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A PROPER MOTION SURVEY IN THE AREA OF THE GALACTIC CLUSTER IN COMA BERENICES

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RESUMEN

Se derivan nuevos movimientos propios para estrellas más brillantes que $m_{pg} = 14.0$ en el área del cúmulo estelar abierto en Coma Berenices. La época más temprana utilizada consiste de nueve campos de la Zona de Oxford del catálogo Carte du Ciel que se redujeron simultáneamente utilizando el método de ajuste de bloques. La época más reciente se basa en placas tomadas con el telescopio Schmidt del CIDA. Epocas intermedias se tomaron de Heckmann (1929) y de los catálogos AGK. Estos se utilizaron como sistema de referencia. Los movimientos propios combinados se utilizarán en un trabajo posterior para establecer las probabilidades de membresía al cúmulo.

ABSTRACT

New proper motions were derived for stars brighter than $m_{pg} = 14.0$ in the area of the open star cluster in Coma Berenices. The earliest epoch used consists of nine fields of the Oxford Zone of the Carte du Ciel which were reduced simultaneously using block adjustment methods. The latest epoch is based on plates taken with the CIDA Schmidt telescope. Intermediate epochs were taken from Heckmann (1929) and the AGK catalogues. The latter served as reference system throughout. The combined proper motions will be used in a subsequent paper to establish probabilities of cluster membership.

Key words: STARS-PROPER MOTIONS – STARS-CATALOGS – ASTROMETRY

I. INTRODUCTION

Recent developments in simultaneous plate reduction techniques by means of block adjustment have been discussed by Stock (1981). This method provides an efficient approach to the utilization of survey catalogues such as the Carte du Ciel (CdC) for the determination of accurate proper motions. Recent proper motion surveys which utilize the wealth of information retained in the CdC are practically non-existent, and what little has been done has been restricted by the lack of accurate proper motions for the reference system stars and the non-existence or inadequate use of plate overlap methods. The general belief that good proper motions can only be obtained using the same instrument for the first and second-epoch plates is in part responsible for the limited use of the CdC. Obviously, this ideal condition cannot always be fulfilled and alternate methods must be used. In our case, the CIDA 100/150/300 cm Schmidt telescope was used to obtain second-epoch plates. The reliability of the Schmidt system for astrometric purposes has been well documented by Dixon (1963), Andersen (1971) and Stock (1978). Their results clearly demonstrate that the positional accuracy of the Schmidt is comparable to that of most astrographs. Our results show that good proper motions can be obtained by combining heterogeneous plate material reduced to the same reference frame.

The area chosen for the proper motion determinations was that of the galactic cluster in Coma Berenices. Previous investigations have shown this cluster to be poor in stars with a total of nearly fifty probable members identified by Trumpler (1938), Mendoza (1963), and Argue and Kenworthy (1969). Trumpler, Argue and Kenworthy, as well as Artyukhina (1955) coincide in estimating that there are probably less than 10 members between photographic magnitudes 10.5 and 15.5. This would imply that the Coma cluster never had or has lost most of the dwarf stars.

It is the purpose of this investigation to test the accuracy of the block adjustment method for the determination of positions from the Oxford Zone I of the CdC catalogue, and to determine precise proper motions for all stars down to its photographic limiting magnitude in a circular area of $4^\circ.7$ in diameter, covering a large part of the cluster in Coma Berenices.

II. THE MATERIAL

Two plates, each containing two fifteen-second exposures centered at $\alpha = 12^h25^m.6$ and $\delta = +27^\circ 3'$ (1950.0), were taken in April 1980 with the CIDA 1-meter Schmidt telescope. Kodak IIa0 emulsion was

used and processed in D-76 developer. 554 stars down to approximate photographic magnitude 11.5 were measured simultaneously on both plates with a Zeiss PSK-2 stereo-comparator. Plate coordinates (x,y) were measured with an average precision of about 1.5 μm. Image diameters were also estimated for a later conversion to photographic magnitudes. Mean values of the four measured coordinates were formed. 109 stars were found to be in common with the AGK 3 catalogue. Positions for these reference stars were extrapolated to the epoch 1980.3 using only the information contained in the catalogue. Theoretical plate rectangular coordinates (ξ, η) were produced by means of the concentric projection. The relation between (ξ, η) and the measured (x, y) coordinates was established by using a third-degree polynomial of the form

