PART II

ABSOLUTE MAGNITUDES FROM GALACTIC CLUSTERS AND ASSOCIATIONS

ATTEMPT TO APPLY THE $U\ B\ V\ B_1\ B_2\ V_1\ G$ PHOTOMETRY TO THE DETERMINATION OF THE DISTANCE OF THE HYADES

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Abstract. A photometric method, using the $U\ B\ V\ B_1\ B_2\ V_1\ G$ system, is suggested to determine the distance of clusters. This method based on the assumption that stars with same seven colours have also same absolute visual magnitude is applied, as an example, to Hyades and Praesepe.

1. Introduction

Several methods have been used to determine the distance of the Hyades. According to Lutz (1970) the distance moduli obtained are between 3.03 and 3.25. Hodge and Wallerstein (1966) have even suggested that 3.42 may be acceptable. We try here to tackle this problem by means of a method totally independant of the above mentioned ones. We now dispose of yet unpublished measurements of 3500 stars in the 7 colours $U\ B\ V\ B_1\ B_2\ V_1\ G$. Of these stars, more than 200 belong to the catalogue of nearby stars by Gliese (1969), more than 100 are presumed to be members of the Hyades, more than 100 to be members of Praesepe. The sample of stars for which we have accurate measurements of the 7 colours is large enough to test the following hypothesis: "The stars for which the 7 colours are almost identical also have almost identical values of θ_{eff}, M_v, χ (chemical composition characterised here by [Fe/H]". The use of models which allow the theoretical computation of fluxes with line blocking shows that two stars for which the 7 corresponding colours do not differ by more than 0.01 mag. have effective temperatures which differ by less than 200 K, gravities which differ by a maximum value of 0.2 in $\log g$, chemical composition different by a maximum of 0.2 in [Fe/H]. Therefore unless proved otherwise by observation, two stars having their 7 respective colours identical within 0.01 mag. could be considered as being identical in effective temperature, chemical composition and absolute magnitude. If this is the case, we can deduce the absolute magnitude of the Hyades stars by looking for all the stars of known trigonometric parallax of which the 7 colours differ by less than 0.01 mag. from 7 corresponding colours of members of the Hyades.

2. Test of the Proposed Hypothesis

The program of observations in $U\ B\ V\ B_1\ B_2\ V_1\ G$ has not been established in view of testing this hypothesis. At the present, we are making use of the capital of measurements collected. Under these conditions, the number of cases in which at least two stars have their 7 colours identical within a margin of $\delta = 0.01$ mag. is limited. Nevertheless, it is possible to put together 163 groups. Each group contains at least

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2 stars. Often a group contains 3 to 4 stars, 5 stars being the maximum number at present. It is interesting to notice that strongly reddened stars never partake in the same group (except for 2 stars of the same cluster), even when the tolerated difference of the individual colours is extended to $\delta = 0.02$ mag. Only those stars having difference of colour excess smaller than 0.01 mag. coexist in a same group. We can conclude that a strongly reddened star does not have the 7 colours of a cooler unreddened star (yet these may coïncide in the case of three colours as the *UBV* diagram shows). We have shown (1973) (see 'Remarks on the Photometric Criteria of Choice of the Standards Stars' in the present Proceedings) that the presence of a companion affects the colours of the main component if the difference in magnitude between these is smaller than 5. There too, at least in our present collection of groups, the 7 colours of a binary rarely coincide with the colours of an isolated star, except when the difference in magnitude is >5 or when both components are nearly identical (except the giants). As far as rotation is concerned, we notice that only those stars having $V \sin i < 150$ km s^{-1} (when this is known) are found in the groups. On the other hand, a great number of stars having a high value of $V \sin i$ belong to no group. In view of showing to what extent the members of a same group are identical, we have only considered 63 groups of which the member stars are unreddened, not binaries or having a companion weaker by 5 mag., and having measurements of weight $p > 3$. We have already published elsewhere (1969) the results concerning the identity of the spectral classes and luminosity classes of stars of a same group. We have shown that the observed dispersion reaches 0.1–0.2 of a spectral class and is within the limits of dispersion due to the heterogeneity of the spectral classifications. If we make use of a very homogeneous classification like that of Cowley *et al.* (1969), for A stars, dispersion rarely reaches $\frac{1}{10}$ of spectral class (15% of cases) and dispersion in luminosity class is negligible. In our groups, there is no coexistence of Am stars with normal stars when these have been the object of a careful classification. On the other hand, marginal Am stars may sometimes coexist with normal stars. In such cases, the stars have identical H and metallic lines and differ only by the Ca IIK line. Similarly, in groups where all the stars are Am, these may differ among each other by the Ca II K line, all other lines being identical. As for groups which contain a single Ap star, our information is still limited. Yet it seems that the stars of a same group may be all Ap, not all of these necessarily having the same particularity. Let us now examine the greatest differences in absolute magnitude ΔM_v among stars of a same group. We distinguish four cases according to the provenance of the absolute magnitude.

(a) Spectroscopic absolute magnitude.

(b) Absolute magnitude obtained from trigonometric parallaxes (quality classes *A* to *F*).

