SYSTEMATIC EFFECTS ON PHOTOMETRIC PARALLAXES FOR FGK DWARFS AND SUBDWARFS

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ABSTRACT

Hipparcos trigonometric parallaxes were used to establish a preliminary absolute magnitude calibration in terms of effective temperature, metallicity and evolutionary stage indicators for FGK dwarfs and subdwarfs. Photometric determinations of metallicity, needed to establish the calibration, were evaluated by the comparison with known spectroscopic metallicities. The new calibration removes systematic trends present in the calibrations available today and it decreases the rms of the residuals.

Key words: Subdwarfs; main-sequence; absolute magnitude; metallicity.

1. INTRODUCTION

The methods used to derive the absolute magnitude of FGK dwarfs and subdwarfs stars are based on the definition of a standard relation on a colour–magnitude diagram, which fits the sequence of stars with standard metallicity (the Hyades metallicity). A term ($\Delta M_v$) is then added to account for different metallicities; this is computed from the position of the star in a colour–colour diagram (Wickley et al. 1982, Luri 1991) or directly through the parameter $\delta(U - B)_{0.6}$ (Laird et al. 1988). In the case of the Schuster & Nissen (1989) calibration, based on the Strömgren-Crawford photometric system, a polynomial expression is fitted as a function of $(b - y)$, $c_1$ and $m_1$ colours.

These methods, based on broad and intermediate band photometric systems, show discrepancies of up to $\Delta M_v = 1$ mag for stars with $\delta(U - B)_{0.6} \approx 0.2$. These differences may be caused by the corrections applied for blanketing effects and the lack of available trigonometric parallaxes.

To cope with this problem all the Hipparcos FGK dwarfs and subdwarfs with $UBVR$ photometry available at the time of internal proposals were selected. Among them, our sample contains the stars with $4 \leq V \leq 12$, $0.3 \leq (B - V) \leq 1.1$, $0 \leq \delta(U - B)_{0.6} \leq 0.30$ and Hipparcos parallaxes better than 20 per cent (i.e. 350 stars). Strömgren-Crawford and $JHK$ photometric data, available for 75 per cent and 50 per cent of the stars, respectively, were compiled from the literature and own observations (Masana 1997). About 75 per cent of the stars in the sample have known radial velocities. Spectroscopic determinations of the metallicities are available only for 25 per cent of the stars.

![Photometric versus spectroscopic (Carney 1979) determination of metallicity. 78 stars for Schuster & Nissen's calibration (Strömgren system) and 82 for Carney's calibration (Johnson system).](image)

**Figure 1.** Photometric versus spectroscopic (Carney de Strobel et al. 1992) determination of metallicity. 78 stars for Schuster & Nissen's calibration (Strömgren system) and 82 for Carney's calibration (Johnson system).

2. METALLICITY, TEMPERATURE AND EVOLUTIONARY STAGE INDICATORS

2.1. Determination of the Metallicity

Due to the lack of spectroscopic determinations of metallicity for most of the stars in our sample, it is
necessary to resort to photometric calibrations. We considered two photometric calibrations: the Schuster & Nissen (1989) calibration using Strömgren indices, and Carney's (1979) calibration based on the Johnson parameter $\delta(U - B)_{0.6}$. In order to analyse the accuracy of these calibrations, spectroscopic determinations of metallicities quoted in the Catalogue of [Fe/H] determinations (Cayrel de Strobel et al., 1992) were compared with both photometric values (Figure 1). The regression lines show that a slight correction should be applied to the Schuster & Nissen (1989) calibration. The obtained correction is in agreement with the one proposed by Alonso (1994), and, since his sample is larger than ours, his correction was adopted in this work.

The rms of the residuals is 0.18 dex for Schuster & Nissen's calibration (after correction) and 0.26 dex for Carney's. So, in this work we derived photometric metallicity from the former. This calibration covers the metallicity range of $-3.6 < [\text{Fe/H}] < 0.2$ for F-type stars and $-2.6 < [\text{Fe/H}] < 0.4$ for G-type stars. We restricted our sample to these limits.

2.2. The Effective Temperature Parameter

A good effective temperature indicator must be insensitive to metallicity and luminosity effects. Traditionally, the colours used as temperature indicators have been $(b - y)$ and $\beta$ for the Strömgren-Crawford photometric system and $(B - V)$ and $(V - K)$ in the case of Johnson photometry.

Alonso (1994) showed that while $(b - y)$ is only slightly sensitive to metallicity, the $\beta$ index is clearly affected by blanketing. Concerning the Johnson system, he showed that $(V - K)$ is a better indicator than $(B - V)$, because the former is practically insensitive to the blanketing and the surface gravity. We used $(V - K)$ as effective temperature parameter, although this index is available only for about 50 per cent of the stars in our sample.

2.3. The Evolutionary Parameter

Strömgren’s $\delta c_0$ parameter is, for late type stars, a good evolutionary indicator (Crawford 1975). It is defined as:

$$\delta c_0 = c_0(\text{obs}) - c_0(ZAMS)$$

$(b - y)$ is used to derive $c_0(ZAMS)$ in Crawford’s calibration.

We used this parameter to take into account the evolutionary stage in our absolute magnitude calibration.

3. THE ABSOLUTE MAGNITUDE CALIBRATION

3.1. The Existing Calibrations

Four calibrations that take the effect of the metallicity into account were considered:

\begin{enumerate}
\item[(a)] Wildey et al. (1962) and Sandage & Kowal (1966),
\item[(b)] Laird et al. (1988),
\item[(c)] Luri (1991),
\item[(d)] Crawford (1975) and Olsen (1984).
\end{enumerate}
The Hipparcos Data

After selecting stars with Strömgren-Crawford photometry and \( V, K \) colour available and removing the stars placed far above the main sequence, our sample was reduced to 127 stars. Figure 4 shows the distribution of the residuals for the four photometric determinations, \( M_v \) (ZAMS) versus the corresponding Hipparcos magnitude. The Hipparcos Data

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the epichromatic effects involved.

It is essential to maintain the balance of the sample so as to

more accurately of calibration. Special care will be

taken in coordinating the presentation of the progress report

with any processing operations. The presentation order

is reported for the entire sample.

Figure 4. (Right panel) The new calibration of absolute magnitude.

Full circles are stars with [Fe/H] < −0.5 and open circles are stars with [Fe/H] > −0.5. The references are Alonso et al. (1999) and Masana et al. (1999).

The CONCLUSIONS

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