$$\xi = \sum_{i,j=0}^{3} p_{i,j} x^i y^j \qquad (1)$$

$$\eta = \sum_{i,j=0}^{3} q_{i,j} x^i y^j \qquad (2)$$

where

$$0 \leqslant i+j \leqslant 3 \ .$$

The values of the ten coefficients in each coordinate were determined by least squares methods. Th polynomial and the projection equations then permitte a conversion of all x and y coordinates to α and δ, an viceversa.

Earlier epoch positions were available from thre sources: Heckmann's (1929) catalogue of positions fo 211 stars in the Coma region and the Oxford Zone of the CdC. The difficulty which must be surmounte in order to derive satisfactory positions from the Cd is that an accurate reference system must be produce for such a distant epoch. This obstacle was overcom by using a step method which utilized intermediat epoch positions for a better determination of prope motions for the reference stars.

As a first step, improved proper motions wer obtained by averaging those determined from the dif ference between the AGK 2 positions (1930.1) and th CIDA positions (1980.3) with those given in th catalogue by Trumpler. The latter was first checked fo systematic differences with the AGK 3 proper motions No such differences were found. The next step in volved the adjustment of Heckmann's catalogue posi tions to this system. First, the improved proper mo tions were used to extrapolate AGK 2 star positions t the epoch of Heckmann's catalogue positions (1926.3) Then α and δ from both catalogues were transforme into a three-dimensional cartesian coordinate system b

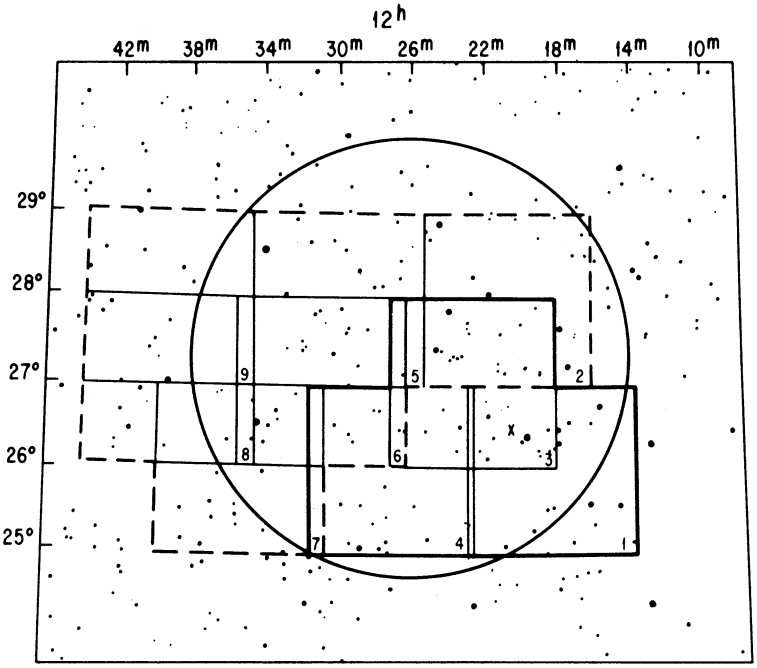

Fig. 1. The Oxford plates under consideration have been divided into two contiguous fields of uniform epoch: one centered a 1899.5 with six plates, the other at 1908.3 with three plates.

$$x = \sin\alpha \cos\delta \quad , \tag{3}$$
$$y = \cos\alpha \cos\delta \quad , \tag{4}$$
$$z = \sin\delta \quad , \tag{5}$$

