SHELL-LIKE STRUCTURE IN 41.9+58, A POWERFUL SNR IN M82

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We have studied the brightest of the many compact radio components, designated 41.9+58, in the central region of M82 (Unger et al. 1984; Kronberg et al. 1985) with the EVN at frequencies of 1.6 and 5 GHz (Wilkinson and de Bruyn, 1984; 1987).

The radio image (resolution 5 m.a.s.) of 41.9+58 reveals an elongated shell-like structure (Figure 1) which at the 5% intensity level measures 33x16 m.a.s. At the distance of M82 (D=3.3 Mpc) this corresponds to a linear size of 0.53x0.26 pc. The total flux density of 41.9+58 at the epoch of our observations, October 1985, was about 60 mJy which corresponds to a 5 GHz luminosity some 80 times that of Cas A at its present age.

Our EVN image, and the steady overall flux decay, leads us to favour the hypothesis that 41.9+58 is indeed a SNR as was first suggested by Kronberg and Wilkinson (1974). The flux density of the source has been decaying steadily for the last 20 years, the decay rate being about 8.5%/year at present at both 1.6 and 5 GHz (Kronberg and Sramek, 1985; Unger et al., in preparation). Since the earliest detection of the source by Bash (1968) the source has decreased in flux density by about a factor 3.5. At 1.4 GHz the reduction in the total flux of M82 (3C231) due to the decay of 41.9+58 alone is 0.7±0.2 Jy in a 25 year timespan and this can be detected in the catalogued and recently measured total flux densities.

We can set a (conservative) upper limit to the angular expansion rate along the major axis at 5 GHz between 1980.0 and 1985.8 of 1 m.a.s./year using our EVN data only. (The formal fits yield an expansion rate of about 0.7 m.a.s./year). A careful analysis of the many fragmentary observations of 41.9+58 which have been made since the mid 1970s shows them to be consistent with this estimate and, in fact, all point to a source diameter greater than 15 m.a.s. We have therefore been forced to discount Geldzahler et al.'s (1977) report that 41.9+58 had a source diameter of 1.5 m.a.s. in 1974. The upper limit of 1 m.a.s./year on the angular expension rate translates to a limit on the radial expansion velocity of 7800 km/s along the major axis. The kinematic age, for undecelerated expansion, is therefore ≳35 years.

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If we fit the observed flux density decay of 41.9+58 by a powerlaw of the form $S \propto t^{-\beta}$ then $dS/Sdt=-\beta/t$. The present rate dS/Sdt equals -8.5%/year hence $\beta/T=(12 \text{ years})^{-1}$, where T is the age of the object. Within the context of Shklovsky's (1968) adiabatically expanding, magnetic flux conserving model, which predicts $S \propto r^{-2\gamma}$, where $\gamma=1-2\alpha$ and $\alpha \sim -0.75$, the value of $\beta=5$ (for dr/dt=constant); the decay age T would then be 60 years. The "Shklovsky' method, when applied to Cas A, yields an age of about 500 years which is about 1.6 times larger than the canonical value of about 300 years. Applying, naïvely, this factor of 1.6 to 41.9+58 would bring its decay age remarkably close to the limit on the kinematic age. We therefore suggest an age of 40 years, i.e. an explosion date around 1945, for the SN that gave birth to 41.9+58.

The extra ordinary radiopower of 41.9+58 puts in in the same class at that of SN1979c, the SNR in NGC4449 (Seaquist and Bignell, 1978; de Bruyn, 1983), and the recently discovered SN1986j in NGC891. We speculate that these SNR's derive from a separate class of type II SNe (radio hyper-novae!) which become about 25-50 times as bright as most (optically normal) type II SNe like SN1970g, SN1980k and SN1981k (Weiler et al., 1986). Cas A might also belong to the class of radio hypernovae. Evidence in support of this contention is presented, along with a more extensive account of the material presented here, in Wilkinson and de Bruyn (1987).

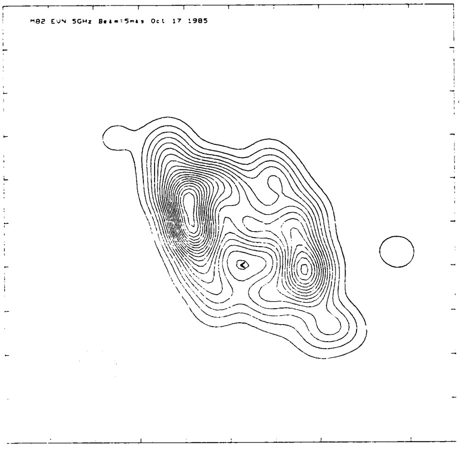

Fig. 1: 5 GHz EVN 5-station hybrid map of the brightest radio source in M82. The total flux density of the source was 60 mJy. Contours are drawn at levels of -5, 5 (5) 95% of the peak flux density of 8.9 mJy. The circular restoring beam measures 5 m.a.s. at half power. Tickmarks are 6 m.a.s. apart, north is up and east to the left.

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