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The RR Lyrae Variables in M54 and the Sgr Dwarf Galaxy

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Abstract. We report on new B, V and I CCD photometry of the globular cluster M54 that was aimed at the study of its variable stars. With respect to the previous most recent work on M54 we have nearly doubled the number of detected variable stars: M54 can now be classified as intermediate in the Oosterhoff groups. The metallicity can be estimated for the cluster and field red giant stellar population, and for the variables.

1. Introduction

The most recent work on M54 (Layden & Sarajedini 2000, hereafter LS2000) studied the variable stars and derived the color-magnitude diagram (CMD).

Our data consist of 54 B, 57 V and 52 I frames taken at the 1.54cm ESO-Danish telescope in July 1999. The data reduction was performed using the ISIS package (Alard 2000), which is based on the method of image subtraction. This technique is particularly powerful when searching for variability in crowded fields, both in terms of detection rate and in terms of photometric accuracy. As an example, in Fig. 1 we show for comparison the V light curves of 3 RR Lyrae variables that were measured by LS2000 with traditional techniques (DoPhot) and by us with ISIS.

2. The RR Lyrae variables

With respect to the previous study by LS2000, the number of detected variable stars has increased from 117 to 211, in particular more small amplitude variables (RRc and long period RRab) have been found. *M54 can now be classified as intermediate in the Oosterhoff groups.*

The reddening can be estimated from the (V–I) colors at minimum light of the RRab-type pulsators and is E(V–I)=0.17 ± 0.02 mag. Assuming [Fe/H]=–1.55 dex for M54, and the relation Mv(RR) = 0.20 [Fe/H] + 0.98 (Fernley et al. 1998), we obtain a distance modulus $(m\text{-}M)_0 = 17.07$ mag for M54, in a distance scale where the LMC has a true distance modulus of 18.44 mag.

The Fourier decomposition of the V light curves provides information on several physical parameters (e.g. metallicity, see below).

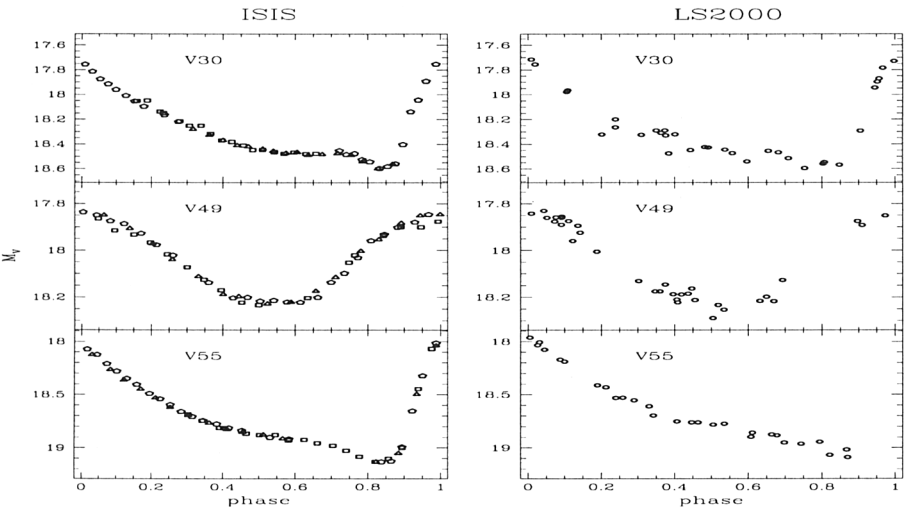

Figure 1. Comparison between our results (ISIS reduction package) and LS2000 (DoPhot) on three common stars.

3. The Color-Magnitude Diagram

We have obtained an improved CMD, where one can clearly identify the contributions of the Galactic disk and bulge contaminating components, the M54 Red Giant Branch (RGB), and the Sgr intermediate and metal-rich RGBs. The various RGB populations, cleaned from the Galaxy contamination, are shown in Fig. 2 along with the respective radial distributions.