(c) Difference of absolute magnitudes deduced from the difference of apparent magnitudes of stars belonging to a same group and to a same cluster.

(d) Absolute magnitude obtained by means of the relations established by Olsen (1969) for the Copenhagen photometry.

We find the average values of the greatest differences to be:

Case (a) 0.95 mag.
Case (b) 0.33
Case (c) 0.18
Case (d) 0.45

In the case of chemical composition, the greatest differences among stars of a same group obtained with the aid of measurements by Peat and Pemberton (1969) are less than 0.07 for MgH and to 0.016 for NaD. As for the greatest differences in [Fe/H] computed by means of the relations established by Olsen, we find an average value of 0.07.

Thus, in spite of the heterogeneous nature of the sources for values of M_v, [Fe/H], Sp, etc., the hypothesis of identity in M_v, θ_{eff}, χ of stars having the same 7 colours could well be acceptable and merit further study.

3. Application to the Distance of the Hyades

In view of increasing the number of stars having their 7 respective colours within 0.01 mag. of those with accurately determined (classes A, B, C) trigonometric parallaxes, we have also considered the stars of Praesepe. This procedure thus necessitates the preliminary determination of the difference of distance moduli between Praesepe and the Hyades. We obtain this by adjusting the V, $[d]$ sequences of these two clusters. The parameter $[d]$ of the $U\ B\ V\ B_1\ B_2\ V_1\ G$ photometry is a measurement of the Balmer discontinuity. The properties of $[d]$ are very similar to those of c_1 of the *uvby* systems. The parameter $[d]$ has an advantage over the parameter Q of the *UBV* photometry in being little dependant on chemical composition. In the interval F8–A7, the $B-V$ indices varies by 0.4 mag. whereas $[d]$ varies by 0.8 mag. This wide interval of variation leads to a lesser slope $\Delta V/\Delta [d]$ than $\Delta V/\Delta (B-V)$ which facilitates the separation of binaries, non members, fast rotating stars seen pole-on, reddened stars ($[d]$ is practically independant of extinction for small masses of interstellar matter). The adjustment of both sequences is done by translation along the axis of magnitudes.

We find

$$(m_v - M_v)_{\text{Praesepe}} - (m_v - M_v)_{\text{Hyades}} = 3.0 \pm 0.05\,.$$

In Table I, we give the list of groups of stars used. The two members of each group have corresponding colours which differ by less than 0.01 mag. In each group, one of the members has an absolute trigonometric magnitude taken from Gliese's catalogue (1969), the other member belongs either to the Hyades or to Praesepe.

The numbers of the Hyades stars are those of Van Bueren's (1952) catalogue and those of the Praesepe stars are those of the catalogue of Klein-Wassink (1927). The V magnitudes have been determined by Rufener and Maeder (1972). The star KW 203 has had its magnitude corrected to account for the presence of a companion

TABLE I

Groups of stars used

No.		M_v (Gliese) V (cluster)
Gr1	HD 17206	$M_v = 3{,}8$ E
	Praesepe KW 293	$V = 9.85$
Gr2	HD 48682	$M_v = 4{,}4$ C
	Hyades 113	$V = 7{,}26$
Gr3	HD 114710	$M_v = 4{,}66$ B
	Praesepe KW 162	$V = 10{,}74$
Gr4	HD 187013	$M_v = 3{,}35$ C
	Hyades 78	$V = 6{,}92$
Gr5	HD 203280	$M_v = 1{,}5$ C
	Praesepe KW 203	$V = 8{,}2$

which is nevertheless sufficiently weak not to influence the colours too much. By assigning to the Hyades and Praesepe stars the same absolute magnitudes as those of co-members of the same groups for which this is known, and by taking into account the difference of distance moduli between the Hyades and Praesepe clusters, we find a distance modulus for the Hyades of 3.25 mag. ± 0.3. This distance modulus is obtained on the basis of a very limited number of groups. We will soon be able to quadruple the number of groups by increasing the number of observations of stars of Gliese's catalogue (work in progress) and by introducing observations of other clusters having approximately the same V, $[d]$ diagram as that of the Hyades and Praesepe.

References

Bueren, H. G. van: 1952, *Bull. Astron. Inst. Neth.* **11**, 452.
Cowley, A., Cowley, Ch., Jaschek, M., and Jaschek, C.: 1969, *Astron. J.* **74**, 375.
Gliese, W.: 1969, *Veröffentl. Astron. Rechen-Inst. Heidelberg*, No. 22.
Golay, M.: 1973, this volume, p. 275.
Golay, M., Peytremann, C., and Maeder, A.: 1969, *Publ. Obs. Genève* **76**.
Hodge, P. W. and Wallerstein, G.: 1966, *Publ. Astron. Soc. Pacific* **78**, 411.
Klein-Wassink, W. J.: 1927, *Publ. Kapteyn Astron. Lab.*, No. 4.
Lutz, T. E.: 1970, *Astron. J.* **75**, 1007.
Olsen, E. H.: 1969, Thesis, Copenhagen University Observatory.
Peat, D. W. and Pemberton, A. C.: 1969, *Monthly Notices Roy. Astron. Soc.* **140**, 21.
Rufener, F. G. and Maeder, A.: 1972, in preparation.

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