Light Echoes from SN 1987A

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In the five years since the outburst of SN 1987A, light echoes have been used as an efficient way of studying the structure of the interstellar medium close to the supernova.

These echoes are evolving rapidly with time. The expansion rate of the ring was found to be approximately 3 arcsec per month, or about 25 times the speed of light (1). The new image shown here is from a 20-minute exposure taken at the NTT telescope with EMMI, using a filter with a central wavelength of 665.93 and FWHM of 6.64 nm. The size of the outer ring is now 125±3 arcsec and that of the inner ring is 73±2 arcsec. Both rings are brighter at the northern side than at the southern side. A new bright patch appeared at the northern top of the outer ring.

If these echoes arise from a sheet of dust cloud, its geometry is described by

$$\theta = (2b/D^2 \cdot c(t-t_o))^{1/2},$$

where b denotes the distance between the supernova and the dust cloud projected on the line of sight, D is the distance to SN 1987A, and t_o is the time interval between the explosion and the part of the light curve producing the echo (1). The parameters t_o and b were derived by Gouiffes et al. (1988) to be 60±17 days and 316±16 pc for the outer ring, and 40±32 days and 122±10 pc for the inner ring. In Figure 2, the above equation is plotted together with the measured points. The dotted lines are the solution of the above equation using the parameters derived from Gouiffes et al. (1988). No large deviations were recorded for both the inner and outer ring during the most recent observation, which is plotted as solid squares in the figure. For the inner ring a better fit is given by the solid curve in this figure, where the parameters t_o and b are found to be 20 days and 105 pc.

At position angle 165°–211°, there is another bright arc close to the outer ring, but it does not follow the curvature established by the other part of the outer ring. This arc has a very well defined sharp edge, and is apparently connected with the diffuse light outside it. A comparison with early data (cf. Gouiffes et al., 1988) shows that this was already there three years ago and shows no change in its location. This is therefore a physical structure whose nature is quite different compared with the two echoes.

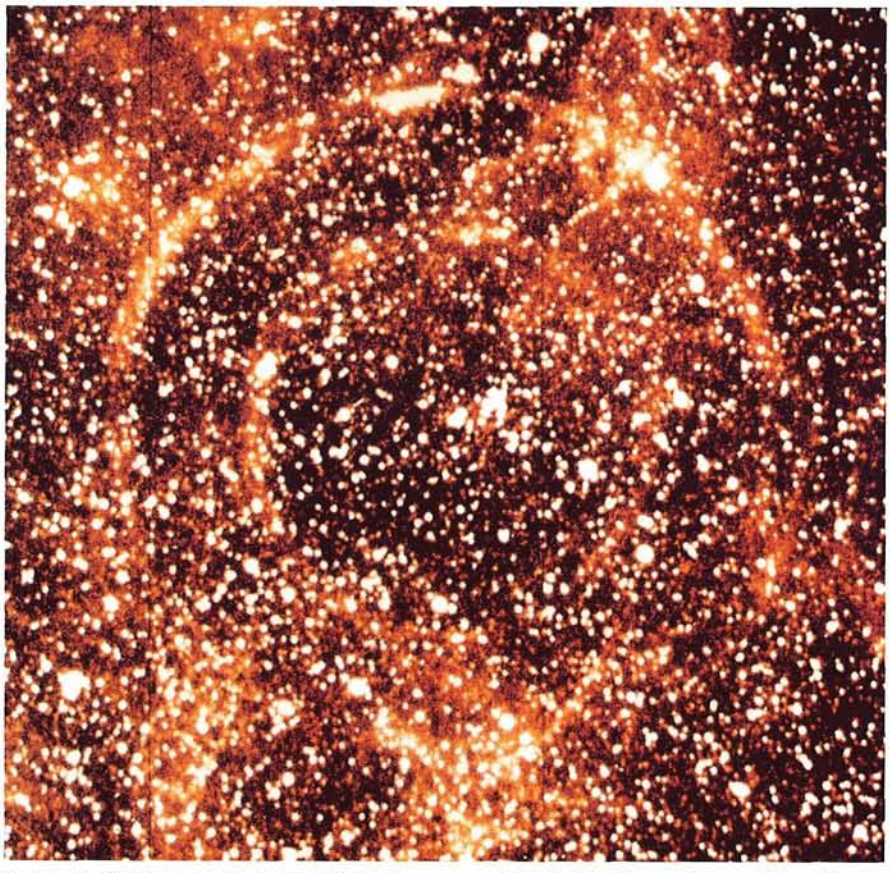

Figure 1: *CCD image from the NTT telescope + EMMI, 665.93nm, 6.6 nm filter, 20-min. exposure, taken on January 17, 1992.*

It is still not certain whether this arc can be related with the early evolution of the progenitor star of the supernova SN 1987A whose winds are believed to have produced interstellar bubbles of size around 50 pc (cf. Ref. 2). An answer to this question depends upon further investigations of chemical abundance and in particular velocity structure of this arc.

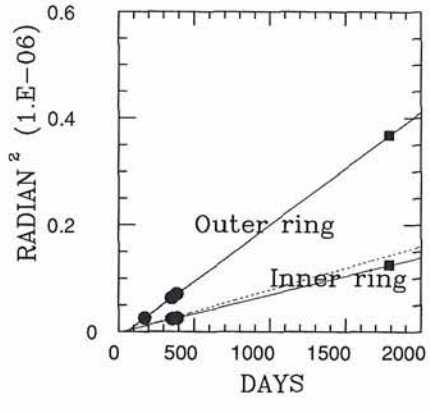

Figure 2: *Expansion diagram, solid circles are from Gouiffes et al. (1988), the squares are from Figure 1. Dotted lines represent fits given by Gouiffes et al. (1988), and the solid lines are fits after taking into account the new points.*

References

1. Gouiffes, C., Rosa, M., Melnick, J., Danziger, I.J., Remy, M., Santini, C., Sauvageot, J.L., Jakobson, P., and Ruiz, M.T. *Astron. Astroph.* **198**, L9–L12 (1988).
2. Chevalier R.A. and Emmering, R.T. *Astrophys. J.* **342**, L75–L78 (1989).