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ORIGINAL ARTICLE

RR Lyrae stars and their distances

Filippina Caputo

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Abstract RR Lyrae variables play an important role in several fields of stellar evolution and cosmology, moreover, they are the most popular primary standard candles for Population II stellar systems. In this paper, their properties are examined within the framework of modern computations of stellar evolution and pulsation models in order to discuss their use as distance indicators. The comparison between selected observed data and predicted relations, for the determination of both apparent and intrinsic distance moduli, is also presented.

Keywords Stars: distances · Stars: evolution · Stars: pulsation · Stars: variables: RR Lyrae

1 Introduction

RR Lyrae stars, which are named after the prototype RR Lyr, represent the most common type of Population II radially pulsating stars. They are observed in globular clusters, in the Galactic halo and in the old Galactic disc, have periods of $\sim 0.2 \div 1$ day, visual amplitudes of $\sim$0.3 to 1.8 magnitudes, and spectral types of A2 to F6. Two sub-classes are recognized: ab-type variables, which pulsate in the fundamental mode with an asymmetric light curve, and c-type variables, which pulsate in the first overtone with roughly sinusoidal and low amplitude light curves. In 1939, Oosterhoff discovered a fundamental property of RR Lyrae-rich Galactic globular clusters: they can be divided into two groups on the basis of the mean periods of their RR_{ab} stars: Oosterhoff type I (OoI) and type II (OoII) clusters with a mean ab-type period of $\sim$0.55 and 0.65 days, respectively (Oosterhoff 1939). Subsequently, the division was associated to the cluster metallicity (Arp 1955; Kinman 1959; Preston 1959; Sandage 1982): metal-rich globular clusters tend to have shorter period ab-type variables when compared with metal-poor ones.

The RR Lyraes also play an important role in several fields of stellar evolution and cosmology: they are fundamental tracers of ancient stellar populations and, via the calibration of their absolute visual magnitude M_V in terms of the measured iron-to-hydrogen content [Fe/H], they are commonly used as standard candles for distance determinations in the Local Group with relevant implications for the cosmic distance scale and the age of the universe. As a fact, the RR Lyrae-based distances provide an independent test for the Cepheid distance scale in nearby galaxies and for the calibration of secondary distance indicators, such as the globular cluster luminosity function, in more distant galaxies (Di Criscienzo et al. 2006). Moreover, the distance to cluster RR Lyrae stars is fundamental to determine the absolute magnitude of the cluster main-sequence turn-off, which is the classical "clock" to estimate the age of these ancient stellar systems.

In the following sections, the theoretical scenario of the RR Lyrae properties is discussed in order to constrain their use as distance indicators. Eventually, the comparison of selected predicted relations with observations is presented.

2 The stellar evolutionary framework

A popular diagnostic to determine RR Lyrae distances is given by the relation between their absolute visual magnitude M_V and the measured iron-to-hydrogen ratio [Fe/H]

F. Caputo (✉)
INAF-Osservatorio Astronomico di Roma, via Frascati 33, 00040 Monte Porzio Catone, Italy
e-mail: filippina.caputo@oa-roma.inaf.it