Dark Matter in Southern Open Clusters

Å. A. E. Wallenquist

Is there dark matter in open star clusters? How is it distributed in the cluster? Is this distribution dependent upon the age of the cluster? These are all-important questions, but they are difficult to answer. On the basis of extensive star counts near southern open clusters, Professor Åke Wallenquist of the Uppsala Observatory, Sweden, has found a possible age effect. The result is not fully conclusive, but it opens very interesting perspectives in cluster research.

In a recent paper (Nova Acta Regiae Societatis Scientiarum Upsaliensis, Ser.V:A. Vol. 3 = Uppsala Astronomiska Observatoriums Annaler, Band 5 N:o 10, 1979) the present writer has made an attempt to investigate dark matter in and around open clusters in the southern sky on the basis of star counts made on glass negative copies of plates taken for the ESO B atlas.

Counting Stars

The counts were performed in the following way (see fig. 1): on the cluster was placed a rectangular reseau with a large number of squares of equal size and furnished with a rectangular coordinate system with the origin at the centre of the reseau. The centre of the reseau was made to coincide as far as possible with the centre of the cluster under investigation. The abscissa was oriented along the direction of the right ascension (W–E) and the ordinate axis along the direction of the declination (N–S). In the case of large clusters, the square of the reseau had an area of 2 × 2 mm², whereas in the case of small clusters or very rich clusters the area of a square was 1 × 1 mm². In the richest cluster more than 80,000 stars were counted! The total number of stars counted amounted to about 1.3 million, distributed over 61 cluster regions.

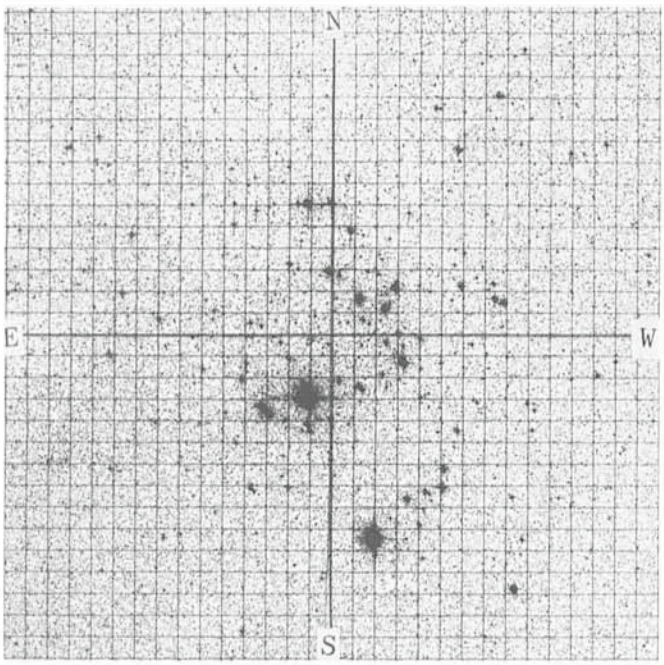

Fig. 1: *The arrangement of the reseau for the star counts.*

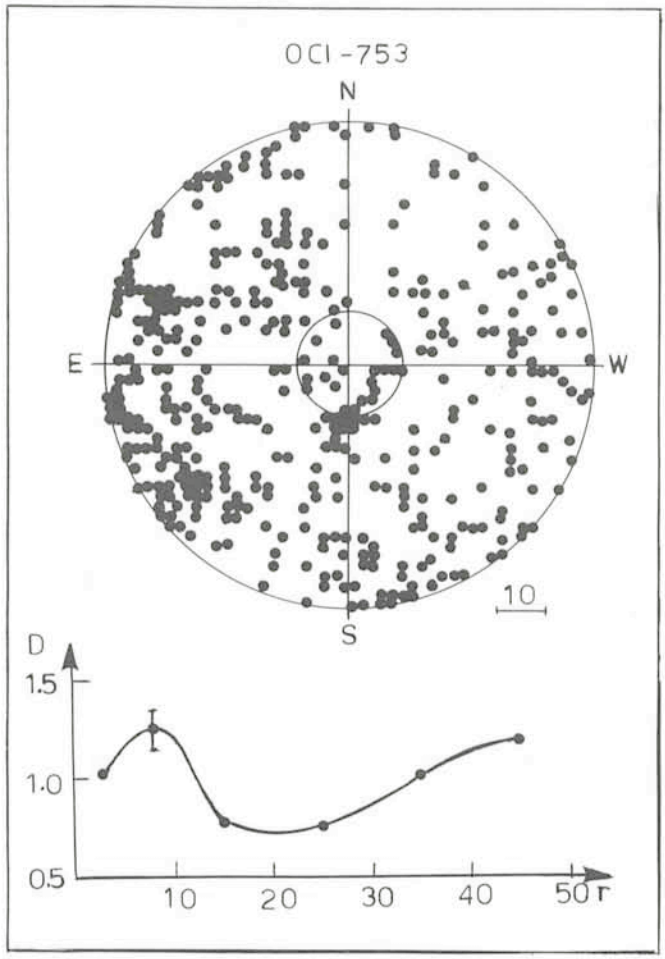

Fig. 2: *The distribution map for the open cluster NGC 2547 (OCl–753).*

The plate under investigation was placed on a special table where it was illuminated from below. The counts were performed with the help of a binocular magnifier with a magnification of about 20 ×. Only well-exposed stars were counted, and faint stars with gray and underexposed images were excluded.

