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ON THE PERIOD–LUMINOSITY RELATION IN THE INFRARED FOR FIELD RR LYRAE STARS

Liu and Janes 1990 (hereafter LJ90) derived $<M_V>$ values for 13 RR Lyrae stars in the galactic field using the modern modification of the Baade–Wesselink method. For 12 of these objects they gave mean observed dereddened $<V>$ and $<I_c>$. Therefore one can easily convert $<M_V>$ to $<M_{Ic}>$: $<M_{Ic}>=<M_V>-(<V>-<I_c>)$. Slightly revised $<M_V>$ magnitudes of these stars have recently been published by Jones et al. 1992 (hereafter J92) ; as a rule the differences equal to −0.03 mag.

I accepted $<M_V>$ magnitudes from J92 omitting (together with these authors) the highly reddened star AR Per. I eliminated also AV Peg owing to its too high metallicity [Fe/H]= + 0.0 being not typical for the majority of RR Lyrae stars, also bearing in mind that $<M_{Ic}>$ magnitudes are not as insensitive to [Fe/H] as $<M_K>$ ones. I consider the weighted mean reddenings for field RR Lyrae stars in LJ90 to bee good, excluding only the case of the RRc star T Sex. I accepted for T Sex E(B−V)= 0.01 instead of 0.05 in LJ90 (se my paper about the HR diagram for variables in the globular cluster M 3 in the infrared, to be published elsewhere). Needed values of interstellar absorptions A(V) and $A(I_c)$ were recalculated for T Sex by the author. Since changing E(B−V) must change also the value $<M_V>$, I introduced the correction $\Delta M_V = +0.14$ for T Sex, taking into account the influence of the reddening error on the derived $<M_V>$ magnitude according to Table 9 of LJ90. The derived magnitudes $<M_{Ic}>$ are given in Table 1 for 10 field RR Lyrae stars together with their log P_F values (for the case of fundamental pulsation, adding + 0.127 for RRc stars). [Fe/H] data in Table 1 are from J92.

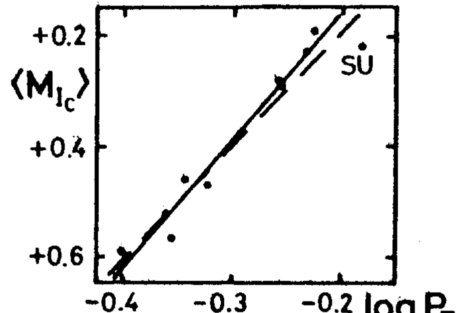

Fig. 1. $<M_{Ic}>$ − log P_F relations for field RR Lyrae stars; dotted line with the evolved star SU Dra included, solid line without it.

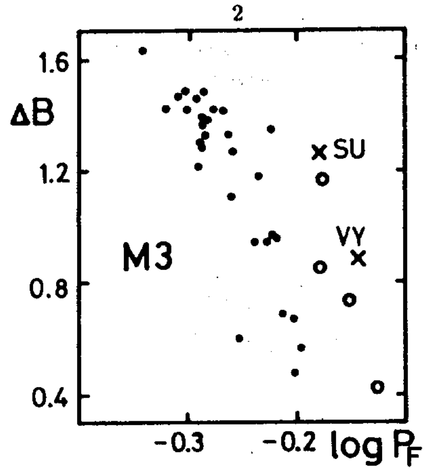

Fig. 2. B light amplitude – log P_F diagram for RR Lyrae stars of M 3 (dots and circles, latter for evolved stars) and for two field variables (SU Dra and VY Ser).

Table 1

Star	log P_F	$<M_{Ic}>$	[Fe/H]
SW And	−0.355	+0.57	−0.15
RR Cet	−0.258	+0.28	−1.25
SU Dra	−0.180	+0.22	−1.60
RX Eri	−0.232	+0.23	−1.40
RR Gem	−0.400	+0.59	−0.20
RR Leo	−0.345	+0.46	−1.15
TT Lyn	−0.224	+0.19	−1.35
T Sex	−0.361	+0.52	−1.20
TU UMa	−0.254	+0.29	−1.25
UU Vir	−0.322	+0.47	−0.55

Fig.1 shows that only $<M_K>$ correlates with log P_F well, but also the magnitudes $<M_{Ic}>$ demonstrate good enough period-luminosity relation for the field RR Lyrae variables:

$$< M_{Ic} >= -2.06 log P_F - 0.22 \text{ (dotted line).}$$
$$\pm 0.18 \qquad \pm 0.06$$

The inclusion of several objects significantly evolved from the zero–age horizontal branch (ZAHB) into the sample of RR Lyraes can change the slope of the derived period–luminosity relation. Sandage (1981, 1990) showed that in a given globular cluster the stars most evolved from ZAHB have the longest periods and they are the brightest among RR Lyrae variables having the same colours or the same light amplitudes. This period shift effect was used by J92 to exclude evolved stars from the whole sample of RR Lyraes having $<M_V>$ and $<M_K>$ determinations.

Comparing the field stars with the cluster objects, J92 did not take into account that some stars in a given cluster can also be evolved objects. As results, VY Ser (log P = −0.146) was not recognized by J92 as an evolved star, and SU Dra (log P = −0.180) was only suspected by them to be an evolved star, both stars being in fact sufficiently evolved RR Lyrae variables. Fig. 2 shows a part of Fig. 11 from J92 with the period −B amplitude diagram for RRab variables in M 3. I plotted by circles in Fig. 2 evolved M 3 stars according to Sandage (1981), with exclusion of the star 96 having not the longest period at its colour; VY Ser and SU Dra are indicated. Both VY Ser and SU Dra well deviate from "normal" M 3 variables. Moreover, VY Ser ([Fe/H] = −1.80), in spite of its metal deficiency being not so strong as that of the RR Lyrae stars in the globular cluster M 15 ([Fe/H] = −2.20), has the same period and light amplitude as the star 9 in M 15, which is an evolved variable in this cluster. Indeed, the analysis of the data from Sandage (1990; his Table 6) shows that the star 9 in M 15 has by far the longest period (log P = −0.146) at its light amplitude (0.90 B), also being at its colour <B> − <V> = 0.40 one of the brightest variables in this cluster.

So, VY Ser and SU Dra must be eliminated from the sample of J92 and, as a consequence, the slope of their relation $<M_K>$−log P_F must be essentially greater than −2.33 log P_F:

$$\begin{array}{l} < M_K >= -2.59 log P_F - 0.98 \\ \qquad\quad \pm 0.21 \qquad\quad \pm 0.07 \end{array}$$

The same conclusion is right for the case of my $<M_{Ic}>$ − log P_F relation, and the real relation must be the following (without SU Dra, an evolved star):

$$\begin{array}{l} < M_{Ic} >= -2.33 log P_F - 0.31 \qquad \text{(Fig. 1).} \\ \qquad\quad \pm 0.16 \qquad\quad \pm 0.05 \end{array}$$

One cannot exclude the possibility that the different slopes of $<M_K>$ − log P_F relations in different globular clusters (Longmore et al. 1990) may be partly connected with an occasional inclusion of significantly evolved members of a given cluster.

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