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Hipparcos open clusters as a test for stellar evolution

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Abstract. By relying on recently improved Hipparcos parallaxes for the Hyades, Pleiades and Ursa Major clusters we find that stellar models with updated physical inputs nicely reproduce the location in the color magnitude diagram of main sequence stars of different metallicities.

Key words. open clusters and associations: individual: Hyades, Pleiades, Ursa Major, Praesepe – stars: evolution

1. Introduction

Generally the comparison of theoretical isochrones with the observed Color Magnitude (CM) diagrams of stellar clusters is sensibly affected by the unknown cluster distance. Hipparcos trigonometric parallaxes for the members of some nearby open clusters has greatly improved the situation, allowing one to apply more stringent constraints to the theoretical predictions. The aim of this work is to check theoretical models for different metallicities. We selected clusters with low or even negligible reddening estimates, namely the Hyades, Pleiades and Ursa Major, from the Hipparcos catalogue corrected by the proper motion analysis by Madsen et al. (2002). We are mainly interested in the region not affected by external convection where the fit does not depend on the free 'mixing length' parameter (α). As already discussed in Castellani, Degl'Innocenti & Prada Moroni (2001, hereafter Paper I), the theoretical prediction for the effective temperatures are indeed unaffected by the α assumption only for stars hotter than $B-V \sim 0.4$ (where the convection vanishes) and cooler than $B-V \sim 1.2$ (where the convection becomes adiabatic).

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2. Fit of the main sequence stars

The reddening of the Hyades is generally assumed to be negligible (see e.g. Perryman et al. 1998); as in Paper I, we assume for this cluster $Z = 0.024$ (Perryman et al. 1998) together with $Y = 0.278$.

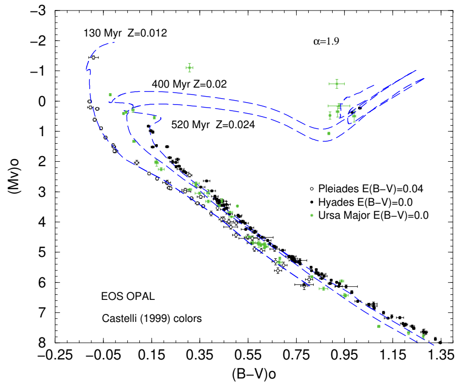

Fig. 1. Observational CM diagram of the Hyades, Pleiades and Ursa Major (by using the parallax values from Madsen et al. 2002) compared with the theoretical isochrones. Visual, spectroscopical and suspected binaries are excluded. The Pleiades data are corrected for the reddening. Error bars indicate observational errors as given by Madsen et al. (2002) for the parallax and by the Hipparcos catalog `http://astro.estec.esa.nl/Hipparcos/HIPcataloguesearch.html` for the colors.

As well known, the interstellar medium inside the Pleiades is not homogeneous, thus the cluster is affected by a differential reddening (see e.g. Hansen-Ruiz & van Leeuwen 1997) which produces a MS slightly scattered. As a first approximation we adopted the commonly accepted average value $E(B-V) \approx 0.04$ mag (see e.g. van Leeuwen 1999). For the Pleiades, recent estimates (Grenon 1999), give $-0.19 \lesssim$ [Fe/H] $\lesssim 0.03$ as discussed below we will adopt the value $Z = 0.012$ for the cluster fit, which is within the observed range of metallicities (see Castellani et al. 2002 for more details). According to the literature Ursa Major should have a solar metallicity ($Z = 0.02$) and a negligible reddening (Mermilliod 1977).

Fig. 1 shows the CM diagram of Hyades, Pleiades and Ursa Major, compared with the theoretical isochrones. Color transformations are from Castelli (1999) for masses greater than 0.7 $M_{\odot}$. For lower masses a careful treatment of the presence of the molecules, which is not included in the Castelli (1999) colors, is needed. Thus for these masses we used the Hauschildt, Allard & Baron (1999) model atmospheres in which the presence of molecules is treated in a suitable way. Theoretical predictions nicely reproduce observations in all regions of the CM diagram. Interestingly enough, one finds that the portion of the MS affected by external convection can be satisfactorily fitted with the same value of the mixing length parameter ($\alpha = 1.9$). We can thus conclude that the adopted stellar models are able to account for the location of H burning structures even with different metallicities, and that there is no evidence against the adopted evolutionary scenario.

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