VLBI OBSERVATIONS OF SUPERNOVA 1987A

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ABSTRACT. VLBI observations at 2.3 GHz of SN1987A on 28 February 1987 yielded no fringes, implying, for an optically thin shell, a lower bound on the (outer) diameter of 1.9 mas. From the comparison of the VLBI and optical results, we infer that the radiosphere of SN1987A was either about equal to, or larger than, the photosphere of the supernova five days after the explosion.

1. OBSERVATIONS

Following the detection of radio emission from Supernova 1987A (Turtle *et al.* 1987), we made VLBI observations on each of the days 28 February and 1,2 March 1987 with an interferometer composed of the 26-meter-diameter antenna in Hartebeesthoek, South Africa, and a 34-meter-diameter antenna (DSS 42) in Tidbinbilla, Australia. The observations of SN 1987A were alternated with those of calibrator sources, mostly of 0537-441 but sometimes also of 0521-365, and lasted for 2.5 to 3.5 hours on each day. The fringe spacing was about 2.9 mas. A bandwidth of 56 MHz, centered at 2280 MHz, was recorded at each site (with an offset of 2 MHz having been inadvertently introduced between the band recorded at one site and that at the other). The data were correlated with the Mark III processor at the Haystack Observatory.

2. RESULTS

No fringes have yet been found from the supernova's radio emissions. Fringes were obtained for both (time-variable) calibrator sources with estimated standard errors of about 10% for the correlated flux densities (2.3 Jy and 0.44 Jy for 0537-441 and 0521-365, respectively) for each day of observations. The results agreed, perhaps coincidently, to within these tolerances with VLBI measurements made at the same resolution, but five years earlier (Preston *et al.* 1985; Nicolson 1987, private communication). The peaks observed in the correlation coefficients from the supernova data for 28 February correspond to correlated flux densities between 20

M. J. Reid and J. M. Moran (eds.), The Impact of VLBI on Astrophysics and Geophysics, 185–186.

https://doi.org/10.1017/S0074180900134436 Published online by Cambridge University Press

and 25 mJy and to positions on the sky widely scattered over our search area of about $7\rlap{.}''$ in right ascension and $3\rlap{.}''$ in declination, centered at $\alpha(1950.0) = 05^h35^m49\rlap{.}^s942$ and $\delta(1950.0) = 69°17'57\rlap{.}''6$. Each of these coordinates is within the uncertainty of about $0\rlap{.}''3$ of White and Malin's (1987) optical coordinates of the supernova. Thus, we conclude that there likely was no signal from the supernova on 28 February with a correlated flux density exceeding 25 mJy. The observations from the other two days have not yet been processed so thoroughly. A somewhat better bound (about 30% lower), or a detection, is expected when the supernova data are processed in an optimum manner (nonstandard processing in the correlation is required due to the 2 MHz offset, mentioned above).

We compared our upper bound on the supernova's correlated flux density with its total flux density of 69 ± 10 mJy (Turtle *et al.* 1987), determined with the Parkes-Tidbinbilla interferometer at 2.3 GHz a few hours before our VLBI observations on 28 February. Measurements with this short-baseline interferometer (baseline length: 275 km) yielded only upper bounds of about 40 mJy at 2.3 GHz for the flux density from the supernova on 1 and 2 March. Hence, no correlated flux density should be expected from the long baseline on these dates.

By matching an optically thin uniform sphere to the upper bound on the correlated flux density, we estimated a lower bound on the sphere's diameter of 2.5 mas for 28 February, *i.e.* about 120 AU, given a distance to SN1987A of 50 kpc. For an optically thin shell with a shell thickness of about 15% of the shell radius, we obtained a lower bound on the corresponding (outer) diameter of about 1.9 mas. These bounds on the diameter, of course, scale directly with the (assumed) distance to SN1987A.

If we assume that the radiosphere has been expanding linearly from a zero size at the epoch of the neutrino detections (Koshiba 1987), our lower bound on the diameter for the assumption of an optically thin shell corresponds to a lower bound on the expansion velocity of the radiosphere of $\sim 1.6 \times 10^4$ km s^{-1}. Such a bound is comparable to the largest value for the expansion velocity of the photosphere of 1.8×10^4 km s^{-1} inferred from the blueshifted minimum of the absorption trough of the P-Cygni profile of the Hα line on 25 February 1987 (Blanco *et al.* 1987; Hanuschik and Dachs 1987) and thereafter.

3. ACKNOWLEDGEMENTS

We thank Turtle *et al.* (1987) for making their first results available to us prior to publication and Tom Reid, Paul Hutchinson and the staff of the Deep Space Communications Complex, Tidbinbilla, for their support. Partial support for this research was provided by the NSF under Grant AST-8519763.

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