A Giant Step: from Milli- to Micro-arcsecond Astrometry
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Simultaneous Bayesian estimation of distances and ages from isochrones: SDSS and solar neighborhood FGK stars

M. Franchini[1], C. Morossi[1], P. Di Marcantonio[1] and M. L. Malagnini[1,2]

[1]INAF – Osservatorio Astronomico di Trieste,
Via G.B. Tiepolo, 11, I–34143 Trieste, Italy
email: franchini@oats.inaf.it

[2]Dipartimento di Astronomia, Università degli Studi di Trieste, Italy
email: malagnini@oats.inaf.it

Abstract. By using a procedure based on the Bayesian probability theory we computed reliable and self–consistent estimates of absolute magnitude and age for about 2000 FKG spectral-type stars from SDSS–DR5, ELODIE, and INDO–US surveys, with effective temperature, surface gravity, and metallicity values homogeneously derived.

Keywords. stars: distances, stars: fundamental parameters, Hertzsprung-Russell diagram

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Age determination of individual stars from isochrones is a typical inverse problem: usually, stellar age is obtained by selecting (or interpolating) the isochrone nearest to the observed data. A different and more robust method to obtain unbiased estimates of the physical parameters is based on the Bayesian probability theory; in our case, Bayes's theorem relates the posterior probability distribution of age and absolute magnitude given the observed data, effective temperature, surface gravity and metallicity, to the prior probability distribution of age and metallicity, and to the likelihood function of the observed data, assuming for them a Gaussian distribution. By integrating over mass and metallicity, in fixed intervals of age and absolute magnitude, we can find the bi–dimensional posterior probability of age and $M_{\rm v}$, $P(\tau, M_{\rm v})$. Note that this approach differs from those published up to now since no a priori estimate of $M_{\rm v}$ is assumed. The importance of deriving simultaneously τ and $M_{\rm v}$ is illustrated in Fig. 1 where two different cases are illustrated: the maximum of $P(\tau, M_{\rm v})$ provides, simultaneously, the best estimate of age and absolute magnitude for the given star.

Our observational data-sets comprise about 2000 FGK stars extracted from the Sloan Digital Sky Survey Data Release (SDSS–DR5; Adelman–McCarthy *et al.*, 2007), the ELODIE collection (Moultaka *et al.*, 2004) and the INDO–US catalogue (Valdes *et al.*, 2004). For all the stars, the homogeneously derived log g, $T_{\rm eff}$ and [Fe/H] values (see Morossi *et al.*, 2008) are used as the input observational parameters.

The theoretical values needed for estimating the likelihood function were taken from two different databases. The first one (Pont & Eyer, 2004) is a Monte Carlo realization, kindly provided to us by Pont, built using the IAC–star stellar population synthesis code. The second one is realized by numerical interpolation of the Padova evolutionary models using a code kindly provided to us by Jørgensen (see for details Jørgensen & Lindegren, 2005).

According to our results, most SDSS stars are old while solar neighbourhood stars are young and span a quite large age interval. A check on the reliability of our method

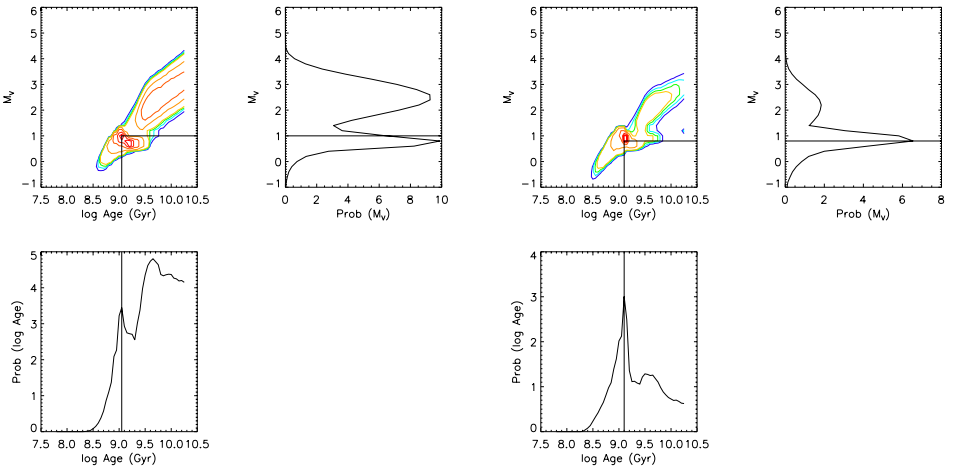

Figure 1. Examples of bidimensional $P(\tau, M_{\rm v})$: the cases of the SDSS star spSpec–52025–0529–330 (left) and of HD 112030 (right) are illustrated.

was performed by comparing the derived $M_{\rm v}$ values with those of the stars with known distance modulus, i.e. the solar neighbourhood dwarf stars with parallactic distances. It shows that the distribution of the difference in absolute magnitudes peaks at $\sim$0.3 mag, with a dispersion of 0.25 mag. As far as τ values are concerned, an indirect estimate of reliability was obtained by applying our procedure to stars with known age. We used the data from de Bruijne *et al.* (2001) for the Hyades main sequence stars. The distribution of the derived ages peaks at 0.7 Gyr, with a mean value of 0.6 ± 0.12 Gyr. Our result is in very good agreement with Hyades age as derived by several authors by comparing observed and theoretical colour–magnitude diagrams. We conclude that our method provides accurate estimates of age and absolute visual magnitude for individual stars. Our technique provides ages and distances used in the contribution to this Symposium by Morossi *et al.* to investigate the Age–Metallicity relation and the chemical vertical gradients in the Galaxy.

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