RADIO MEASUREMENTS OF POSSIBLE PROTO-PLANETARY NEBULAE

C.R. Purton and P.A. Feldman
York University, Toronto, Canada, and Herzberg Institute of Astrophysics, NRC, Ottawa, Canada, respectively.

A number of objects which may be proto-planetary nebulae are being studied. They were found through a radio search of early-type emission-line stars, and the radio emission is believed to originate in extensive circumstellar ionised gas. The objects have an infrared spectrum which indicates the presence of dust, and a continuum radio spectrum characteristic of prolonged mass outflow from the central star. Of the five objects discussed here, Vy2-2, Hb12, HD167362, Hl-36 and V1016 Cygni, a distance is available for only the last: for that object the calculated mass of the ionized gas is .02 $M_\odot$ (see Ahern et al, 1977). If this is typical of the five, then they may represent the early stages of the low-mass planetary nebulae discussed by Wood and Cahn (1977).
References: (1) Ahern, F.A., Fitzgerald, P.M., Marsh, K.A., and Purton, C.R. 1977, Astron. & Astrophys., in press. (2) Wood, P.R., and Cahn, J.H. 1977, Astrophys. J. 211, 499.

DISCUSSION

Kwok: I would like to comment on Dr. Zuckerman's criteria for proto-planetary nebulae. He suggested that the formation of a planetary nebula is the result of continuous mass loss of 10^{-5} $M_\odot yr^{-1}$ over a period of 10^5 years. If we adopt an ejection velocity of 10 kms^{-1}, the size of the circumstellar envelope is greater than 1 pc. This can certainly be responsible for the CO and dust emission in the outer parts of NGC 7027, but unlikely to be responsible for the nebula itself, which is more likely to be the result of a massive ejection within a short period of time. In conclusion, a red giant with a mass loss rate of e.g. $10^{-6}M_\odot yr^{-1}$ should not be excluded from the possibility of becoming a planetary nebula and planetary nebulae will not be formed exclusively from carbon stars.

Purton: The mass loss rate determined for V1016 Cygni is $3x10^{-5}$ $M_\odot yr^{-1}$, but apparently this mass loss continued only a few hundred years.

Feldman: I would like to emphasize the opportunity we now have in the case of HM Sge to study the early stages of formation of a possible proto-planetary object like V1016 Cyg. HM Sge brightened by $\geq$ 5 m during 1975 and has an emission line spectrum quite similar to that of a high-density planetary nebula. Recently, in May 1977, I have found a continuum radio source associated with this object. The radio source, of strength $\sim$40mJy at 10.5 GHz, apparently was not present in November 1977. Thus the radio emission has emerged several years after the optical outburst.