The role of fundamental stellar parameters in determining ages via interstellar extinction

When estimating the ages of globular clusters, an isochrone, which is calculated directly from stellar evolution models, must be fitted to the cluster’s observed colour-magnitude diagram (CMD) to derive an estimate of the cluster age. These isochrones give absolute-magnitude CMDs, and thus require the addition of an extinction parameter to account for the distance to the cluster and the interstellar environment between the cluster and the observer. The current treatment of extinction for clusters assumes a constant extinction for all stellar objects in the cluster.

In this project, a grid of ATLAS9 stellar atmosphere models was employed, covering objects with effective temperatures in the range 3,500K ≤ *T*eff ≤ 50,000K, surface gravities in the range 0.0 ≤ log(*g*) ≤ 5.0 and metallicities in the range -2.0 ≤ [Fe/H] ≤ 0.5. These spectral energy distributions were combined with the response functions for wide-field filters in the Gaia, HST ACS and HST WFC3 systems and the equations for wavelength dependent of extinction from Cardelli, Clayton & Mathis (1989, hereafter CCM89) to produce tables of bolometric corrections (BCs) via the standard equations. Two sets of BC data were produced for each filter, one at zero extinction and the other at a Johnson *V*-band extinction value of *Av* = 1. The difference between these two datasets represents the ratio of extinction in each filter to *Av*, *Afilter*/*Av*. The overall spectral range covered by these filters runs from the soft-ultraviolet (UV) to the near-infrared (IR).

Overall, the results show significant variation of *Afilter*/*Av* with *T*eff, log(*g*) and [Fe/H], with low *T*eff values producing the largest effects, with a decrease in *Afilter*/*Av*, which becomes constant for *T*eff ≥ 10,000K in all cases. Analytical mathematical models were created and fitted to these results, describing them accurately to within δ(*Afilter*/*Av*) = ± 0.1 for UV filters and to within δ(*Afilter*/*Av*) = ± 0.01-0.03 (depending on the exact filter) for visible and near-IR filters. The forms and coefficients for these models are presented. The accuracy for *T*eff < 3,500K is unknown, but likely to be lower than for the *T*eff values covered by the ATLAS9 grid.

These extinction models are then applied to stellar isochrones obtained from the BaSTI stellar model database and then compared to the same isochrones when treated using a constant global extinction, as plotted in several common CMD axes from the systems. The apparent ages produced by both treatments were compared using the main-sequence turn-off (MSTO).

The first conclusion to be drawn from this comparison is that the choice of model for the constant extinction value is crucial. If each filter is given a value for a model with *T*eff ≥ 10,000K, the entire isochrone may become significantly redder in colour, depending on the filters involved.

If each filter is given a value such that the main sequences of both treatments are aligned (*T*eff = 5,000K, log(*g*) = 5.0, [Fe/H] = 0.0 was the specific model used here), it can be seen that, to a greater or lesser degree depending on the specific CMD and the distance to the cluster, the MSTO for the 10Gyr isochrone with function-form extinction occurs further down the projected MS than for a 10Gyr fixed-extinction isochrone. At the same time, the 10Gyr function-form isochrone produces a red giant branch (RGB) which is bluer than the 10Gyr fixed-extinction isochrone.

Thus, using a fixed extinction produces a MSTO that mimicks that of a younger isochrone using the models used in this project, while mimicking an older isochrone in the RGB. This could impact significantly upon globular cluster age estimates.