For 91 stars in common between the catalogues, Heckmann's x,y, and z were transformed into the corresponding AGK 2 coordinates by

$$x = a_{11}\ x_h + a_{12}\ y_h + a_{13}\ z_h \quad , \tag{6}$$
$$y = a_{21}\ x_h + a_{22}\ y_h + a_{23}\ z_h \quad , \tag{7}$$
$$z = a_{31}\ x_h + a_{32}\ y_h + a_{33}\ z_h \quad . \tag{8}$$

If no field distortion terms were present in either catalogue, the coefficient a_{ij} should define a rotation matrix which would absorb the precession. Since orthogonality was not imposed upon the matrix, linear distortion terms would also be absorbed. The nine coefficients were determined by least squares methods. Positions for all stars on Heckmann's list were converted to α and δ for equinox 1950.0 and epoch 1926.3 in the AGK 3 system. 127 stars of Heckmann's list were in common with the CIDA catalogue and new proper motions could be determined for them. These proper motions then were used to again improve the list of proper motions. 21 of these stars are not present in either of the proper motion lists used above. However, in view of the very high accuracy of Heckmann's data, it was decided to make use of these stars also in the steps to follow.

Nine plates from the Oxford Zone of the CdC were selected as a source of early epoch positions for stars in the neighborhood of the Coma cluster (Table 1). The CdC lists image diameters and plate coordinates (x,y) for all stars to a limiting photographic magnitude of ~14.0. The nine plates which we have used are located in a pattern as shown in Figure 1. The rather large overlap between plates makes them an ideal case for the block adjustment method proposed by Stock. The projection geometry in this case is the tangential projection.

The epochs of the Oxford plates under considerations are not very uniform. However, they may be divided up into two contiguous fields of uniform epoch, one centered at 1899.5 with six plates, the other at 1908.3 with three plates (see Fig. 1). Thus, we first formed two separate blocks and then checked all stars in the area in common for large position differences which would indicate high proper motions. Since no large motions were found, a block of all nine plates was formed for the final adjustment.

The α and δ obtained for 1438 stars of the CdC were transformed into rectangular (x,y) coordinates for the CIDA Schmidt telescope. All stars on the Oxford list which were not measured initially were then found and measured on the CIDA plates. In the reduction of 1980.3 positions care was taken to assure that the initial measuring parameters were repeated.

III. THE PROPER MOTIONS

Proper motions for most stars were obtained from the difference between the CIDA and the Oxford positions. When more than two positions were available, linear regression methods were used. In the great majority of cases, the rms error was below ± 0″.2. Proper motions were determined in this way for 953 stars. These

TABLE 1

POSITIONS OF PLATES USED FROM OXFORD ZONE

Ident. Fig. 1	Oxford No.	Epoch	Plate center (1900.0) α	δ
1	2669	1908	12^h16^m	26°
2	1774	1901	12 18	28
3	2774	1909	12 20	27
4	2654	1908	12 24	26
5	1775	1901	12 27	28
6	1004	1896	12 28	27
7	1185	1898	12 32	26
8	1510	1900	12 36	27
9	1776	1901	12 36	28

