BARREL-SHAPED SUPERNOVA REMNANTS

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Abstract: We argue that the majority of radio supernova remnants have a three-dimensional distribution of emissivity which is barrel shaped, with little emission from the end-caps. We examine some mechanisms which could produce this distribution.

Introduction. Shell-type supernova remnants tend to be roughly circular in outline, suggesting that their emissivity has spherical symmetry. Closer examination reveals systematic departures from circularity - these "defects" have been interpreted as the result of an interaction with irregularities in the interstellar medium. (Whiteoak and Gardner, 1968; Tenorio-Tagle et al, 1985). We offer a simpler explanation: the remnants have cylindrical symmetry.

Two definite barrels : G296.5+10.0 & G327.6+14.6

Maps of G296 and G327 (SN1006) obtained at 843 MHz with the Molonglo Observatory Synthesis Telescope (Mills, 1980) are shown in figure 1. There are three characteristics which are quite inconsistent with spherical symmetry, but are compatible with a barrel shape, (cylindrical symmetry):

* a single axis of mirror symmetry. (In effect, a two-arc appearance).
* a gradient in brightness along the the arcs.
* regions of low (or null) emission where the axis intersects the shell boundary.

These two remnants are at high galactic latitude where a uniform interstellar medium can be expected.

Are all remnants barrels?

Few remnants are as simple and symmetrical as the two examples discussed above. We argue that what is seen is in general a distorted version of the three characteristics: the underlying "barrel" modified by the surrounding medium. The observed brightness distribution depends also on on the orientation of the barrel axis relative to the line of sight. A barrel seen end-on is ring-shaped, whereas it will have a two-arc appearance when seen edge-on .

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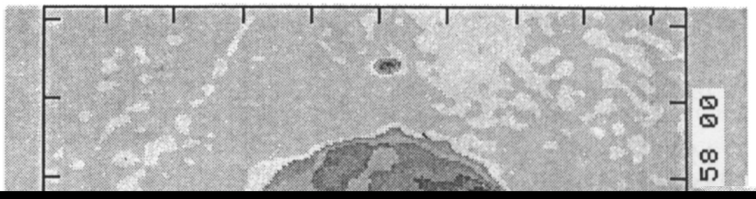

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The expected proportions of each category in the population at large are given below, along with the observed proportions. The agreement is fair, suggesting that a large fraction of all remnants are barrel-shaped.

Supernova remnant morphologies: predicted and observed distributions.

Appearance	Probability of occurrence	
	Predicted	Observed
Ring-shaped	10%	6% (4)
Two arcs	70%	63% (44)
Intermediate	20%	31% (22)
		(70 remnants)

What causes barrels?

(a) Some axial order in the interstellar medium? A smooth density gradient, or a uniform magnetic field will impose some measure of cylindrical symmetry on a remnant. The deep nulls along the cylinder axis are difficult to explain, however.

(b). A cylindrical supernova outburst? G327 is a young remnant (981 years old); G296 is most likely old (Clark and Caswell, 1976). The barrel shape is thus unlikely to be the result of an evolutionary process. We suggest that the remnants are intrinsically barrel-shaped. This might be the result of an outburst concentrated to the equatorial plane. (Bodenheimer and Woosley, 1983).

Conclusions.

* Most remnants have a barrel-shaped distribution of emissivity;
* The cylindrical symmetry is likely to be intrinsic to the supernova outburst, and not imposed on the remnant by some interaction with an ordered structure in the interstellar medium.

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