Radio Supernova Candidates in the M82 Starburst

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An entire population of radio supernova and SNR candidates has been discovered and monitored in the region near M82's nucleus. VLA maps at a resolution of 150 milliarcseconds have thus far detected the order of 100 discrete radio sources in the inner 600 pc nuclear region. None is optically identified due to obscuration, but the brightest sources have radio luminosities and variability behaviour which are comparable to some identified radio SN in other nearby galaxies.

The radio spectra for a dozen of the brightest sources have been well defined up to either 15 or 22 GHz. The spectral indices at 5 GHz are steep, between 0.6 and 1.1, with most being close to $\sim$0.8. These values are typical of radio supernovae in external galaxies, and are steeper than those of galactic SNR's.

For the brightest of these, flux densities at 0.408 GHz and 1.66 GHz have been determined by Unger et al. (1984) with the Jodrell Bank MERLIN array at resolutions comparable to the VLA. For these sources, such data complement the 1.4, 5, 15 and 22 GHz fluxes at the VLA. It appears as a result that the spectra of nearly all the brightest sources exhibit a low-frequency turnover at a few hundred MHz. The fact that their turnovers are all so similar suggests a common cause which is extrinsic to the sources. It is most likely due to free-free absorption in the dense interstellar medium of M82's inner 600 pc region.

Kronberg and Sramek's VLA-monitoring of the flux densities of 30 of the M82 sources has been combined with preliminary population modelling of the brightest 40 sources by B. Glendenning at the University of Toronto. The flux density monitoring programme (as of March 1985) shows wide differences in the sources' variabilities. One source decayed by a factor of 10 in 14 months; some sources show no significant decay or increase at 5 GHz, while others show flux decays ranging from 3 to 9 %/yr. The rate of flux decay does not correlate with flux, as might be expected in a homogeneous population of radio supernovae. The cm- wave spectral index of the brightest

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source, 41.9+58, is constant at 0.9 over the past 5 years, while its luminosity has decreased by 33%.

The histogram of luminosities (Kronberg, Biermann and Schwab, 1985) gives a good form fit to an exponential in log P at the high luminosity end. We have done a simple equation of continuity analysis on the M82 radio source population at a single epoch. We assume that new sources are "born" at an unknown rate, with an initial luminosity "width" centred on a luminosity which is 150 times that of Cas A. They are assumed to decay in flux density until they fall below the detection threshold. We find that the observed form of the luminosity distribution is incompatible with the assumption of an exponential flux decay. It is, however, consistent with a single, common power law decay law, $P(t) = P_1 t^{-m}$. For this case, the best fit gives $m = -0.9 \pm 0.2$, in which case the injection rate is one new source every 2 to 20 years. The derived injection rate is very sensitive to m.

These results must be regarded as preliminary however, since, as discussed above, direct flux density monitoring has shown that the observed rates of flux decay vary widely. This appears prima facie to violate the above assumption of a single decay law in the population analysis. Our program of flux monitoring is planned to continue over the next few years, and will hopefully further clarify the nature and mix of sources involved. They should also detect the next M82 supernova within the near future. Multi-frequency radio smapshots with the VLA are continuing.

I can summarize our present findings by concluding that, when we compare variability and spectral index, there are at least 4 different kinds of radio behaviour among M82's population of nuclear radio sources.

PROTOTYPE	SPECTRAL INDEX	FLUX-TIME BEHAVIOUR	SIZE (mas)
41.9 + 58	-0.9	33 % decay over 5 years	<100
41.5 + 597	-1.1	∿ 100% in one year	<100
44.0 + 595	∿ 0	∿ stable	<100
41.3 + 596	-0.6	stable or slowly decaying	∿300

It could be argued that sources of type "D" are further evolved versions of type "A", a possibility suggested by their larger angular sizes. If so, however, we would have to conclude that the optically thin spectral slope flattens, rather than steepens with time.

At 110 milliarcseconds resolution a large fraction of the sources are partially resolved, and most show strong departures from symmetry. This suggests that in the relatively dense ism near M82's nucleus, radio SN form jet-like structures. In any case we can conclude that their expansion is often very asymmetrical while they are in a radiobright phase.

References

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