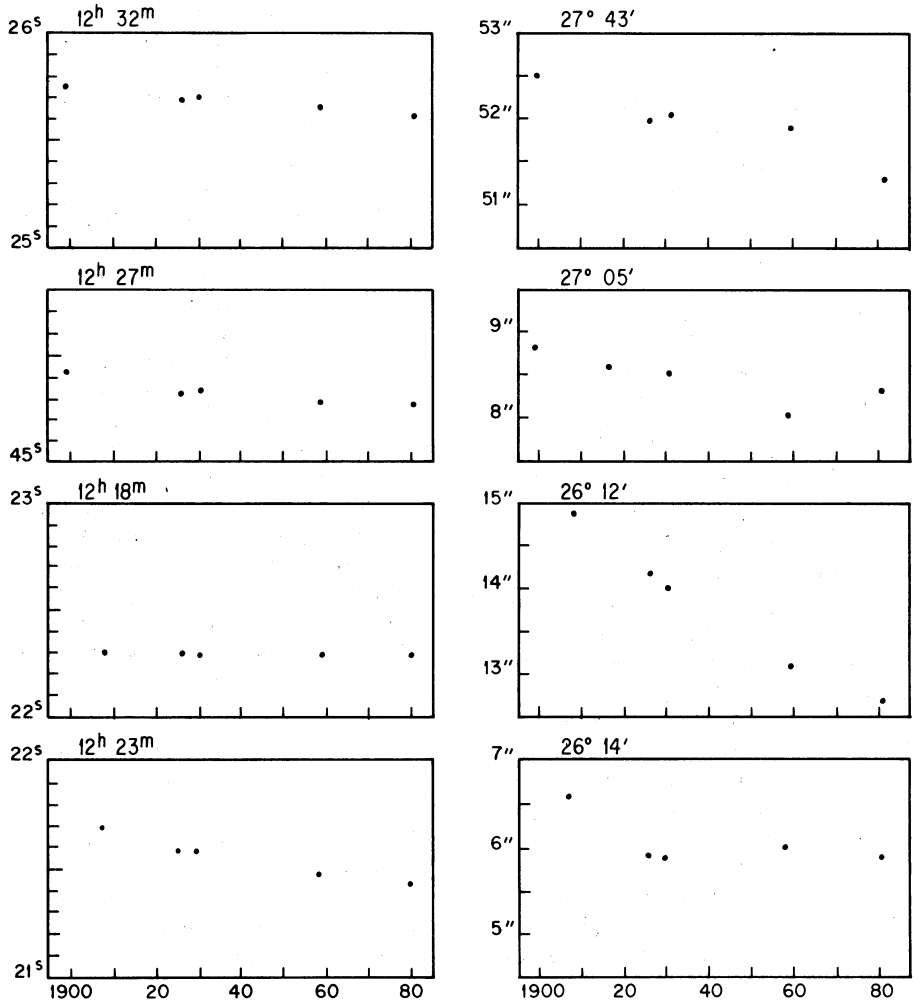

Fig. 2. Representative examples of the proper motions obtained by the block adjustment method (see text for details).

include improved proper motions for 159 AGK stars on the list. A few representative examples of the results are illustrated in Figure 2.

Trumpler's (1938) proper motions were used to check our results since neither his positions nor his proper motions intervened significantly in the step method described above. The results of the comparison for 98 stars in common are shown in Figure 3.

IV. CONCLUSIONS

Presently, there exists a great need for accurate proper motions. The CdC catalogues contain accurate positional data for stars down to a photographic magnitude of ~ 14.0. The only problem lies in the retrieval of the positions. Two important obstacles must be overcome. First, a method must be devised which allows the use of a different telescope for the second epoch. Second, an accurate system of reference stars mut be established for these early epochs.

We have come to the conclusion that both of these obstacles can be resolved by using a Schmidt telescope for the second epoch and by applying a block adjustment method such as that elaborated by Stock (1981) for the simultaneous reduction of the overlapping plates. The results, of course, will depend on the accuracy of the proper motions available for the reference stars. A step method such as that described above will be of great use in this respect.

