A Period-Luminosity Relationship for Mira-like variables in the LMC

In Kwok S. and Pottasch, S.R. (eds), 1987. *Late Stages of Stellar Evolution*, pp 51-54, Reidel, Dordrecht.

I.S. Glass, R.M. Catchpole, M.W. Feast & P.A. Whitelock
South African Astronomical Observatory

I.N. Reid
Royal Greenwich Observatory

ABSTRACT. A large sample of mira-like variables is found to obey a period-luminosity relation at K (2.2μm) with an r.m.s. scatter of 0.15 mag. Most of the longer period (>250^d) members of the sample are carbon stars.
The M-type variables follow the relationship

$$K_0 = (-3.79 \pm 0.18)\log P(\text{days}) + (20.17 \pm 0.42)$$

and have an r.m.s. scatter of only 0.13 mag about it.

1. OBSERVATIONS

A period-luminosity relationship for mira variables in the LMC was shown to exist by Glass and Lloyd Evans (1981), based on observations of 11 stars. The r.m.s. scatter was found to be 0.22 mag. Subsequently lists of mira-like variables in the LMC have been published by Wood, Bessell & Paltoglou (1985) and Glass & Reid (1985). Feast (1984) showed that the Wood et al. variables followed the P-L relationship.

In this work, 75 mira-like variables in the LMC were studied intensively in order to better determine the precision of the $P - L$ relationship and its limitations. Stars on the aforementioned lists as well as some unpublished ones (Reid & Glass, in preparation; Lloyd Evans, private communication) were observed.

An average of 7 observations per star were obtained. Many of the light curves remain poorly determined. Spectra have been taken of 32 of the objects (Wood et al. 1985; Reid & Glass). From the available evidence it appears that the final sample of 73 stars (two stars near S Dor were rejected due to crowding) contains 37 probable carbon stars, 12 M stars, 3 S stars, 20 probable M stars and 1 possible K star. A reddening of $E_{B-V} = 0.07$ has been assumed.

2. THE TWO-COLOUR DIAGRAM

Figure 1 shows the two-colour diagram for the sample. The M and S stars, a probable K star and 2 carbon stars lie in the clump exhibiting galactic late-type stellar colours in the bottom left corner. The other points correspond to the probable carbon stars.

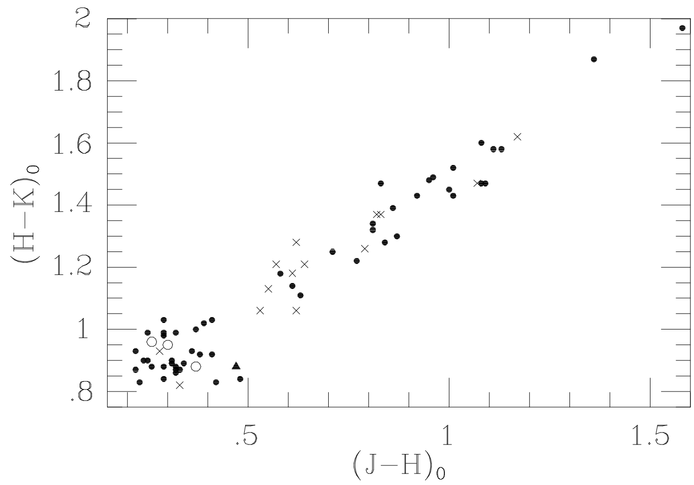

Figure 1: The $(J-H)_0, (H-K)_0$ two-colour diagram for the variables under discussion. Spectroscopically determined types are denoted as follows: open circles, S stars; crosses, carbon stars and the triangle, a possible K star.

THE P-L RELATIONSHIP

For the whole group of 73 (Figure 2) we find

$$K_0 = (-3.52 \pm 0.16)\log P + (19.53 \pm 0.38); \sigma = 0.17$$

σ = r.m.s. scatter about the relationship). Omitting only 1 star, the reddest carbon star found, we obtain:

$$K_0 = (-3.64 \pm 0.14)\log P + (19.82 \pm 0.34); \sigma = 0.15$$

For the 35 M- and S- type stars (Figure 3) we obtain:

$$K_0 = (-3.78 \pm 0.20)\log P + (20.15 \pm 0.48); \sigma = 0.15$$

Omitting only 1 deviant star, (No. 1 of Wood et al., 1984), we have for M & S stars:

$$K_0 = (-3.79 \pm 0.18)\log P + (20.17 \pm 0.42); \sigma = 0.13$$

For each star, K_0 has been taken as the average of the maximum and minimum fluxes observed, expressed as a magnitude.

