IS IT POSSIBLE TO DERIVE THE POSITION OF A STAR IN THE HR DIAGRAM FROM MULTICOLOR PHOTOMETRY?

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In the preceeding paper of this Symposium by Cayrel and Perrin (1978), HR diagrams have been discussed, in which the [Fe/H] ratio and effective temperatures are derived from model atmosphere analyses and absolute bolometric magnitude from apparent visual magnitude, parallax and bolometric correction. The use of parallaxes imposes a very severe restriction on the number of objects, as parallaxes of at least 0".050 are needed to have an absolute magnitude good to $\pm 0^m.4$.

We have therefore given great attention to two recent papers by Golay et al. (1977) and Golay (1978) suggesting that the concept of photometric boxes could make a similar study possible without appealing either to detailed analyses nor to luminosities derived from parallaxes, but getting all this information from the seven color photometry of the Geneva system. In particular, one of our aims, i.e. to obtain the luminosity function and a non-biased age-distribution in the galactic disk, would be possible with purely photometric data available and in a much greater volume of space.

Indeed, Golay, as he has explained in part VI of this Symposium (Golay, 1978), claims that stars in a same photometric box (having Geneva colors, not more different than $0^m.01$ from the colors of the central star of the box) have also the same physical parameters as those of the central star of the box, such as: spectral type, visual absolute magnitude, chemical composition, equatorial rotation, multiplicity, interstellar extinction, etc., hence perhaps, mass, radius and age.

To check the physical reality of this concept, we have tried to find stars belonging to photometric boxes, having also available

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the other type of data as [Fe/H] ratio, effective temperature and absolute bolometric magnitude. We have used the Catalogue of Lausanne (Morel et al., 1977), but unfortunately we have found stars belonging to only two boxes (three belonging to the box of 16 CygB and two to the box of HD 10307). These five stars have also been studied by Hardorp (1976, 1977). Hardorp agrees with Golay that the continua of the stars in the same box are almost identical. The various data concerning the stars are given in Table I and II.

TABLE I: THE GENEVA PHOTOMETRIC DATA (RUFENER, 1976)

HD	Name	Sp.T	U	V	B_1	B_2	V_1	G
186427	16 CygB	G5V	1.420	0.129	1.107	1.291	0.889	1.174
76151	-	dG3	1.419	0.138	1.102	1.290	0.889	1.177
20630	κ Cet	G5V	1.418	0.126	1.103	1.285	0.880	1.162
10307	-	G2V	1.366	0.198	1.081	1.313	0.951	1.250
34411	λ Aur	GOV	1.378	0.199	1.076	1.308	0.947	1.246

TABLE II: VARIOUS PARAMETERS CONCERNING THE STARS (MOREL et al. 1977, PERRIN et al. 1977).

HD	B_2-V_1	d	m_2	π''	M_{bol}	$\log T_{eff}$	log g	[Fe/H]
186427	0.402	0.576	-0.368	0.036	3.92	3.763	-	+0.10
76151	0.401	0.586	-0.371	0.085	5.58	3.748	4.5	0
20630	0.405	0.575	-0.367	0.107	4.88	3.753	4.45	+0.08
10307	0.362	0.617	-0.397	0.087	4.59	3.763	4.38	+0.12
34411	0.361	0.634	-0.400	0.067	3.77	3.768	4.11	+0.22

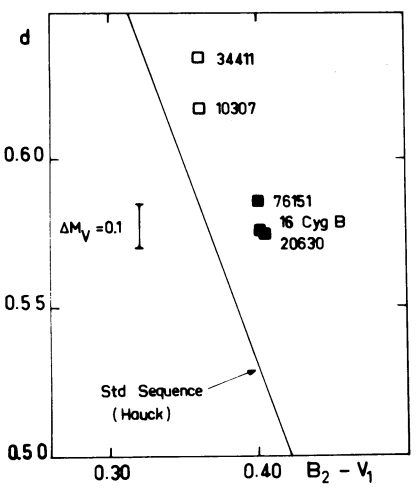

Fig. 1. Geneva luminosity indicator d versus (B_2-V_1).

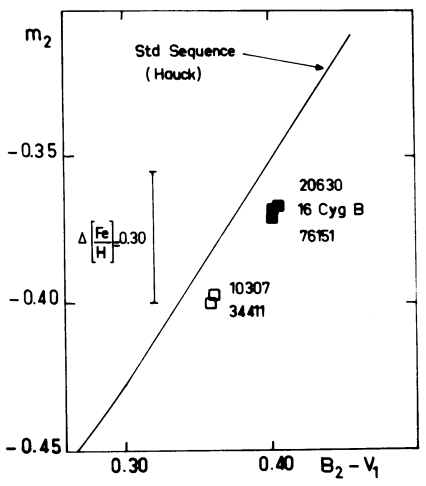

Fig. 2. Geneva metallicity indicator m_2 versus (B_2-V_1).

