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STAR POSITIONS IN THE AREA OF THE PERSEUS DOUBLE CLUSTER OBTAINED PHOTOGRAPHICALLY AND WITH A CCD

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RESUMEN

Se presenta un catálogo con posiciones estelares para tres épocas diferentes y recientes en el área del Cúmulo Doble de Perseo. Dos de las épocas fueron observadas fotográficamente con el Telescopio Refractor de 65-cm del CIDA y la tercera con una cámara CCD adaptada al Telescopio Cámara Schmidt de 100-cm también del CIDA. Se comprueba que con una adecuada planificación de las observaciones y la aplicación de un método de reducción en bloque a las exposiciones con CCD, es posible obtener posiciones de un campo con calidad astrométrica.

ABSTRACT

A catalogue with star positions for three different recent epochs in the area of the Perseus Double Cluster is presented. Two epochs were observed with the CIDA 65-cm Refractor on photographic plates, and a third epoch with a CCD camera attached to the CIDA 100-cm Schmidt Telescope. It is shown that with an appropriate planning of the observations and the application of a block adjustment CCD exposures can yield positions of astrometric quality.

Key words: **ASTROMETRY — CATALOGS**

1. INTRODUCTION

With the planning and the execution of the Astrographic Catalogue at the end of the last century photograpy became the principal means for the determination of positions and proper motions. Because of its panoramic property it cannot easily be replaced by detectors which have taken over in other areas of astronomy. For the time being the photographic plate retains its superiority in wide-field astrometry. As a detector, naturally, the CCD is far superior in at least two ways: it is more sensitive, and its output is directly accessible to computers.

The resolution of a CCD is limited by its pixel size. Higher resolution for a given field size evidently means an increase in the required computer capacity, particularly at the telescope. In this paper we want to show that a modest CCD can be astrometrically useful if it is combined with overlap techniques. The results can be equal to or even better than those obtained with photographic plates when the star density in the respective field is relatively high. Thus CCD astrometry may be applicable particularly to star clusters.

In this paper we present star postions in the area of the Perseus Double Cluster for three different epochs. Two of these have been obtained with photographic plates taken with the CIDA 65-cm Refractor, and the third with a CCD attached to the 100-cm CIDA Schmidt Telescope. The epochs of the observations with the Refractor are 1982.8 and 1992.8 respectively. The CCD observations consist of two series, one taken in 1992, the other in 1993, with a mean epoch of 1993.2. The limiting magnitude is similar in all series , being about 12.5 photographic magnitude.

Due to the difference in the focal distance — 1050.0-cm for the Refractor and 309.0-cm for the Schmidt— the positions obtained with the CCD are least acurate than those obtained from plates. Thus in the catalogue a CCD position is given only if either for the same object a photographic position is available also or if three independent CCD positions have been determined.

The principal purpose of this paper is to develop and test a method to apply a CCD to astrometric work. We are fully aware of the fact that the rather large pixel size of the CCD presently available to us does not make it very appropriate for this purpose. However, we expect to have a new CCD with smaller pixels available to us in the near future. At the same time we feel that our final positions are accurate enough to contribute two new epochs to the study of the motions of the cluster. In fact, proper motions for the area derived on the basis of our positions only demonstrate the quality of the material, as shown in Figure 1.

2. THE PHOTOGRAPHIC OBSERVATIONS

The first of the two series of plates mentioned in the previous section was actually taken as part of a parallax program which remained unconcluded. It consisted of 13 plates. The second series was planned to be the reference material for testing a CCD as a position measuring device, consisting of 11 plates. For both series Kodak 103 aG plates combined with a yellow filter were used.

The entire set of plates of the two series were taken with nearly the same field center, a fact which impedes the application of a plate overlap method for the determination of the field distortion, as was done by Abad (1993) for a different telescope. Field distortion, nevertheless was allowed for by introducing non-linear terms and magnitude-dependent terms into the linear block adjustment procedure developed by Stock (1981). The PPM Catalogue by Roesler & Bastian (1991) served as the reference source. Tables 1 and 2 give the mean rms errors of the final positions for the photographic series.