BOLOMETRIC MAGNITUDES

Bolometric magnitudes were determined for each observation of each star by fitting blackbody curves to the photometry using the method of least squares. The characteristic temperatures of the blackbodies which best fit the observations of the carbon stars are lower than those for the M stars. The C stars also

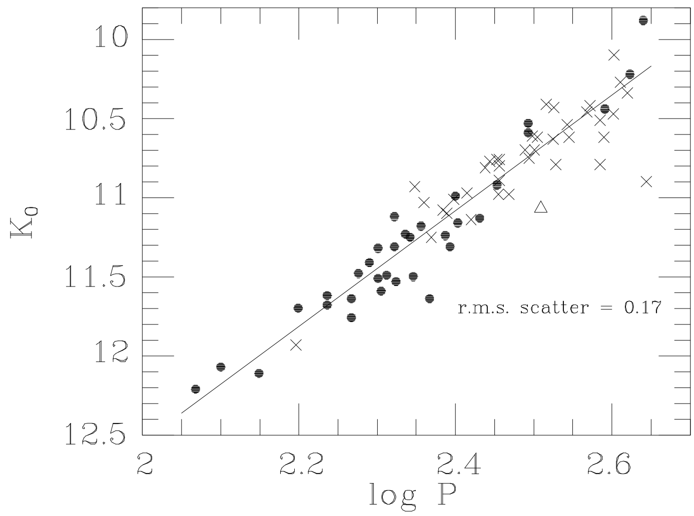

Figure 2: K_0 vs log P for all stars in the sample. The crosses are probable C stars and the triangle is the possible K star (Wood et al. 1985, No 126).

exhibit a larger scatter than the M's about the $P-L$ relation. Most C stars appear to be fainter in $m_{\rm bol}$ than M stars of the same period. It is quite possible that flux removed by the high molecular opacities of C stars atmospheres in the J (1.25μm) and H (1.65μm) bands is reradiated at much longer wavelengths or that it otherwise distorts the values of $m_{\rm bol}$ obtained by the present method.

Thus it is at present uncertain whether the apparent displacement between the C and M type miras in a period $m_{\rm bol}$ plot is real or not. The close agreement in the $P-L$ relations for the two types at K is remarkable. If this is taken as evidence for agreement in $m_{\rm bol}$ then there would seem to be a conflict with the predictions from models (Wood, Bessell & Paltoglou 1985; Fox & Wood 1982).

For the M and S stars alone, again excluding W1, we have:

$$m_{\rm bol} = (-3.34) \pm 0.21)\log P + (22.12 \pm 0.50); \sigma = 0.16.$$

REFERENCES

Feast, M.W., 1984. MNRAS 211, 51p

Fox, M.W. & Wood, P.R., 1982. Ap. J. 259, 1982.

Glass, I.S. & Lloyd Evans, T., 1981, Nature, 291, 303.

Glass, I.S. & Reid, I.N., 1985. MNRAS 214, 405.

Wood, P.R., Bessell, M.S. & Paltoglou, G., 1985. Ap. J. 290, 477.

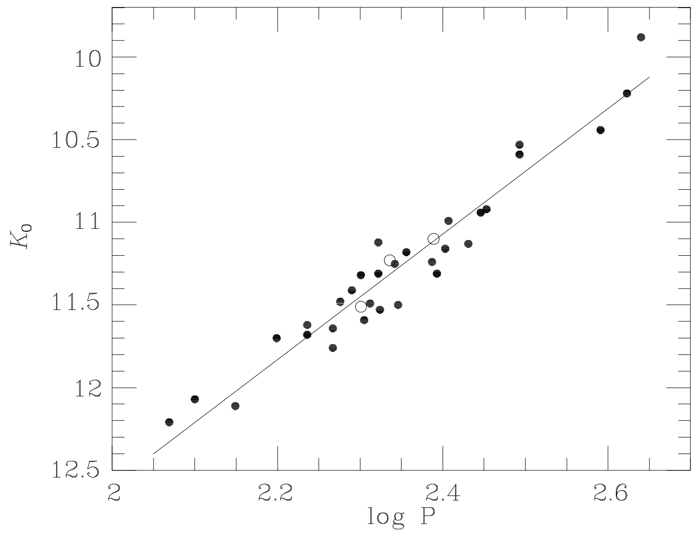

Figure 3: K_0 vs log P for S, M and probable M stars only.

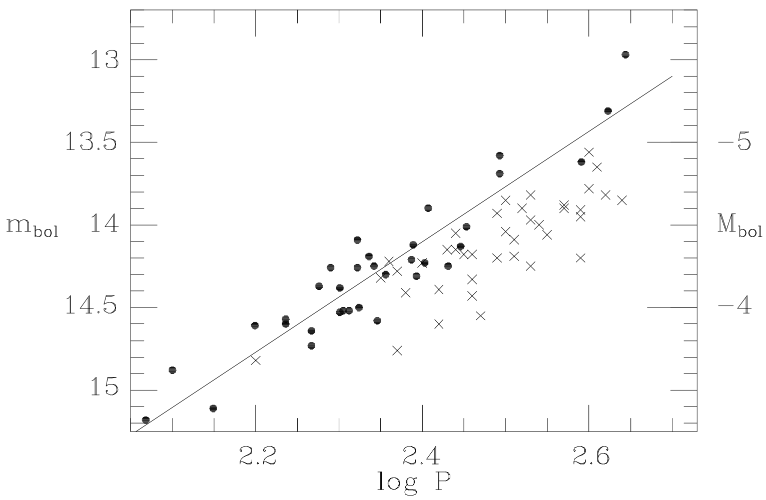

Figure 4: $m_{\rm bol}$ vs log P for the whole sample. The line is the relationship for probable M and S stars. the crosses denote known and probable C stars. An $M_{\rm bol}$ scale based on a distance modulus of 18.5 for the LMC is also given.