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The stars have been plotted in the (d, B_2-V_1) and (m_2, B_2-V_1) diagrams of the Geneva photometry (Fig. 1 and 2). The differences $\Delta M_V = 0\overset{m}{.}1$ and $\Delta [Fe/H] = 0.30$, indicated respectively in Fig. 1 and 2 by a bar, come from the calibration of Hauck (1973). The stars belonging to the same box are tightly clustered. They may be supposed to have the same luminosity and metal content.

The stars have been plotted in an observational ($\log T_{eff}$, M_{bol}) diagram (Fig. 3). They are represented with their proper error of M_{bol}. The average error of T_{eff} is drawn at the left side of the diagram. The position of the Sun is also shown. These stars have been compared with five ZAMS computed by Hejlesen (1975) for several chemical compositions (Z or Y) as shown in the diagram.

The position of the stars in this diagram is very different from that of Fig. 1. Here the difference in magnitude between the less evolved and the more evolved star of the same box reaches $1\overset{m}{.}7$ whereas it does not exceed $0\overset{m}{.}1$ in Fig. 1. The main fact which seems arise from this comparison is the insensitivity of the Geneva photometry in the range of spectral type considered here (middle G) to rather large evolutionary effects. This may come from a concomitance of several physical effects acting in opposite way, and/or, may it come from the fact that the luminosity criterion of the Geneva photometric system (the Balmer jump) loses its sensitivity for solar and later type stars?

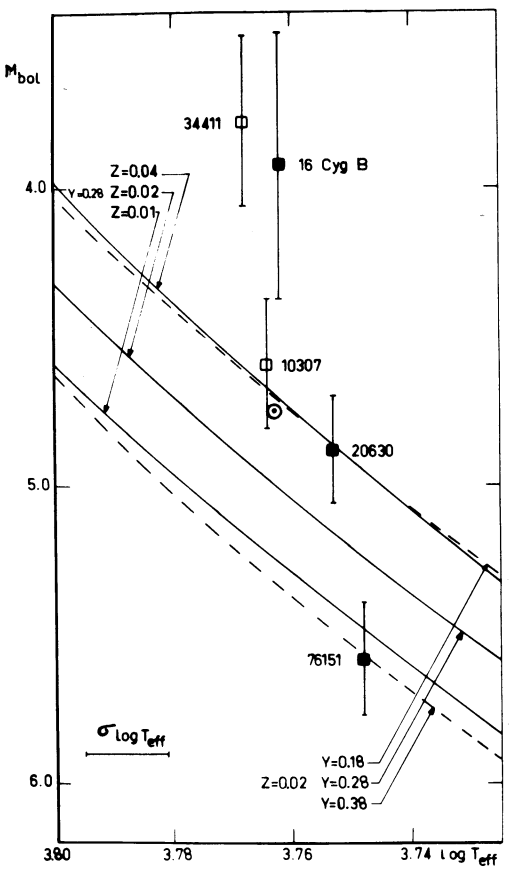

Fig. 3. Observational ($\log T_{eff}$, M_{bol}) diagram.

A complete discussion of the position of the stars in the observational HR diagram would imply a discussion of the helium content of the stars (a parameter which is not taken into account in the Geneva photometry). Such a discussion has been attempted for cooler, non evolved stars in Perrin et al. (1977). Let us just indicate here the case of HD 76151 and HD 20630, which are of solar metal content. One of these stars is surely not evolved and the other, according also to its spectroscopic gravity, is probably not evolved. From their position in the HR diagram these

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two stars could differ in He-content by an amount as high as 0.33 dex.

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DISCUSSION

BELL: Probably only the Geneva U depends on gravity for these stars. A small error in this quantity could cause the stars you mention to fall in the same box, whereas in part their gravities could be different.

HARDORP: I should like to say a word in favor of the Geneva system. There is a good correlation between the Geneva photometry and the ultraviolet absorption features of solar type stars: Stars in the same box as 16 Cyg B are similar to the Sun, in spite of their different locations in the $M_{bol}/\text{Log } T_{eff}$ diagram, whereas HD 10307 differs appreciably in the UV, in spite of its closeness to the Sun in this diagram, and in spite of it being an MK standard for G2V.