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by

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On the Absolute Magnitudes of N-type Stars

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SUMMARY

"The mean visual absolute magnitude of N-type stars which are not known to be variable has been calculated from differential galactic rotation. Comparison with the absolute magnitudes of N–type semi-regular variables and N-type stars in clusters and binaries indicates that non-variables are comparable in brightness to the variables at mean light rather than at maximum light."

I. INTRODUCTION

The mean absolute magnitudes of carbon stars in general, and of N-type stars in particular have been determined, among others, by Sanford [1] and by Gordon [2] (See a review by Mavridis [3]). It is well known that a large fraction of N-type stars are variable in light of differing amplitude. It seems customary to combine the non-variables with the variables at maximum light in calculating the mean absolute magnitudes. Recently, the mean absolute magnitude of N-type Semi-Regular (SR) variables has been calculated from secular and statistical parallaxes and from differential galactic rotation [4]. A comparison of the result for SR variables with the absolute magnitudes of a) variables and b) non-variables in galactic clusters and binary systems determined by Gordon [2] suggested that variables may be brighter, at maximum, than the non-variables by nearly a magnitude [4]. It was therefore considered useful to calculate separately the mean absolute magnitude of N–type field stars which are not known to be variable and to compare the result with that of the variables. Here we determine the mean absolute magnitude using differential galactic rotation and compare it with other determinations (Section 3 and 4).

2. THE DATA USED

The radial velocities, apparent visual magnitudes and positions were taken from Sanford's Catalogue of N– and R–type stars [1], from Wilson [5] and from Yamashita [6]. The known variables were excluded from a total of about 200 stars. In identifying the known variables we have used the General Catalogue of Variable Stars [7,8]. The variability of one star, MSB 57, has recently been reported by Baumert [9]. We note in passing that 77 percent of our sample of N–type stars and 32 percent of R-type stars are variable. It may be that all N-type stars are variable to some extend.

Apparent visual magnitudes from Sanford were used, since the number of N–type stars with photoelectric magnitudes is too few. However, it was possible to make a comparison between m_V in Sanford's catalogue and photoelectric magnitudes using class R stars: The photoelectric catalogue of Blanco et al [10] contains 40 R–type stars which are also in Sanford [1] and which are not known to be variable. The differences $V-m_V$ suggested a slight dependence on position in the sky but a colour equation appears to be more apparent as seen from the table below:

Sp type	R0 — R2	R2 — R4	R4 — R6	R6 — R8
$V - m_V$	$+0^m.17$	$-0^m.07$	$-0^m.29$	$-0^m.37$
No. of stars	11	10	12	7

The B–V colours of R–type stars range from 1.22 at R0 to 2.10 at R8 [11]. It is therefore not unlikely that there exist a similar systematic error in the apparent visual magnitudes of N-type stars used here if the photoelectric magnitudes (mainly by Vandervort, [11]) are error free. Nevertheless, the mean difference

$\overline{V-m_V} = -0^m.12 \pm 0^m.06$ (s.e.) is small so that the effect on the mean absolute magnitude is not likely to exceed $0^m.1$

3. THE MEAN ABSOLUTE MAGNITUDE FROM DIFFERENTIAL GALACTIC ROTATION

The equation of condition with first order differential galactic rotation was written as

$$\rho = u \cos l \cos b + v \sin l \cos b + w \sin b + A' \, 10^{0.2(m-10)} \sin 2l \cos^2 b \quad (1)$$

where ρ is the observed radial velocity of a star, l and b its galactic longitude and latitude. u, v, w are the components of the star's space motion with respect to the sun (towards the galactic center, in the direction of galactic rotation and towards the north galactic pole, respectively). m is the apparent magnitude corrected for absorbtion and $A' = A \, 10^{-0.2M}$. If a value for the Oort constant A is adopted the mean absolute magnitude is calculated from

$$\overline{M} = 5 \log \frac{A}{A'} + 0.23 \, \sigma^2$$

where σ is the standard error of one distance modulus due to errors in the apparent magnitudes and dispersion in absolute magnitude.

