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ORIGINAL ARTICLE

Distance indicators from colour-magnitude-diagrams: main sequence, red clump and tip of the RGB

Maurizio Salaris

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Abstract The location of the lower Main Sequence in the Colour Magnitude Diagram, the magnitude of the Red Clump and the magnitude of the tip of the Red Giant Branch are three popular stellar distance indicators. With the present observational capabilities they can be applied to reach distances ranging from the Galactic Disk and Halo populations, to galaxies beyond the Local Group. The techniques devised to exploit these distance indicators are presented, together with a discussion of their calibration, the main sources of systematic errors and the predicted impact of the results from the GAIA mission.

Keywords Stars: abundances · Stars: evolution · Cosmology: distance scale

1 Introduction

Deep Colour-Magnitude-Diagrams of stellar populations coupled to results of stellar evolution theory provide three widely employed distance indicators, that with the present observational capabilities can be applied to reach distances ranging from the Galactic Disk and Halo populations, to galaxies beyond the Local Group. These three 'standard rulers' are the CMD location of the Main Sequence (MS), the magnitude of the Red Clump (RC) and the magnitude of the tip of the Red Giant Branch (TRGB).

The MS is typically employed to determine distances to stellar populations expected to have uniform initial chemical composition and age, and its use as standard ruler can be empirically calibrated by high precision stellar parallaxes. TRGB and RC are usually applied also to stellar populations with non-homogeneous metal content and multiple ages, but currently their calibration as standard rulers needs the use of theoretical results and/or a zero point calibration based on another, independent distance indicator.

A basic description of the techniques employed to exploit MS, TRGB and RC as distance indicators will be presented in the next three section, together with a discussion of the main sources of systematic errors associated to each technique. A final summary discussing the impact of GAIA on the calibration of these methods will follow.

M. Salaris (✉)
Astrophysics Research Institute, Liverpool John Moores University, 12 Quays House, Birkenhead, CH41 1LD, UK
e-mail: ms@astro.livjm.ac.uk

2 Main sequence

A comparison of theoretical isochrones at a given metallicity (and He content) shows that the brightness of the lower MS is typically unaffected by age. If one considers an upper limit to stellar ages equal to 14 Gyr, magnitudes and colours of the MS at M_V larger than ∼5.0–5.5 are age independent, and are affected only by the initial chemical composition. These properties are exploited by the MS-fitting method, widely employed to determine star cluster distances (see, e.g. Sandage 1970; Gratton et al. 1997; Pont et al. 1998; Reid 1997; Carretta et al. 2000; Gratton et al. 2003; Percival et al. 2003; An et al. 2007a, for just a few examples). In case of clusters whose CMD morphology clearly identify as 'young', brighter sections of the MS can be employed, and this allows to apply the MS-fitting technique to reach distances outside the Galaxy (see e.g., Salaris et al. 2003b, for an application to a LMC cluster).

A visual representation of the method is displayed in Fig. 1. One needs to determine observationally a deep CMD of the target population, and consider a template MS of known absolute magnitudes and dereddened colours, with the same chemical composition—that we label here in terms