3. CCD-OBSERVATIONS

Recently a new series of observations was made with a CCD attached to the CIDA Schmidt telescope. The CCD is a Thomson TH-7883 with 384 × 573 pixels. The field covered is about 9 × 14 arcmin. The pixel size of 23 μm corresponds

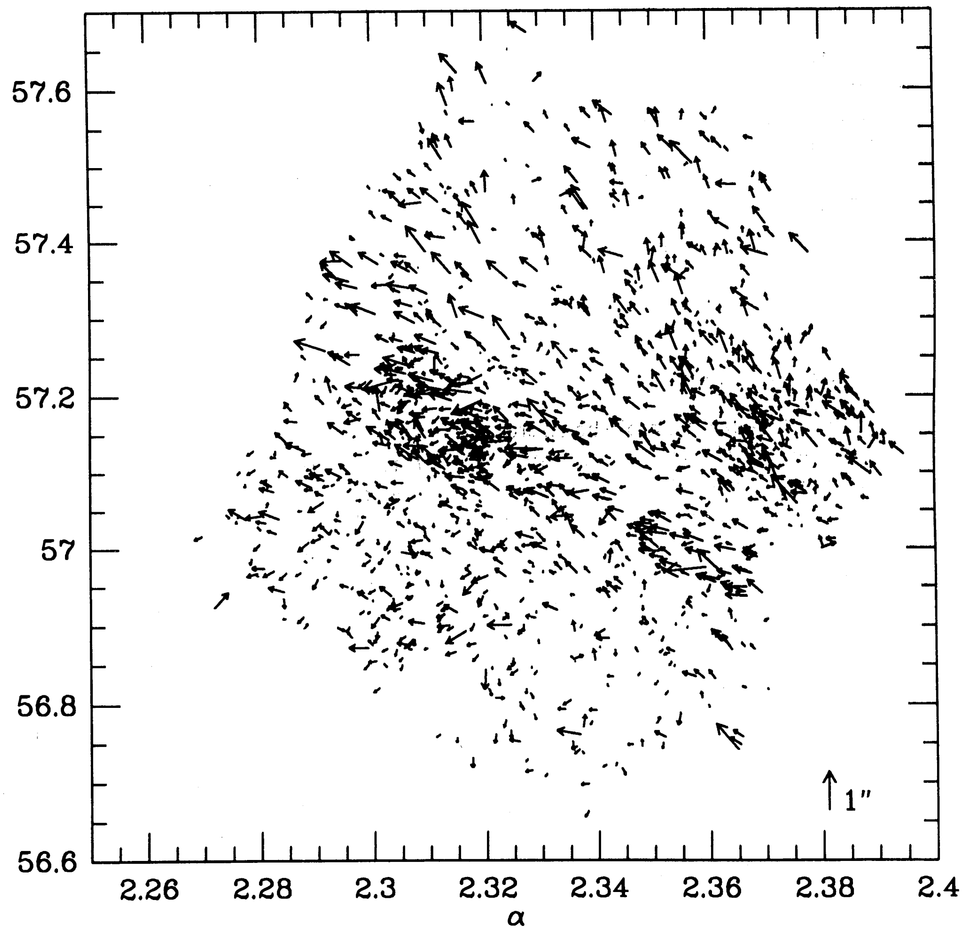

Fig. 1. The distribution of proper motions in the cluster area, as derived from the positions given in the Catalogue.

TABLE 1

MEAN ERRORS FOR α AND δ COORDINATES[a] FOR THE PLATE SERIES OF 1982.8

	Mean errors		
Mag.	(α)	(δ)	N. Images
5	0.023	0.16	13
6	0.023	0.14	48
7	0.018	0.11	41
8	0.017	0.13	325
9	0.017	0.10	1473
10	0.015	0.11	2422
11	0.017	0.13	5085
12	0.019	0.15	4504
13	0.008	0.25	6
Total	0.017	0.13	13917

[a] Given in sec of time and arcsec respectively and distributed by magnitude.

TABLE 2

MEAN ERRORS FOR α AND δ COORDINATES[a] FOR THE PLATE SERIES OF 1992.8

	Mean errors		
Mag.	(α)	(δ)	N. Images
6	0.021	0.25	18
7	0.026	0.23	45
8	0.019	0.15	190
9	0.018	0.15	901
10	0.019	0.14	2251
11	0.024	0.18	5009
12	0.023	0.19	481
Total	0.022	0.17	8895

[a] Given in sec of time and arcsec respectively and distributed by magnitude.

to approximately 1.5 arcsec. An overlap scheme for CCD exposures can be constructed exactly the same way it would be done with photographic plates. Here again one has to make sure that each exposure has a sufficient number of stars in common with neighboring exposures. The exposures were arranged in a mosaic around the h Per cluster with sufficient overlap to ensure that each star in the cluster area would be present on at least two exposures. The overlap scheme also allows the determination of field distortion terms. The total area covered is practically identical to that covered by the photographic plates discussed in the previous section. The mean epoch of the CCD observations is 1993.2.