Parenago's formula $A_v = a_0 \beta \operatorname{cosec} |b| \{ 1 - \exp(-r(\sin|b|/\beta)) \}$ was used to calculate the galactic absorbtion of a star at a distance r(pc) and latitude b. The constants a_0 and β for 118 regions covering the whole sky were taken from Sharov [12] A_v was calculated in the direction of each star for various distance moduli m–M. A_v corresponding to the uncorrected distance modulus based on the adopted absolute magnitude from an initial solution was obtained by linear interpolation from an array m–M + A_v against A_v (internal error of M_v from the linear interpolation is less than $\pm 0^m.05$).

The least squares solutions of equation (1) was carried out with and without a K-term. The results are given in Table I

TABLE I

Radial velocity solution

	Solution 1	Solution 2
u_0 (km s^{-1})	—16.2 ± 4.9	—18.6 ± 5.0
v_0 (km s^{-1})	—11.9 ± 5.1	—10.6 ± 5.4
w_0 (km s^{-1})	—14.3 ± 13.9	(—7.0 adopted)
A' (km s^{-1}kpc^{-1})	33.5 ± 11.2	40.8 ± 11.1
K (km s^{-1})	6.6 ± 3.4	(0.0 adopted)
No. of stars	45	45

For solution 2 $w_0 = -7.0$ km s^{-1} was adopted [13]. The K-term in solution 1 is about twice its standard error. It should be noted that no K-term was indicated by the radial velocities in the case of SR variables [4]. If the above value of K is real the mean absolute magnitude from solution 1 is $M_v = -1^m.6 \pm 0^m.6$, while solution 2 gives $M_v = -2^m.1 \pm 0^m.5$; where we have used A = 14.3 km s^{-1} kpc $^{-1}$ [14] and $\sigma = \pm 0^m.9$ on the basis of individual absolute magnitudes of N–type stars in clusters and binaries [2,4]. The error of M_v was calculated from the error of A′ in Table I only.

4. DISCUSSION

We now compare the above results with other determinations. The mean visual absolute magnitude of field N-type semi-regular variables derived from statistical parallaxes and differential galactic rotation [4] is M_v (max) $= -2^m.7 \pm 0^m.4$ at maximum (M_v (max) $= -3^m.0 \pm 0^m.6$ from differential galactic rotation alone). The individual absolute magnitudes of N-type variables (eight stars) in clusters and binaries give M_v (max) $= -2^m.9 \pm 0^m.3$ [2,4]. We adopt M_v (max) $= -2^m.8 \pm 0^m.3$. Therefore, remembering that the semi –amplitude of SR variables is about $0^m.9$ their mean visual absolute magnitude et mean brightness would be M_v (mean) $= -1^m.9 \pm 0^m.3$. This is in good agreement with the mean absolute magnitude of field non-variable stars derived from Table I above, suggesting that non-variables are fainter than the variables at maximum light.

On the other hand, the mean absolute magnitude of non-variable stars in clusters and binaries (five stars) [2,4] appears at first sight to be fainter than both variables and non-variables in the field. For clarity we quote here the individual magnitudes assigned by Gordon [2] and point out that the apparent discrepancy is in the absolute magnitudes of N-type members of binaries: Cluster members: $-1^m.4$, $-2^m.0$; Binary members: $-0^m.4$, $-0^m.8$ or $+2^m.2$, $-0^m.4$ or $+2^m.1$; where the alternative values of M_v in the last two casses are due to the alternative luminosity classes, F8 III–V: and F6 III–V:, assigned to the companions [2]. We see that the mean for the two cluster stars,

$M_v = -1^m.7$ is in agreement with the M_v of variables at mean light and non-variables in the field already mentioned. But the members of binaries are fainter than one would expect; also they do not appear to fit Gordon's spectral type–M_v relationship [2]. More accurate luminosity classification is needed if the binary nature of the stars is established.

From the foregoing discussion one may perhaps conclude that the phase at which the variables should be compared with the nonvariables is the phase of mean light rather than that of maximum light.

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ÖZET

Değişen oldukları bilinmeyen N–tipi yıldızların ortalama vizüel mutlak kadiri, diferansiyel galaktik dönmeden hesap edilmiş ve N-tipi yarı düzenli değişen yıldızlar ile kümeler ve çift yıldızlardaki N-tipi yıldızların mutlak kadirleriyle karşılaştırılmıştır. Sonuç, değişgen olmıyan yıldızların değişen yıldızlara, parlaklıkça, maksimum ışıktan ziyade ortalama ışıkta kıyaslanabilir olduğunu gösteriyor.

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