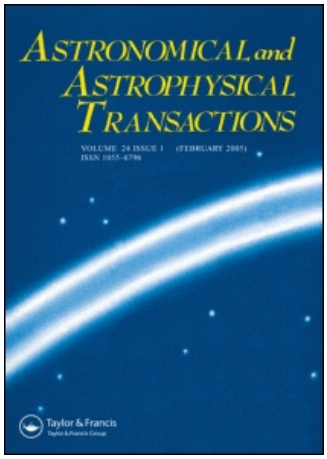

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Absolute proper motions of globular clusters

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Absolute proper motions of globular clusters

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The absolute proper motions for a total of 92 globular clusters of the Milky Way (60% of all clusters included in the catalogue published by Harris) are inferred from the UCAC2 proper motions of their likely member stars. The median formal error of the cluster proper motions is equal to 0.8 marcsec year^{-1} in both right ascension and declination, whereas the proper-motion errors of individual clusters range from 0.2 to 3 marcsec year^{-1}. Tests performed demonstrate the overall validity of the cluster motions; the resulting transverse velocities remain, on the average, virtually constant out to a heliocentric distance of 15 kpc and the full space velocity of most of the clusters relative to the Galactic centre remains, on the average, unchanged near 190 km s^{-1} out to a Galactocentric distance of about 20 kpc, in agreement with the overall isothermal structure of the Galactic halo.

Keywords: Globular clusters; Milky Way; Proper motions; Kinematics

1. Introduction

Globular clusters are objects of greatest importance for the studies of the structure, kinematics and dynamics of the Galactic halo. They have a number of important advantages over other halo probes (e.g. RR Lyr-type variables) because most of these objects in the Milky Way, firstly, have already been catalogued [1] and, secondly, have been thoroughly studied including the determination of accurate heliocentric distances, heavy-element abundances and radial velocities. As a result, globular clusters allow us to probe virtually the entire Galactic halo and not just the solar neighbourhood. However, the lack of sufficiently extensive, consistent and homogeneous proper-motion data (the largest data set contains 41 objects [2, 3]) so far has prevented the analysis of the three-dimensional kinematics and dynamics of this population.

2. The data

The release of The Second US Naval Observatory CCD Astrograph Catalog (UCAC2) [4] makes it possible to change the situation dramatically. This catalogue provides proper

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motions accurate to about 1–3 marcsec year^{-1} for stars to the twelfth magnitude, and to about 4–7 marcsec year^{-1} for fainter stars to the sixteenth magnitude for the sky area from $-90°$ to $+40°$ declination, going up to $+52°$ in some areas, leaving only three known globular clusters (M92, NGC6229 and Pal1) out of the total of 147 objects in Harris's [1] catalogue in the yet uncovered part of the sky.

3. The method

A high density and strong concentration of stars toward the centres of globular clusters make them convenient objects for the determination of their absolute proper motions, because likely members are easy to identify, unlike the situation with open clusters where determination of the membership is one of the key problems. The only difficulty arises because of star crowding in the vicinity of the cluster core, resulting in a degraded quality of the stellar proper motions in the centremost areas. On the other hand, far from the centre the sample becomes contaminated with field stars. This results in a characteristic dependence of the scatter of proper motions as a function of cluster-centric distance (figure 1); the scatter is usually large near the centre and decreases outwards (because of the decreasing influence of crowding), then reaches a plateau and, finally, starts to increase in the outskirts of the cluster (near its tidal radius) owing to increasing contamination by field stars. We therefore use stars in the cluster-centric distance interval from a certain R(min) to R(Tidal) to determine the mean proper motion of the cluster.