For the determination of the coordinates of the images within each frame a centering routine of the IRAF program package was used. The mean rms error of a single position was found to be 0.137 pixels. The pixel size as well as atmospheric effects contribute to this value. Considering that the epoch of the second series of plates is almost identical to that of the CCD observations, and that furthermore due to the considerable larger scale of the refractor as compared to that of the Schmidt telescope the accuracy of the photographic positions can be expected to be considerably higher than that to be expected from the CCD observations, the photographic positions can serve as the reference system for the latter. The limiting magnitudes of both the photographic and the CCD observations are quite similar, such that practically every star present on a CCD frame could be used as a reference star. The reduction method to be employed here consists of a transformation of the original plane rectangular coordinates into three-dimensional coordinates on a unit sphere. Subsequent rotation can then transform the coordinates from each exposure into a common system. Table 3 gives the mean rms errors of the final positions for the CCD observations. The results show that with this particular CCD attached to the Schmidt telescope practically the same positional accuracy can be obtained than would be with photographic plates taken with the same telescope and measured with a hand measuring machine such as the Zeiss PSK2. No field deformations were discovered. Considerable improvement is expected once a new CCD with 13 μm pixels, covering nearly the same field is installed.

TABLE 3

MEAN ERRORS FOR α AND δ COORDINATES[a] FOR THE CCD OBSERVATIONS

	Mean errors		
Mag.	(α)	(δ)	N. Images
6	0.026	0.35	8
7	0.027	0.43	6
8	0.016	0.25	13
9	0.019	0.19	180
10	0.021	0.19	604
11	0.023	0.20	3527
12	0.029	0.25	4174
13	0.034	0.27	46
Total	0.026	0.23	8558

[a] Given in sec of time and arcsec respectively and distributed by magnitude.

4. THE CATALOGUE

The difference between the epoch of the first photographic series and that of either of the other two is too large to average the positions into one single epoch. Instead the catalogue gives the final positions and their mean errors separately for each of the three series. Most of the observed stars have been identified in the catalogue by Oosterhoff (1937) who also gives charts for the cluster area. Magnitudes are based on visual estimates of the image diameters, calibrated with the magnitudes given in the PPM catalogue by Roesler & Bastian (1991), extrapolated to the limit of our observations. The internal accuracy is of the order of 0.2 mag.

In order to reduce the physical size of the catalogue we decided to give the hours and minutes in right ascension and the degrees and minutes in declination only for the first epoch, while the seconds of time and arcsec are given for every epoch. A blank in any of the latter columns means that the object was not observed at the respective epoch. The three epochs are 1982.8, 1992.8 and 1992.96. The positions are given in the J2000.0 system.

The catalogue, will be submitted for publication in the *Bulletin d'Information du CDS de Strasbourg,* where it will be avalaible for distribution. It is also available at CIDA via e-mail upon request to (abad@cida.ve) and contains the following information:

Column 1: running number; column 2: number in the Oosterhoff catalogue; column 3: photographic magnitude; columns 4-6: hours, minutes, seconds of right ascension of the first series; column 7: mean error of the right ascension of the first series in 0.001s; columns 8-10: degrees, minutes, arcseconds of the declination of the first series; column 11: mean error of the declination of the first series in $0.01''$; column 12: number of observations for the first epoch; column 13: seconds of time of the right ascension of the second epoch; column 14: mean error of the right ascension of the second series in 0.001s; column 15: arcseconds of the declination of the second series; column 16: mean error of the declination of the second series in $0.01''$; column 17: number of observations for the second epoch; column 18: seconds of time of the right ascension of the third epoch; column 19: mean error of the right ascension of the third series in 0.001s; column 20: arcseconds of the declination of the third series; column 21: mean error of the declination of the third series in $0.01''$; column 22: number of observations for the third epoch.

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