A Ground-Based Proper Motion Study of 12 Nearby Globular Clusters

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We derive relative proper motions of stars in the fields of 12 galactic globular clusters: M12, NGC 6362, M4, M55, M22, NGC 6752, NGC 3201, M30, M10, NGC 362, M5, and 47 Tucanae. We determine membership probabilities for over 446 000 objects, and show that using them is an efficient method for separating members of the cluster from field stars. In particular, membership probabilities of variable stars including RR Lyrae stars, eclipsing binaries, and blue/yellow/red stragglers are determined.

1 Introduction

Globular clusters (GCs) are important laboratories to study both stellar evolution and dynamics as well as chemical evolution of the whole universe. The presented analysis is a part of the CASE project (Cluster AgeS Experiment, Kaluzny et al., 2005). The project is devoted to a search for and to follow-up observations of detached eclipsing binaries in the fields of nearby GCs, which are useful for determining distances and ages of GCs. An additional result of the project is the discovery of a large number of previously unknown variable stars of other types found in the fields of the GCs, for example RR Lyrae stars, which might be interesting for asteroseismic studies (Smolec et al., 2017). However, to fully benefit from such studies of the properties of the GCs, it is important to separate members of the clusters from the field stars. This can be achieved, for example, by a proper motion study.

2 Proper Motions (PMs) and Color Magnitude Diagrams (CMDs)

The images in V and B filters analyzed in this paper were collected within the CASE project between the years $1997 - 2015$, using the 1-m Swope telescope located at Las Campanas Observatory in Chile. Two CCD cameras were used: SITe#3 with the field of view $14.8 \times 22.8\,\mathrm{arcmin}^2$ and a scale of $0.435\,\mathrm{arcsec/pixel}$ during years $1997 - 2010$ and E2V CCD231-84 with a field of view of $29.7 \times 29.8\,\mathrm{arcmin}^2$ and the same pixel scale in 2015.

The procedure employed to derive relative proper motions was similar to that of Anderson et al. (2006), in which positions of stars in different epochs are determined

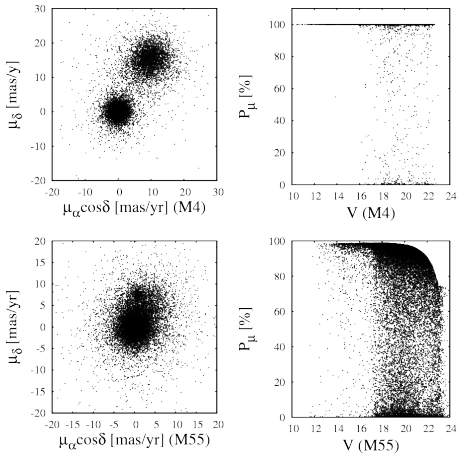

Fig. 1: Left panels: Vector Point Diagrams (VPDs) for M4 and M55 showing different stages of separation between cluster and field stars (well-separated M4 top panel and poorly separated M55 bottom panel). Right panels: P_μ as a function of V for both GCs.

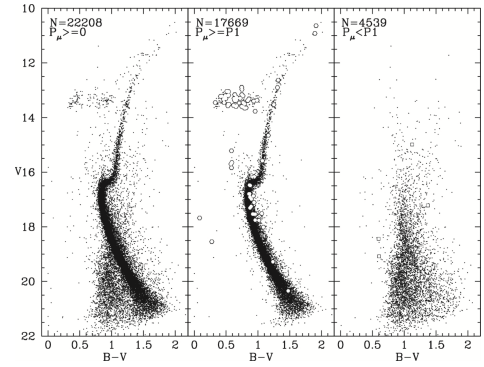

Fig. 2: CMD of M4. All stars with measured PMs and colors (left); stars with $P_\mu \geq P1$ (middle); stars with $P_\mu < P1$ (right), where $P1 = 70\%$. Variable stars are marked with large dots and squares. Figure adopted from Narloch et al. (2017), figure 11.

with respect to nearby cluster members. This is the so-called local transformation method (see Fig. 1). Next, for each star we calculated a membership probability (P_μ; see Fig. 1).

We verified the reliability of the obtained P_μ in four GCs (M4, NGC 3201, M55 and NGC 6752) by comparing the values calculated for individual stars brighter than the main sequence turn off with their radial velocities (v_r) taken from appropriate catalogs, which showed that most stars with a v_r close to the average v_r of the cluster have high P_μ.

Figure 2 presents the CMD of M4, which illustrates the effect of CMD cleaning based on P_μ. Not surprisingly, the CMD-cleaning procedure works better for GCs with VPDs of well-separated cluster and field stars.

Full results of this study were published in Narloch et al. (2017).

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