MEMBERSHIP AND INTERNAL MOTIONS OF FAINT STARS IN THE GLOBULAR CLUSTER M 3

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SUMMARY. A proper motion study from Tautenburg Schmidt plates is presented for the globular cluster M 3 and its vicinity. The plates were scanned with the Automated Photographic Measuring (APM) system in Cambridge (UK). With a limiting magnitude of $B = 21$, proper motions of 2 to 3 mas/yr accuracy have been obtained for stars with $B < 19$. The proper motions were determined applying a stepwise regression method with 3rd order polynomials in the plate-to-plate solutions with about 2000 reference galaxies. We used the results for the determination of membership probabilities and looked for internal motions of M 3.

1. Observations and Measurements

The Tautenburg Schmidt telescope with a 2 m mirror, a 1.34 m correction plate and a focal length of 4 m has a plate scale of 51.4 arcsec/mm. With a useful plate size of 24 cm, each plate covers some 3° x 3° of sky, providing in higher galactic latitudes large numbers of background galaxies to define an absolute inertial reference frame. Five pairs of B-plates centred on the globular cluster M 3, with epoch differences between 20 and 27 years (these measurements had already been used by Scholz, Odenkirchen & Irwin 1993), and some V plates were measured on the APM with the aim of absolute proper motion and B, V magnitude determination. The measured objects were classified into stars, nonstellar objects, noise images and merged objects using the standard APM software.

2. Photographic Photometry and Star Counts in M 3

The internal magnitude calibration as described by Bunclark & Irwin (1983) was applied to the measurements. The calibrated APM magnitudes on the two deepest plates of different colour were converted to B and V magnitudes, respectively, using the photoelectric photometry of Sandage (1970). The magnitudes were estimated to have an accuracy of 0.1 mag.

There were about 23,700 objects matched on the two deepest plates (in B and V), i.e. 2000 more objects than were found by Scholz & Schmidt (1992) from matching two Tautenburg B–plates. Therefore, we repeated the star counts in the whole field, binning in radial shells with the origin in the cluster centre. Within 5 arcmin from the cluster centre, individual stellar images could not be reliably identified so that we were not able to investigate the core of M 3. Outside

H. T. MacGillivray et al. (eds.), Astronomy from Wide-Field Imaging, 461–463.

a radius of 27 arcmin (corresponding to 75 pc at 9.5 kpc distance of the cluster) the object density is no longer decreasing. From our star counts we determined the spatial density distribution of stars in M 3. At $r = 17$ arcmin (corresponding to 47 pc) a change of the cluster structure can be observed.

3. Determination of Absolute Proper Motions

The plate matching, selection of reference galaxies and stars and the procedure of proper motion determination had already been described in the previous work by Scholz, Odenkirchen & Irwin (1993), dealing with the mean absolute proper motion of the cluster. The global plate-to-plate transform models for each pair of plates were obtained with different samples of reference galaxies using 3rd order polynomials and the method of step-wise regression described in Hirte et al. (1990). The removal of coordinate dependent systematic errors in the proper motions of individual stars was somewhat different to that used in Scholz, Odenkirchen & Irwin (1993) for the correction of the mean cluster proper motion. Separately for each plate pair only the periodic APM errors were removed whereas large scale systematic effects were not corrected for.

The averaging of the proper motions from five pairs of plates allowed us to determine an internal error of the proper motion of each star. For stars with $12 < B < 19$ an internal proper motion accuracy of 2 to 3 mas/year was obtained. For stars fainter than $B = 19$ the errors increased rapidly. In comparison to the more accurate proper motion studies in the M 3 field of Cudworth (1979) and Tucholke, Scholz & Brosche (1993) we obtained a catalogue of proper motions which extends to a fainter magnitude limit and over a larger area.

4. Membership Probabilities

The basic assumption for the determination of membership probabilities is that the distribution function of all stars corresponds to the sum of two normal distributions for the field stars and for the cluster stars, respectively. At high galactic latitudes we usually observe two different samples of near and distant field stars with different proper motion dispersions. Therefore, a restriction of the sky area considered was needed. Within the maximum possible cluster radius of 27 arcmin a good separation of cluster stars and field stars was achieved. A large magnitude dependent systematic error in the y proper motion was obtained and corrected for.

5. Internal Motions of M 3?

Transforming the proper motions to a polar coordinate system with the origin in the cluster centre, radial and rotational proper motion components were determined and averaged for the cluster and the field stars. There was no significant rotation of the cluster. A small radial drift as obtained for the cluster stars seems to be a residual systematic error as far as the same trend was seen for the field stars.

References

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