OBSERVATIONS OF NOVAE WITH THE GMRT

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Abstract

GMRT observations of the remnant of classical nova, GKPersei and evolution of the 2006 outburst of recurrent nova, RSOphiuchi have yielded interesting results presented in this paper. The radio emission from the shell of GKPer is non-thermal and shows spectral evolution at lower radio frequencies. RSOphiuchi was detected for the first time at low radio frequencies during 2006 outburst. The evolution of radio flux at GMRT frequencies is similar to rapid evolution of typeII supernovae. The spectrum is non-thermal. All the frequencies exhibit a power-law decay. Evidence for variation in density of the circumstellar material is seen.

1 The classical nova, GK Persei

Continuum observations of the nebular remnant of GK Per were obtained at 330, 610 and 1280 MHz[1]. The remnant, detected at all frequencies, was found to have the same extent as in the optical. Comparing the GMRT observations with previously published data and VLA archival data, it was found that there could be at least two populations of electrons dominating the global emission at frequencies below and above 1.4 GHz. The flux density at 1.4 GHz and 4.9 GHz showed an annual secular decrease of 2.1% between 1984 and 1997 with no change in the spectral index (-0.7; ($S \propto \nu^{\alpha}$)) (see Fig. 1). However no such decrease was observed at frequencies below 1 GHz where we find that the spectrum is steeper (-0.85; see Fig. 1) contrary to the index of -0.4 deduced from observations of the nova remnant in 1985 ([2], [3]). This suggests that the spectrum at the lower frequencies has evolved in 20 years. It is likely that acceleration dominates over electron losses at frequencies above 1 GHz whereas electron losses dominate at the lower frequencies, thus explaining the evolution of the composite spectrum [4]. The properties of the nova remnant are similar to supernova remnants and in particular to the young supernova remnant Cas A. More GMRT observations have been obtained and are being analysed to further the radio study of this interesting nova remnant.

2 The recurrent nova, RS Ophiuchi

The outburst of the recurrent nova RS Ophiuchi was detected, for the first time, at radio frequencies < 1.4 GHz with the GMRT, during its recent 2006 outburst [5]. It was detected at 610 MHz on day 20 with a flux density of ~ 48 mJy and at 330 MHz on day 38 with a flux density of ~ 44 mJy [5]. This is in contrast with

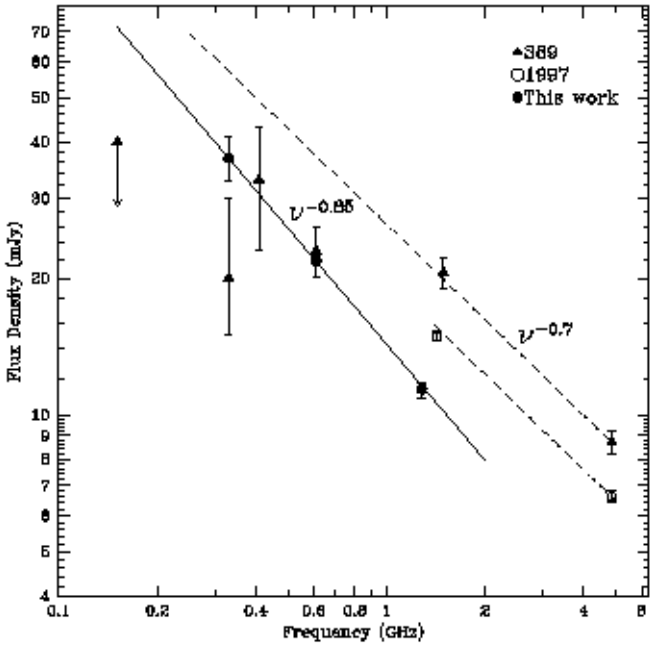

Figure 1: Spectrum of GK Persei at different epochs. Plotted is data from 2002 [1], data taken from [2] and VLA archival data from 1997. Note that the spectrum at frequencies > 1.4 GHz has a spectral index of −0.7 which remains constant between 1989 and 1997 but there is a decrease in the strength of the nova remnant at these frequencies at the rate of 2.1% per year. The spectrum is steeper at the lower frequencies. Figure from [1]

