URSI AP-RASC 2019, New Delhi, India; 09 - 15 March 2019

Long-term behaviour of a Type IIP supernova SN 2004dj in the radio bands.

Nayana A.J.*(1), Poonam Chandra(1), and Alak K. Ray(2)
(1) National Centre for Radio Astrophysics, Tata Institute of Fundamental Research, PO Box 3, Pune, 411007, India; email: nayana@ncra.tifr.res.in
(2) Homi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, Mankhurd, Mumbai, 400088 India.

SN 2004dj is one of the nearest Type IIP supernova (SN) exploded at a distance of $\sim$ 3.5 Mpc in the galaxy NGC 2403. We carried out radio observations of this supernova spanning a wide frequency and temporal range of 0.24 - 43 GHz and $\sim$ 1 day to 12 years since the discovery (Nayana et al. 2018). We modelled the radio light curves and spectra with the standard mini-shell model (Chevalier 1989) and derived the properties of the progenitor stellar system. The radio observations and modelling are consistent with the interaction of the supernova with an outer ejecta density profile $\rho \sim r^{-11.4}$ with a circumstellar density field created by a pre-SN steady stellar wind. We derive the shock deceleration parameter $m \sim 0.9$ ($R \sim t^m$) indicative of a mildly decelerating shock wave. Assuming free-free absorption to be the dominant absorption process, we derive the mass-loss rate of the progenitor star as $\dot{M}$ = $(1.37 \pm 0.11) \times 10^{-6}$ $M_{\odot}\mathrm{yr}^{-1}$ for a progenitor stellar wind speed of 10 km s^{-1}. The mass-loss rate derived from our observations are consistent with the progenitor star of mass $M \sim 15 M_{\odot}$ from stellar evolution models (Schaller et al. 1992). Our mass-loss estimate is in accordance with the range of red supergiant mass-loss rates of type IIP SNe (Chevalier 2006). We calculated the radio spectral indices at multiple epochs and reported steepening in the spectral index values for an extended period. We explain this as a signature of electron cooling happening at the supernova shock. We estimated the cooling timescales for inverse Compton cooling and synchrotron cooling and conclude that inverse Compton cooling is the dominant cooling process. We also calculated the break frequencies for both synchrotron and Inverse Compton cooling from standard formulas and showed that the break frequency seen in our data is consistent with inverse Compton cooling rather than synchrotron cooling. SN 2004dj is the only Type IIP SN with both spectral and temporal coverage of over two orders of magnitudes and this allowed us to study this supernova as a prototype of Type IIP SNe. Our results are published in the Astrophysical Journal (Nayana et al. 2018).

References

[1] Chevalier, R.A. 1982, *ApJ*, **259**, 302

[2] Chevalier, R.A., Fransson, C., & Nymark, T.K. 2006, *ApJ*, **641**, 1029

[3] Nayana A., J., Chandra, P., & Ray, A.K. 2018, *ApJ*, **863**, 163

[4] Schaller, G., Schaerer, D., Meynet, G., & Maeder, A. 1992, *A&AS*, **96**, 269