A PROPER MOTION STUDY OF THE PLEIADES CLUSTER

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Abstract. The first results of an extensive proper motion study of the Pleiades cluster are presented. A total of 166 exposures covering a 3 by 3 degrees area are now incorporated. The accuracies of the centennial proper motions range from 0".015 in the central region to 0".2 in the outermost region.

Introduction. A good segregation of cluster members in the central 2.5x2.5 degrees region of the Pleiades down to m(pg)=16 has been obtained by Hertzsprung(1947). The internal motions in the cluster centre have since been measured successfully by Jones(1971) and Vasilevskis et al (1979). Three papers dealt with an astrometric detection of members in the outer parts of the cluster: Trumpler(1921), Arthyukhina and Kalinina(1971) and Van Leeuwen(1983) (vL hereafter). The astrometric selection criteria obtained in these papers are not sufficient to rely on for a membership selection. In general, improvements should come from an extention of the field and magnitude range for the internal motions, improvement of the accuracies of internal motions, and an extention and improvement of the membership segregation for stars that occupy the cluster halo.

For the length of astronomical photography, the Pleiades has been a popular subject to picture. The plate material existing at different observatories is therefore likely to be sufficient to improve significantly each of the above mentioned studies. This would allow us to derive a reliable picture of the distribution of masses, energy and angular momentum in the cluster. Moreover, the detection of late type members by means of proper motions has become very important for the study of the pre-main sequence evolution of these stars (see Van Leeuwen 1983, Stauffer et al 1984).

The present paper is an intermediate report on an extensive study of the Pleiades cluster. It provides in the first section a review of the plate material and reduction techniques used. The second section describes the star catalogue and the updating mechanism used in

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collecting data. Section three provides some of the results obtained and section four gives a brief outline of further extensions to the catalogue.

The data. In the most recent catalogue the following data have been incorporated: 161 exposures taken with the Leiden Astrograph (39".3/mm) and 5 exposures taken with the Paris Astrograph (60".0/mm). The Leiden plates cover 1.5x1.5 degrees, the Paris plates 2.5 by 2.5 degrees. The epochs of the plates range from 1898 to 1979. Positions of stars on these plates have been measured with the Leiden Observatory ASTROSCAN automatic measuring device (see Swaans 1981, vL).

The Leiden plates cover the 3x3 degrees field with 9 plate centres, in a four-fold overlap. The first problem that had to be solved was the connection of these non-central overlapping plates. A similar problem has been treated by Eichhorn et al(1970) using multiple plate solutions, involving large matrix manipulations. Systematic errors in the positions thus obtained were claimed by Vasilevskis et al(1979). Here too, we made as a first step a multiple plate solution, using only stars within 7.5 cm from each plate centre. A transformation from rectangular to spherical coordinates is necessary, for which a determination of the position of the projection point was needed. The iterative solution to this position was described by vL. The overlap reduction has been satisfactory and allowed me to perform a reduction of each individual plate, including those exposed with the Paris Astrograph, to the composite Leiden field without significant loss of accuracy. A detailed comparison with the positions presented by Eichhorn et al(1970) is foreseen for the near future.

In addition to an astrometric reduction, also photometric reductions were performed. The density measurements by ASTROSCAN in squares of 20 by 20 micron over the whole stellar image alowed me to obtain from Leiden Astrograph plates magnitudes with an accuracy better than 0.05. As calibrating sequence I used the B magnitudes of the VBLUW photometry presented by vL. Thus, most of the mean magnitudes in the catalogue have an internal accuracy better than 0.01.

The catalogue. The catalogue consists of two files. The first contains information on all exposures incorporated in the catalogue. The second file contains all the star records, each of which contains a reference number for the star and three information matrices (results of least squares solutions by means of Householder transformations). These matrices contain all the information on position, proper motion and magnitude needed for updating the catalogue. An interpretation program is used to represent the catalogue in positions, proper motions and magnitudes, giving for each of these the up to date accuracies. Incorporating new data into the catalogue involves updating with Householder transformations the information matrices, which represent all the previously incorporated data. The updating process is automatic, but allows for manual interaction in order to prevent erratic data to enter the catalogue. A star is only accepted as a catalogue entry if at least five independent data points are available, so that checks on errors are possible. Stars that do not fulfil this requirement yet are stored on a temporary data file in the form of the observation equations.

Some results. The present catalogue contains information on some 1850 different stars, out of which 193 are likely to be cluster members. The accuracies of their centennial proper motions range from 0".015 to 0".1 for 95 percent of these stars. It allows one to study the internal proper motion dispersions up to 2.5 pc (1.2 degrees) from the cluster centre, for stars down to m(pg)=14.5 (mass range 4.0 to 0.6 Mo). A preliminary investigation into these dispersions for stars brighter than m(pg)=11.5 confirms the results obtained by Jones(1971) and Van Leeuwen(1980) out to a radius of 1.5pc. Beyond that radius further interpretation in radial and transverse proper motion dispersions becomes virtually impossible due to the uncertainty in the parallactic influences on the proper motions. Beyond 2 pc these influences cause dispersions greater than the internal dispersions and introduce too much noise too allow further interpretation. The stars fainter than m(pg)=11.5 show projected on the cluster centre a proper motion dispersion of at most 0".06/cent., which is only half the value observed for the brighter stars. Both groups, however, have entirely different spatial density distributions, which do not allow any straight forward interpretation. At larger radii, these fainter stars show virtually only effects of parallactic motion and measuring inaccuracy, and do not allow for a dynamic interpretation.

Five new probable members and one possible member have been detected. In addition, six stars from the list of probable and possible members in the outer regions of the cluster by G.Pels (see vL) have been confirmed : P52, 57, 58, 60, 71 and 142. One of the probable new members is a star from the catalogue by Hertzsprung(1947), Hz 5. This star is situated very close to the edge of the field measured by Hertzsprung. Search maps for these stars have been prepared and are to be presented for publication to the supplements of one of the main journals soon.

Future work. The measurements of more than 500 exposures are ready and waiting to be added to the existing catalogue. They cover mainly the outlying region of the cluster. An incorporation of the original measurements used by Eichhorn et al(1970) is also foreseen. They will not add much weight to the proper motions, but allow for a check on the accuracy of the positional system and the origin of the magnitude error claimed by Vasilevskis et al (1979). In addition, I hope to measure some other old and deep exposures in order to increase the magnitude range of the catalogue to m(pg)=16 or 16.5. This would allow a study of the internal proper motion dispersion over a still wider mass range, and may in addition add some certainty about the membership in this spectral region of the cluster. Any communication on the existence of old plates (within a radius of 5 degrees from the cluster centre and preferably with scales not worse than 60" per mm) would be most appreciated.

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