3.1. The metallicity distribution

For the RGB stellar components the metallicity has been estimated by comparison with template RGB ridge lines of Galactic globular clusters at various metallicities (Saviane et al. 2000). For the RR Lyraes the metallicity has been estimated by Fourier decomposition of the V light curves (Kovacs & Jurcsik 1997). In Fig. 3 we show the metallicity distributions for the RGB stars of the Sgr field (about half a degree away from M54 - Bellazzini et al. 1999), the RGB stars in the field of M54, and the RR Lyrae variables in the field of M54.

- The RGB stars in the Sgr field show two clear components peaking at [Fe/H] about –0.6 and –1.55 and the hint of a component at about –2.1.
- In the field centered on M54 one can identify the same components as above, at [Fe/H] = –1.55 and –0.6, albeit with different relative proportions. The hint of the component at –2.1 is not seen, possibly because they were included in the decontamination from the Galactic disk/bulge contribution. A small but detectable intermediate Sgr population appears at about –1.2 .
- The RR Lyrae stars belong to populations at three different metallicities, i.e. –1.55 (produced by M54 and the Sgr field), and –1.2 and –2.1 (produced by the Sgr field only). The metal-rich Sgr field population at –0.6, as expected, does not produce RR Lyraes.

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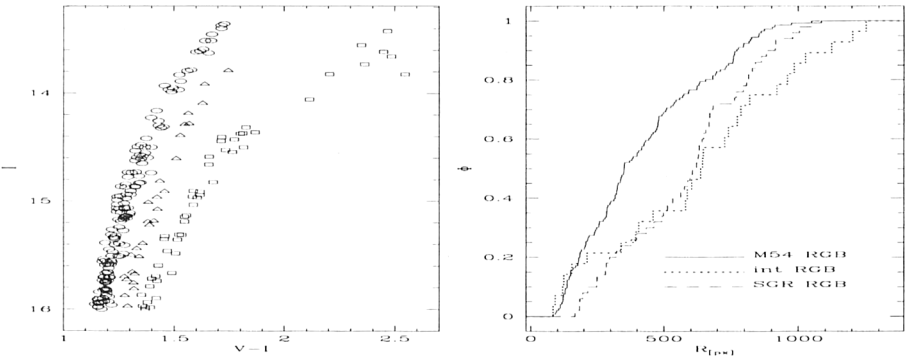

Figure 2. Upper CMD (left panel) and radial distribution (right panel) of the RGB stellar populations belonging to M54 (metal-poor) and to the Sgr field (intermediate and metal-rich).

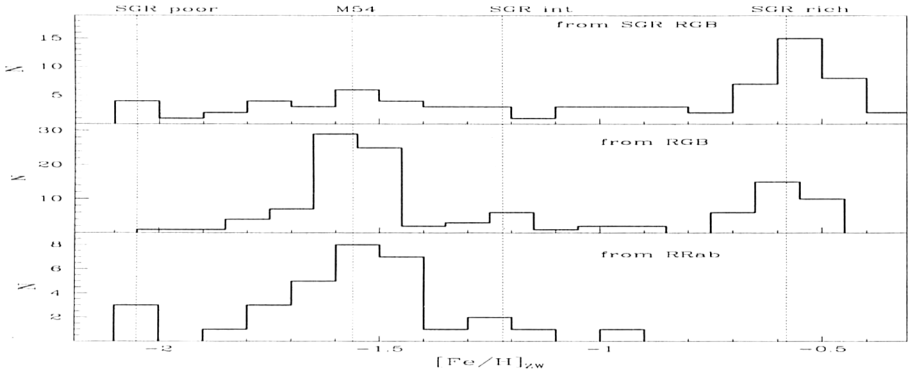

Figure 3. Metallicity distributions. Upper panel: RGB stars in the Sgr field half a degree away from M54. Middle panel: RGB stars in the M54 field. Lower panel: RR Lyrae variables in the M54 field.

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