THE ENIGMA OF RX PUPPIS

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RX Puppis is a southern symbiotic star (R.A. $08^h12^m28^s.2$, Dec. $-41°33'18''$ (B1950). For almost a century it has been seen to have had a violent history at optical wavelengths. In 1974 it was discovered, at 5 GHz, to be a weak radio source. Shortly after, its radio spectrum was found to be of the optically thin type, having approximately the same flux density at all frequencies between 2.7 and 22 GHz. This implied that the RX Puppis system contained dispersed, ionized gas having a linear size $>10^{15}$ cm.

From 1974 we have monitored RX Puppis regularly at different frequencies with the Parkes radio telescope. We paid it particular attention following the optical outburst reported by several authors in the early 1980s. During 1984 we found that its radio spectrum had dramatically changed. At 22 GHz its flux density had increased from ~20 to 120 mJy whilst its 5 GHz flux had increased from 20 to only 30 mJy. The radio spectral index had changed from near 0 to ~+0.8.

The radio spectrum of thermally emitting radio stars provides direct evidence about the distribution of ionized gas around the stars. For example, a star losing ionized gas at a uniform rate has a density distribution that drops off as the inverse square of the distance from the star. This produces a radio spectral index of +0.6. The value of +0.8 now observed for RX Puppis is not easy to understand. It is, however, similar to the value that we find for many other symbiotic stars.

Models to explain the radio emission from these stars have been proposed by Allen (1984) and Taylor and Seaquist (1984). In essence, a Mira giant star is losing (neutral) gas at a rate of $\sim10^{-5}$ solar masses per year and at a velocity of ~20 km s^{-1}. A distant, hot, compact companion star - probably a white dwarf - ionizes part of the circumstellar gas. But both models suffer from the disadvantage that the parameters needed to produce the +0.8 index are highly specific: we would not expect so many stars to have indices in the range +0.8 to

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+1.0, as we in fact observe. Furthermore, these models cannot explain how the index of RX Puppis rose from ~0 to +0.8.

What, then, is the distribution of ionized gas around RX Puppis? It seems likely to us that the models mentioned above are correct in their essentials. However, there is observational evidence for mass-loss from the hot, compact star, and we feel that successful modelling of the RX Puppis sytem must take this into account. The distribution of ionized gas would then be decided by the momentum balance of the two stellar winds as well as the ionizing flux from the hot star.

Valuable new evidence from observations with the Very Large Array has recently been published by Hollis et al. (1986). They confirm that the +0.8 index applies to the radio spectrum of RX Puppis even up to frequencies around 100 GHz. This result sets very tight constraints on any modelling attempts. In addition, they report an angular size of around 1 arcsec for the radio emitting region. At the distance of RX Puppis (2 kpc) this corresponds to a linear size of $\sim 3 \times 10^{16}$ cm, comparable to, or greater than, the separation of the two stars.

This latter finding presents us with the enigma. On at least three different occasions RX Puppis has been seen to flare at 5 GHz over a period of ~10 min. But the size of 3×10^{16} cm from the VLA measurements corresponds to a light-travel time of ~10 days. How can a fast flare be produced by a region that is thousands of times bigger?

One possibility is that there are TWO radio emitting regions, the ionized gas and a compact non-thermal source located on, or near, the compact star. Even so, the extended ionized gas must not fill the circumstellar volume if the fast flares are to be seen. This follows, since a fast variable source cannot be seen through surrounding, ionized gas which is optically thick at the frequency of the variations. Another possibility is that the radio flares come from the Mira star and that we are viewing the symbiotic system from such a direction that only neutral gas lies between us and the flaring star. However, we have no convincing evidence that other Miras can emit radio flares.

RX Puppis is one of the strongest symbiotic stars at radio wavelengths: it is also one of the most active. At present we have no plausible model that accounts for all the changes at radio, optical and other wavelengths. Thus we believe that it merits close and continuing study in the future: it may hold the key to a better understanding of all symbiotic stars.

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