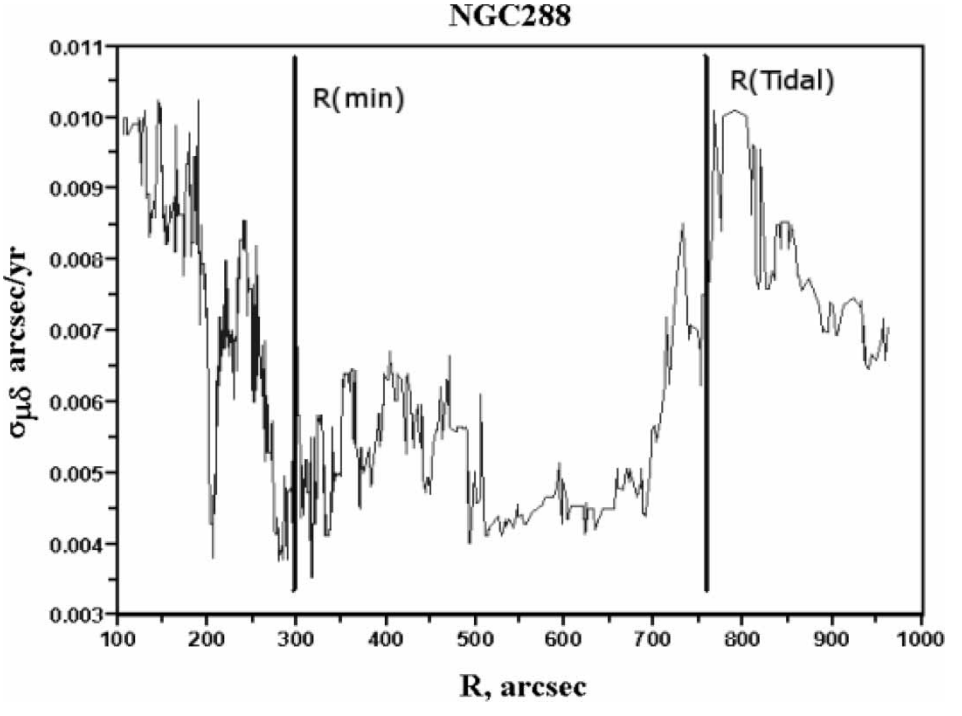

Figure 1. Scatter of the proper-motion component in declination for stars of the NGC288 cluster as a function of cluster-centric distance. Only stars in the cluster-centric distance interval from R(min) to R(Tidal) are used to determine the proper motion of the cluster.

4. Results

We succeeded in determining the absolute proper motions for a total of 92 open clusters out of 147 objects listed in the catalogue published by Harris [1]. The median formal error of our

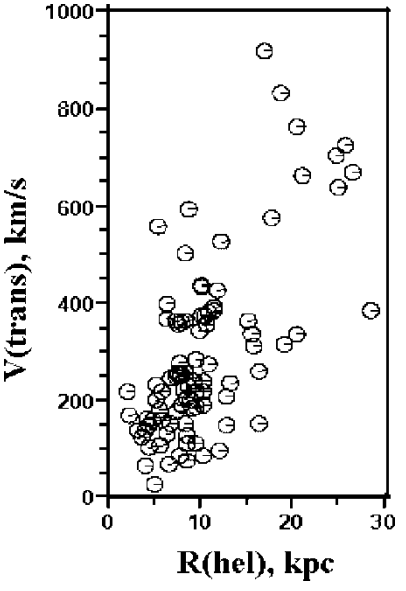

Figure 2. Transverse velocity as a function of the heliocentric distance. Most of the clusters within 15 kpc from the Sun can be seen to have transverse velocities lower than 300 km s^{-1}.

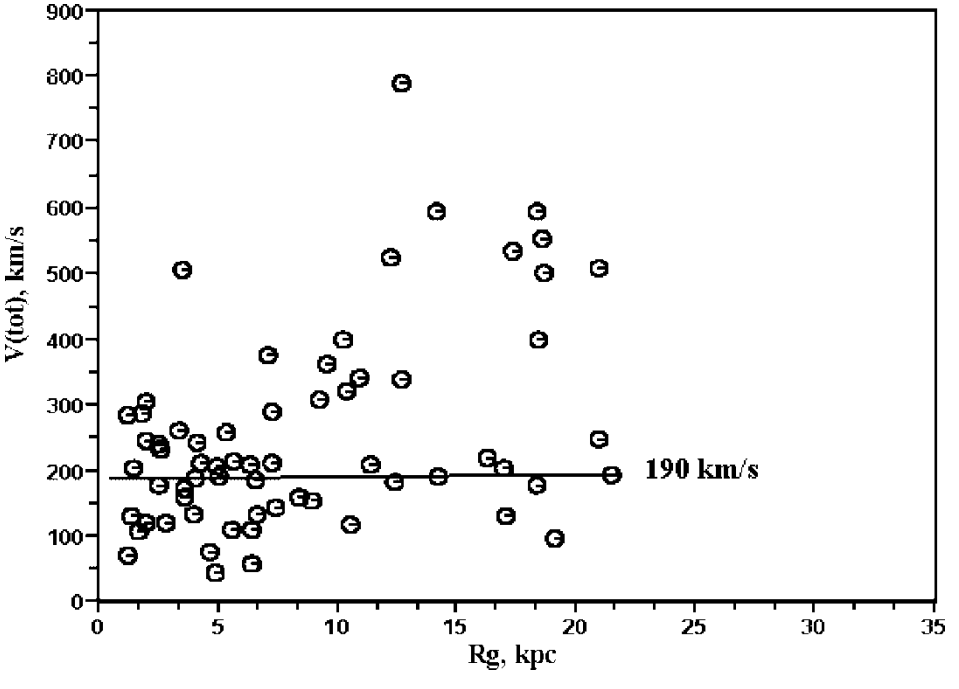

Figure 3. Full space velocity relative to the Galactic centre as a function of the Galactocentric distance.

cluster proper motions is equal to 0.8 marcsec year^{-1} in both right ascension and declination, whereas the proper-motion errors of individual clusters range from 0.2 to 3 marcsec year^{-1}. The transverse velocities implied by our proper motions can be seen to remain within 300 km s^{-1} for most of the clusters located within 15 kpc from the Sun (figure 2). The full space velocity of most of the clusters relative to the Galactic centre can be seen to remain near 190 km s^{-1} out to a Galactocentric distance of about 20 kpc, in agreement with the overall isothermal structure of the Galactic halo (figure 3). The two results can be viewed as a corroboration of the overall validity of the cluster proper motions inferred.

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