less than the association age of 5 Myr inferred from the main-sequence turnoff. Pushing all the scaling parameters to reasonable limits ($L_{38} = 0.2$, $n_o = 10$, and $D_{1.5} = 1.2$), one could arrive at a bubble age of 10^6 yrs – still a factor of 5 less than the inferred association age.

We favor a scenario involving non-coeval star formation. The evolved supergiants in the H-R diagram probably formed several Myr earlier than the 25 – 45 $M_\odot$ stars now on the main sequence. Non-coeval star formation has also been suggested to explain the H-R diagrams in three Magellanic Cloud clusters (Massey et al. 1989a,b). If we adopt an age for Cyg OB1 in the range 1 – 2 Myr, the initially most massive stars may now be Wolf-Rayet stars, and the superbubble could be driven entirely by stellar winds.

Thus the Cyg OB1 shell appears to be an example of a very young supershell, recently formed from the overlap of subassociation bubbles. The process may be continuing as the shell expands and encompasses new energy sources. The superbubble's nonspherical morphology is probably a result of the spatial distribution of the massive stars in this region.

Following the identification of the Cyg OB1 supershell, we have begun a search of the IRAS data for other supershell candidates using an updated catalog of OB stars (Garmany & Stencel 1992). We have found three examples that may illustrate the evolution of such shells.

IRAS data in the region of Cas OB6 shows two distinct IR bubbles around two sub-clusters of the association. The IR bubbles are coincident with the optical shells in Cas OB6 but differ substantially in morphology. These bubbles may represent an early stage in the development of shells like the one in Cyg OB1; over time they may expand and overlap to form a similar structure.

Another limb-brightened oval cavity can be seen in the IRAS images near Cyg OB8. Since no cluster members are found within the shell, it may be the relic of a previous episode of star formation. A different kind of shell can be seen near the OB association R103, not as a limb-brightened cavity, but as a "blow-out" of the Galactic plane with only a few well defined filaments along its edge. Shells that grow to sufficent size may eventually blowout in this manner, venting material to the Galactic halo.

References

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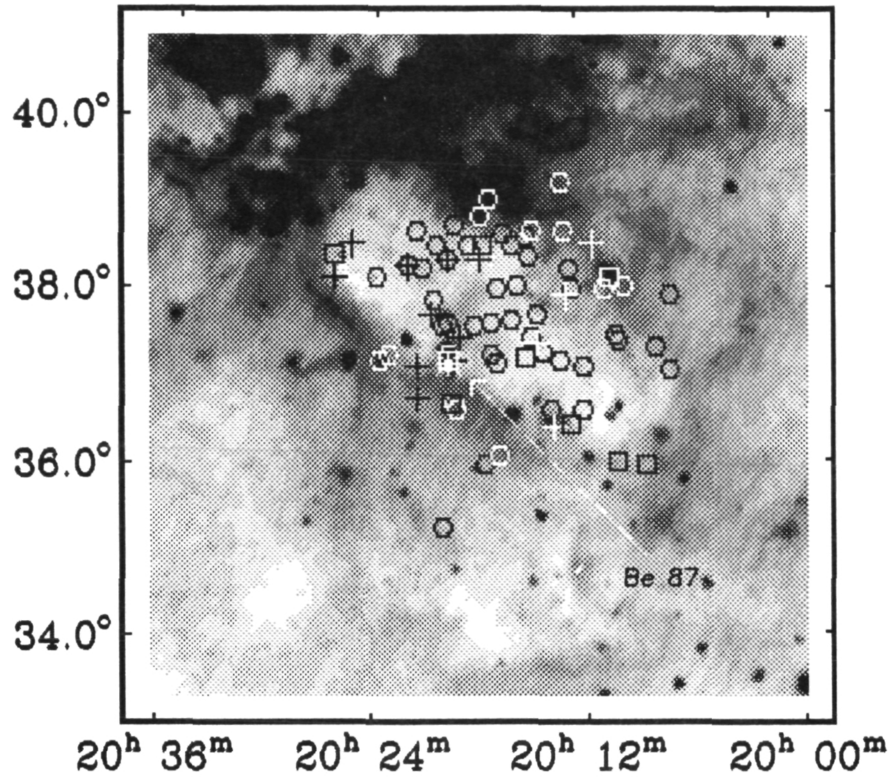
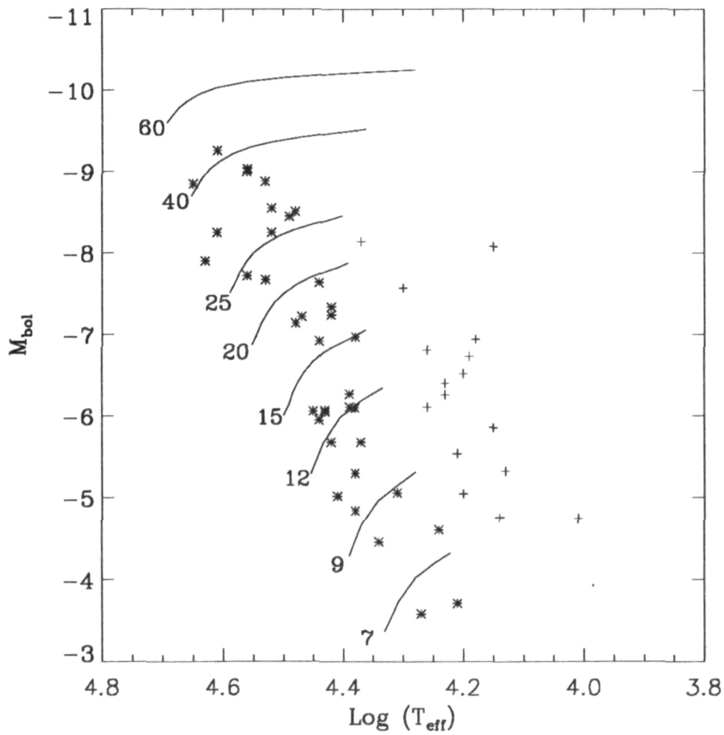


Closeup view of the IRAS supershell overlaid with 77 member OB stars (Garmany & Stencel 1992) and 9 Wolf-Rayet stars near the Cyg OB1 Association. For clarity, all symbols are black or white, depending on the background. Post-main-sequence OB stars are plotted with crosses and Wolf-Rayet stars with squares. Because of the IRAS pixel resolution, only 54 distinct OB stars are shown. The open cluster Be 87, which contains the Wolf-Rayet star WR 142, is shown as an asterisk near the center of the southern cavity boundary.



Hertzsprung - Russell diagram of 53 stars in Cyg OB1 for which estimates of bolometric magnitudes and effective temperatures are available (Garmany & Stencel 1992). Post-main-sequence stars are plotted with a cross. Mass tracks from Maeder & Meynet (1989).