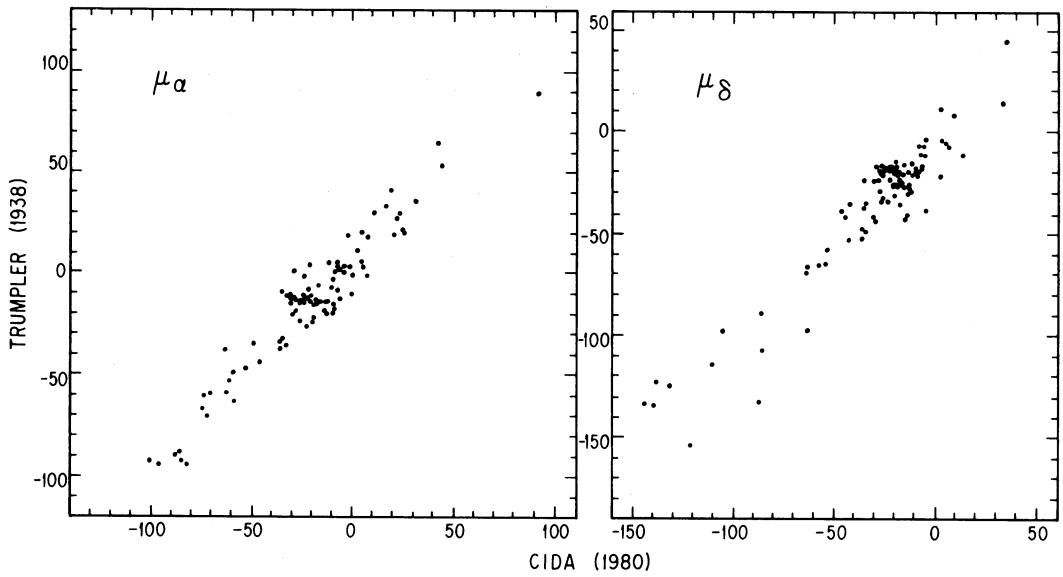

Fig. 3. Comparison of the proper motions from this work and Trumpler's (1938).

The results of this investigation show that if color r magnitude-dependent terms are present in either the IDA or the CdC catalogue, they must be very small. : is improbable that such terms exist in the CIDA chmidt telescope, but Günther and Kox (1972) have iscovered such effects in the Oxford Zone II cata- ›gue of the CdC. It would be desirable to attempt an nalysis of these terms in zone of more uniform epoch rior to extensive use of the catalogue positions for roper motion determinations.

No further analysis of the results in terms of ıembership probabilities was included in this paper nce the area examined does not cover the Coma uster in its entirety. It is the intention of the author › extend the scope of this investigation to an area hich will not only cover the cluster, but also that ›ne in which members might be found.

V. THE CATALOGUE

The catalogue of positions and proper motions is ailable from the author upon request. Included in e catalogue are positions for epoch 1980.3, photographic magnitudes, spectral types (when available), proper motions, and cross identifications.

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REFERENCES

Andersen, J. 1971, *Astr. and Ap.*, **13**, 40.
Argue, A.N. and Kenworthy, C.M. 1969, *M.N.R.A.S.*, **146**, 179.
Artyukhina, N.M. 1955, *Trudy Gos. Astr. Inst. Sternberga*, **26**, 3.
Dixon, M.E. 1963, *M.N.A.S.S.A.*, **22**, 32.
Günther, A. and Kox, H. 1972, *Astr. and Ap. Suppl.*, **6**, 201.
Heckmann, O. 1929, *Veröff. Univ. Sternw. Göttingen*, **5**, 141.
Mendoza, E.E. 1963, *Bol. Obs. Tonantzintla y Tacubaya*, **3**, 137.
Stock, H. 1978, in *Modern Astrometry, IAU Colloquium No. 48*, eds. F.V. Prochazka and R.H. Tucker (Vienna: University Observatory), p. 411.
Stock, J. 1981, *Rev. Mexicana Astron. Astrof.*, **6**, 115.
Trumpler, R.J. 1938, *Lick Obs. Bull.*, **18**, 167.

DISCUSSION

Fuenmayor: Deseo comentar que sería interesante estudiar la posibilidad de aplicación de este método para localizar estrellas de muy alto movimiento propio, conectadas posiblemente con el defecto de masa alrededor del sol.

Peimbert: ¿Tienen resultados preliminares sobre probable membresía de objetos en el cúmulo estelar de Coma?

Cova: La intención de este trabajo ha sido más que todo probar la utilidad del catálogo astrográfico. Ya demostrado, vamos a continuar con una área de $12^\circ \times 12^\circ$. Trumpler (1938) demostró que existen miembros a casi 3° del centro del cúmulo y en nuestro campo de prueba no se incluye la totalidad del cúmulo. Ya comprobada la utilidad del catálogo de Oxford y tomando en cuenta que no intervinieron términos de color y magnitud, seguiremos con el campo mayor y la determinación de probabilidad de membresía.

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