"Dark Squares"

By means of statistical methods the influence of the systematic increase of the surface density of the stars towards the centre of the cluster and the influence of external dark nebulosities or rich star clouds were, as far as possible, eliminated. For each cluster a distribution map was constructed where those squares where the number of stars was at least 25 % less than the average number of stars within the squares in the region investigated were regarded as "dark squares" and were denoted by black dots on the maps.

In order to obtain a clearer view of how the dark squares (dark matter) were distributed with regard to the centre of

the cluster, the surface densities of the dark squares were computed for successive distances from the centre of the cluster. Below each distribution map is the surface density curve for the dark squares; it shows, consequently, the variation of the surface density (D) with the distance from the centre of the cluster expressed in mm on the plate (r).

In figure 2 the distribution map for the cluster NGC 2547 (OCl–753) is reproduced. The circle in the centre of each map indicates the apparent extension of the cluster and the scale of each map is indicated by a horizontal line having the length of 10 mm on the ESO plates (~ 11 arcmin).

Dust and Cluster Age

For the statistical investigation only 28 clusters could be used. The *intensity* of absorption (a), expressed in an arbitrary measure, the *distance* of the absorption zone (that is the maximum of the surface density curve) from the centre of the cluster, with the radius of the cluster as the unit (d) and the *relative* absorption within the cluster, expressed as the ratio between the average surface density for the dark squares within the cluster and that for the whole region (D_c), were studied in the relation to the age of the clusters.

The clusters were, consequently, divided into four groups according to age (log t; t in years) and for each group the mean values of the above-mentioned quantities were computed. The results are given in figure 3, which is self-explanatory. The mean value of each group is represented by a black dot and error bars represent the mean error of the mean.

As shown in the figure, there is a slight indication that the intensity of absorption as well as the distance of the absorption zone from the centre of the cluster increases with the age of the cluster, whereas the absorption within the cluster decreases with increasing age. (The same result was found in an earlier investigation on dark matter in open clusters mainly situated in the northern sky.

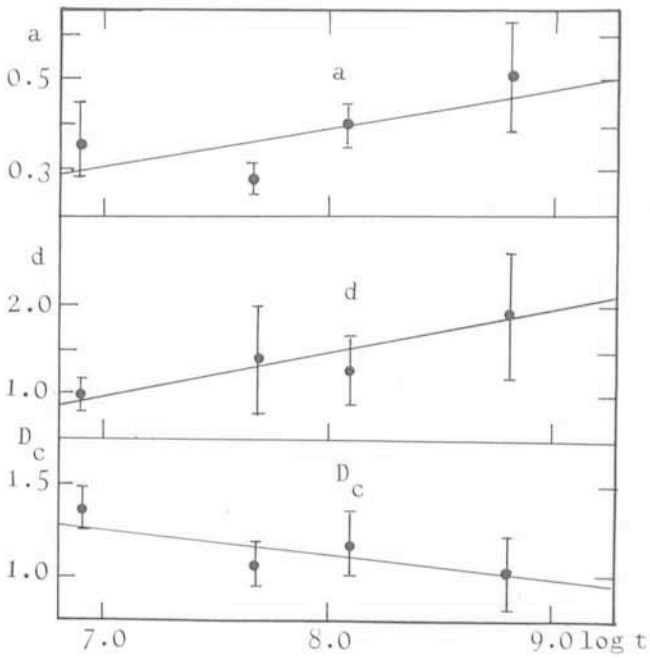

Fig. 3: *The variation of the intensity of absorption (a), the distance of the absorption zone from the centre of the cluster (d) and the absorption inside the cluster (D_c) with the age of the clusters (log t).*

Taking into account the small number of clusters investigated as well as the large mean errors, the result cannot be regarded as fully conclusive. It nevertheless gives an indication that the dark matter (dust) has been driven away from the cluster and that the remaining dark matter inside the clusters has decreased with increasing age.

Astrometry of the Optical Images of Some Southern Radio Sources

H. G. Walter and R. M. West

Radio interferometry has enriched positional astronomy with extremely accurate celestial coordinates of extragalactic sources. As these objects are ideal points for an inertial reference frame, the problem of measuring the positions of optical counterparts with high accuracy is of central importance. Drs. H. G. Walter, Astronomisches Rechen-Institut, Heidelberg, Fed. Rep. of Germany, and R. M. West, ESO, recently measured 41 objects in the southern sky with the ESO S-3000 measuring machine. Several new identifications and improved optical positions resulted from this undertaking.

Radio Sources and their Optical Counterparts

Like stars of bright and intermediate magnitudes, selected extragalactic objects are very useful objects in astrometrical observing programmes aiming at the establishment of a general reference system of positions and proper motions. Due to their large distances, galaxies have proper motions which amount to 0.″00002 per year at most and which are therefore negligible over centuries, even in case of precise observations with present high-performance instruments. The absence of proper motions makes galaxies and other very distant objects the natural representatives of a stable reference system.

The astrometrical, optical observing programmes of galaxies that were executed during previous decades did not arrive at results which were satisfactory in every respect, because most galaxies are diffuse and extended objects and are therefore difficult to measure. For this