# SYMBIOSIS IN RADIO STARS WITH INFRARED EXCESS

F. CIATTI and A. MAMMANO
*Asiago Astrophysical Observatory, Italy*

**Abstract.** An outline is given of the observing programme of peculiar radio stars with combination spectrum at the Asiago Observatory.

We have started a spectroscopic survey (in the spectral region 3800–10900 Å) of peculiar early-type emission-line stars, which present the following properties: large infrared colors (Allen, 1973), occurrence of forbidden lines, and radio-emission.

A first group of BQ[ ] stars (see Wackerling, 1970), MWC 17, MWC 349 and HD 51585, revealed nebular lines not compatible with radial stratification, and absorption features as are found in late-type stars of M or C class (Ciatti *et al.*, 1974). These results led to a picture where a cool giant, loosing mass at a rate of the order of $10^{-6}\,\mathfrak{M}_{\odot}\,\mathrm{yr}^{-1}$, is responsible for a very extended gaseous envelope which is excited by a hot source, producing nebular lines and radio-emission. According to the model of Gehrz and Woolf (1971), condensation of dust grains takes place in the inner region where we find higher density and lower excitation.

An evolutionary trend, in which some BQ[ ] stars may evolve into a kind of compact planetary nebulae, has been suggested from the comparison of the morphological properties common to both classes.

A second group of objects studied at Asiago (Ciatti and Mammano, 1974) includes MWC 349, MWC 137, M 2–9 and R Aqr, all radio stars with infrared excess and with surrounding nebulae of different dimensions. They may represent successive steps of the formation of nebulae expanding from BQ[ ] stars. Radio observations of MWC 349 indicate a region of angular diameter 2″.4 (Gregory and Seaquist, 1973). The presence of an evolved star of carbon type and possibly of the Cygnid class is indicated by CN bands and accounts for the observed characteristics.

MWC 137 is one of the many objects listed among both emission-line stars and planetary nebulae, since it lies in the nebula Sh 2-266 (80″ × 56″). The stellar spectrum again shows CN bands, and nebular lines of high density ($\mathrm{Ne}\sim 10^{6}$–$10^{7}\mathrm{cm}^{-3}$) together with low-excitation emissions (strong O I 8446 Å and Ca II infrared triplet) which distinguish the spectrum of a BQ[ ] star from that of a gaseous or planetary nebula. Ejection of matter from the late-type component may have formed Sh 2-266 whose spectrum indicates $\mathrm{Ne}\leqslant 10^{4}\ \mathrm{cm}^{-3}$.

In the peculiar planetary nebula M 2-9, the core shows high density features of different ionization regions, while in the wings not emitting in the infrared, a lower temperature and density are deduced (see also Allen and Swings, 1972). We include M 2-9 in the evolutionary sequence, although in this case the presence of a cool component has not yet been ascertained.

R Aqr is a symbiotic system with a long-period variable, a hot companion, and a

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nebula very close to the star. The shielding effect revealed by variations of [O II]/[O III] and the radio variability can be explained by mass transfer between the two components. R Aqr is also surrounded by a low density nebula ([N II] > Hα, [S II]) extending 140″ which is very likely due to mass lost from the long-period variable and excited by the hot component. Our evolutionary sequence includes circumstellar nebulae, as are found in the radio stars with infrared excess V 1016 Cyg and HBV 475, both known to have a binary nature and considered proto-planetaries (see Ciatti *et al.*, this Symposium, p. 389).

We have shown how some evolved stars, loosing mass, may produce compact or extended nebulae excited by a hot companion. Other evolved stars without such a companion may have ejecta revealed by other means, for example, the carbon star IRC+10216 surrounded by an extended (140″)CO halo (Wilson *et al.*, 1973). Occurrence of nebulae around stars of different spectral type and evolutionary phase will be the subject of a further investigation.

## References

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