IS THERE A SIGNATURE OF ICE IN THE IRAS LRS SPECTRA OF SOME MIRA VARIABLES?

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Some M Miras show the 9.7 and 20μm silicate emission. Recently, Vardya, de Jong & Willems (1986; hereafter VDJW) discovered using IRAS LRS spectra a weak broad emission feature ∿12μm; this new feature may be silicate (VDJW). Here we investigate whether this can be due to H_2O ice.

$H_2O(g)$ is important as a source of opacity in M stars (cf Vardya 1970), and has been detected in IR (cf Merrill & Ridgway 1979), in mm (Bowers & Hagen 1984) and the excess emission between 5-8μm in μ Cep and R Cas has been attributed to $H_2O(g)$ (Tsuji 1978).

Recently, de Muizon, d'Hendecourt & Perrier (1987) have explained excess absorption ∿12μm in some cool stars as due to ice, based on the presence of 3μm ice band. Hence, 12μm emission feature in M Miras can be signature of ice.

12μm emission feature is most prominent among 19 stars of VDJW in RU Her, R Aur and T Cas (Fig. 1); the light curves are fairly symmetric as f values indicate, defined as the ratio of the number of days between visual light minimum and the following maximum to period (P), and $P \gtrsim 450$d. RU Her also shows the 9.7μm emission. The visual light curves in Fig. 2 (Campbell 1955) show a hump or a change in gradient in the rise part, unlike smooth rise as in RR Aql, which shows no 12μm feature.

In the log S_{12}/S_{25} vs f plot of VDJW, where S_λ is the IRAS source flux density, there are two stars below the 400°K line - Z Cyg of small period, a normal light curve but no 12μm feature, and WX Psc of very long period and 12μm emission.

Thus, it appears, that 12μm emission is more probable when the light curve is nearly symmetric with a hump or change in gradient in the rise part, the period is long, attains low temperature at minimum light and has low IR temperature.

The 9.7μm emission in M Miras is present when $f \leq 0.45$ (VDJW); this is qualitatively understood if smaller the f is, stronger is the shock. This shock drives the mass loss and the condensates in the flow depend on the physical conditions. If f is small, ρ_g is high near the surface, freeze out occurs close to the surface at high temperature and silicates are the only condensates. As f increases, ρ_g is not that high and freeze out occurs further out at low temperature with formation of other

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condensates as well.

The hump or change in gradient in the light curve indicates double shock. Hence ρ_g is not high and in these three stars, the freeze out occurs far out at low enough temperature for ice to form, if the condensation time, proportional to P, is long. WX Psc with low IR temperature, shows the 12μm feature; this strenghthens the above argument. Non-detection of gaseous H_2O in these stars (Bowers & Hagen 1984) may indicate depletion due to condensation.

Concluding, a case has been made that the 12μm emission feature in some M Miras may be due to ice. One needs to expand the list of stars with this feature and confirm the existence of ice by 3μm spectrophotometry.

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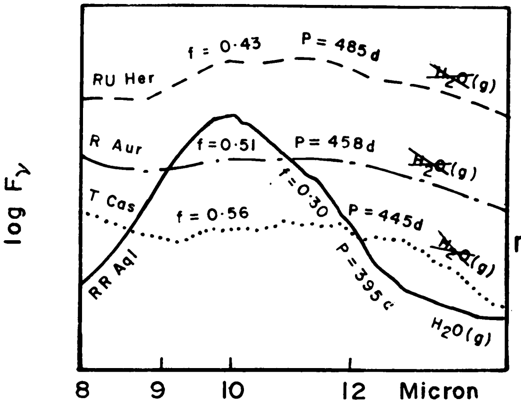

Fig. 1. IRAS LRS spectra of M Mira variables around 12μm.

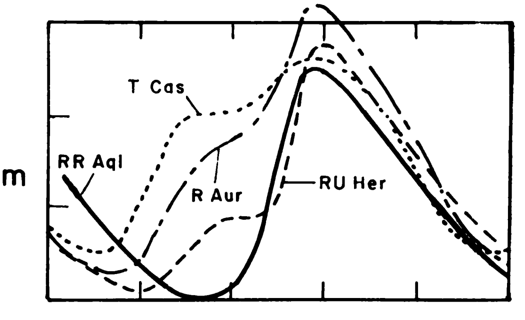

Fig. 2. Visual light curves of M Mira variables (Campbell 1955)