the 1985 outburst, when it was not detected at 327 MHz even on day 66 [6]. The light curves at 610 and 330 MHz from the 2006 outburst obtained with the GMRT is compared to that at 1.4 GHz from the 1985 outburst [7] in Fig. 2. The emission at low radio frequencies was found to be clearly non-thermal and well explained by a synchrotron spectrum of index ~ -0.8 suffering foreground absorption due to the preexisting, ionized, warm clumpy red giant wind. The detection of radio emission at low radio frequencies, and the earlier turn-on of radio emission during the 2006 outburst compared to the 1985 outburst are interpreted as being due lesser foreground absorption during the current outburst. The overlying wind densities in 2006 were estimated to be only 30% of those in 1985 [5].

3 References

1. G. C. Anupama & N. G. Kantharia, "A multiwavelength study of the remnant of nova GK Persei", *Astronomy & Astrophysics*, 435, 2005, pp. 167-175.

2. E. R. Seaquist, M. F. Bode, D. A. Frail, J. A. Roberts, A. Evans, J. S. Albinson, "A detailed study of the remnant of nova GK Persei and its environs", *Astrophysical Journal*, 344, 1989, pp. 805-825.

3. P. L. Biermann, R. G. Strom, H. Falcke, "Cosmic rays. V. The non-thermal radio emission of the old nova GK Persei: a signature of hadronic interactions?", *Astronomy and Astrophysics*, 302, 1995, pp. 429-437.

4. N. G. Kantharia, G. C. Anupama, Prasad Subramanian, "Cosmic ray electron acceleration in the remnant of nova GK Persei?", *29th International Cosmic Ray Conference Proceedings*, Pune, India, 2005, 3, pp. 245-248.

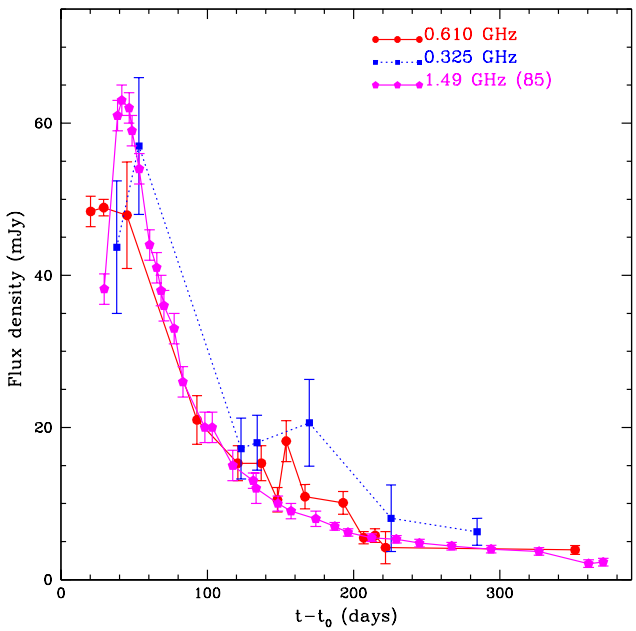

Figure 2: Time evolution of the radio emission at 610 and 330 MHz from RS Ophiuchi after the 2006 outburst compared to the evolution at 1.4 GHz after the outburst in 1985 (Figure from [5]). Note the very similar light curves.

5. N. G. Kantharia, G. C. Anupama, T. P. Prabhu, S. Ramya, M. F. Bode, S. P. S. Eyres, T. J. O'Brien, "Giant Metrewave Radio Telescope observations of the 2006 outburst of the Nova RS Ophiuchi: First detection of emission at radio frequencies < 1.4 GHz", *The Astrophysical Journal*, 2007, 667, pp. L171-L174.

6. T. A. T. Spoelstra, A. R. Taylor, G. G. Pooley, A. Evans, J. S. Albinson, "Pointers to conditions in the remnant of RS Ophiuchi from radio observations", *Monthly Notices of the Royal Astronomical Society*, 1987, 224, pp. 791-799

7. R. M. Hjellming, J. H. van Gorkom, E. R. Seaquist, A. R. Taylor, S. Padin, R. J. Davis, M. F. Bode, "Radio observations of the 1985 outburst of RS Ophiuchi", *The Astrophysical Journal*, 1986, 305, pp. L71-L75.