ON THE PROJECT OF A NEW FOURFOLD COVERAGE OF THE NORTHERN HEMISPHERE

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Abstract. The fully inherent information of the AGK 2 plate material, covering the northern hemisphere down to $\delta = -2.5°$ with homogeneous epoch and limiting magnitude has not been used to establish the AGK2 catalogue. A new measurement will provide positions for all stars with at least $m_{pg} = 12$ in the FK4 system, yielding an estimated accuracy of $\sigma = 0''.14$.

In March 1973 a newly developed zone astrograph for the yellow spectral-region has been set in operation at the Hamburg observatory which would be available about 1975 for a new fourfold coverage of the northern hemisphere. A technical description of the instrument is given. Details of the fourfold plate coverage and the observing program are discussed. As a suitable reference star system the AGK3R catalogue, updated with recently derived proper motions to that epoch, is adopted. A final positional accuracy $\sigma = 0''.11$ of the new catalogue is expected. The available epoch difference of 45 years up to that date will then provide proper motions in the FK 4 system with an estimated accuracy of at least $0''.005/a$ for all stars of the northern hemisphere down to $m_{pg} = 12$.

1. Introduction

The recent installation of a newly developed zone astrograph at the Hamburg observatory has offered the possibility to consider the project of a new fourfold coverage of the northern hemisphere in the yellow spectral-region. Adopting for this catalogue a limiting magnitude of about $m_{pg} = 12$, the full magnitude range of the AGK2 plate material, which has not been utilized to establish the AGK2 catalogue, can now be exhausted. Performing a new measurement of the AGK2 plates (epoch 1930) to their limiting magnitude, a combination with the new catalogue positions will provide then proper motions in the FK4 system for all stars of the northern hemisphere down to $m_{pg} = 12$.

If the catalogue project would be realized in the next years, say 1975, it will not be necessary to establish a reference system from new transit-circle observations, because the AGK3R catalogue, updated to that epoch, can be used without appreciably influencing the inherent accuracy of the new photographic catalogue positions. With an automatic measuring machine, fully available for this catalogue work and allowing an on-line preliminary reduction of the plate measurements, the performance of the whole catalogue project should be possible within 6 years.

Together with the just finished fourfold coverage of the southern hemisphere by the Cape observatory (Clube, 1970), the whole sky will then be covered with a nearly similar photographic network, obtained in the same spectral region, and reaching at least a common limiting magnitude of $m_{vis} = 11.5$ for both hemispheres.

2. The AGK2 Plate Material

The AGK2 catalogue, planned as a repetition of the AGK1 by photographic means,

Gliese, Murray, and Tucker, 'New Problems in Astrometry', 209–215.

covers the northern hemisphere down to $-2^{\circ}5$ Decl. The plate material, which will be considered here, had been obtained at the observatories of Bonn (720 plates, Decl. between $+20^{\circ}$ and -2°) and Bergedorf (1219 plates, Decl. between $+90^{\circ}$ and $+20^{\circ}$) with two similar 'AG-type' zone-astrographs as quoted at the beginning of the following section. The two zones have a small common overlapping region, extending to $2^{\circ}6$ in Decl. All plates were taken in a time interval of 3 years, centered around 1930.0. The adopted plate overlap pattern was a center-edge pattern, so that each star appears on at least two plates (see Figure 3, upper part), the plate size is $5^{\circ} \times 5^{\circ}$.

According to the guidelines of the AG-zone commission (Bauschinger, 1927) each plate contains 2 exposures with a duration of 10 min and 3 min, respectively, the short exposure was taken mainly for identification purposes. For obtaining the catalogue positions only the 10 min image was measured, and in accordance with the limiting magnitude of the (visual) AGK1 catalogue the majority of the measured stars have magnitudes up to about $m_{pg}=9.5$.

The great value of this plate material for future astrometric work arises from the fact that the photographic plates in reality go far beyond this limiting magnitude. With the 10 min exposure all stars with at least $m_{pg}=12$ were recorded, whereas the 3 min exposure includes already all AGK2 catalogue stars and a limiting magnitude of about $m_{pg}=11$ has been reached.

The AGK2 plate material therefore contains almost all stars ($\geqslant 90\%$) of the Astrographic Catalogue but in contrast to the latter, the whole northern hemisphere is covered with homogeneous limiting magnitude, and all plates have been taken at nearly the same epoch. The complete plate material is still immediately available at Hamburg and Bonn and in excellent condition for a new measurement. Using a Galaxy-type automatic measuring machine, the new measurement of all plates to their limiting magnitude could be performed in less than 2 years.

Due to imperfections of both objectives, the Hamburg and Bonn positions are affected by systematic errors, depending on magnitude and colour and position on the plate as well (Kox, 1950). The Bonn objective has further introduced a tangential distortion, due to imperfect alignment of the components of the objective (Kohlschütter and Schorr, 1957). The colour and magnitude errors have been carefully investigated in connexion with the AGK3 work, where a new reduction of the (original) AGK2 plate measurements x; y have been made (Dieckvoss, 1960, 1962, 1971, 1973). However, these corrections have been obtained only for the magnitude range under consideration for the AGK2 and AGK3 catalogue. The proposed new measurement of the plates, including the 3 min exposure will further improve the accuracy of the star positions and strengthen the statistical significance of magnitude and colour terms over an extended range. In addition, in certain selected sky areas, cluster proper motions (de Vegt, 1973) and similar available data from the Selected Areas could be used for a closer investigation of magnitude and colour relations up to the limiting magnitude of the plates.

The new reduction of the whole plate material will be performed by blockadjustment methods (de Vegt and Ebner, 1972, 1973) using the AGK2A catalogue (trans-

formed to the FK4) for reference star positions. The expected overall positional accuracy from the new reduction will be $\sigma = 0''.14$, for the mean plate epoch 1930.

3. The New Zone Astrograph

In 1967 W. Dieckvoss and the writer began detailed plannings for a new zone astrograph which should replace the so-called AG-astrograph ($f = 2058$ mm, F:19, field $5° \times 5°$, blue corrected four-component objective) now for more than 40 years in operation. The new instrument has been designed for about the same focal length and field size but, in opposition to the former, the objective is corrected for the yellow spectral-region, and a larger aperture has been introduced. After the necessary financial support had been provided by the Deutsche Forschungsgemeinschaft in 1968, the instrument was built by C. Zeiss, Oberkochen, and was set in operation at Bergedorf in March 1973. The main optical data of the instrument are summarized in Table I.

TABLE I

Optical data of the zone-astrograph

1. Photographic telescope		
Aperture	230 mm	
Focal length	2065 mm	
Appr. scale value	$100'' \text{ mm}^{-1}$	
Focal ratio	1:9	
Field angle	$\pm 4°.7$	
Utilized field size	$5° \times 5° \hat{=} 180 \times 180$ mm	
Plate size	$240 \times 240 \times 6$ mm	
Appr. utilized spectral range	5300–5800 [Å]	5300–6400 [Å]
Filter + emulsion	OG515 + Kodak 103aG	OG515 + { Ilford R 40 / Ilford HP 3
Field distortion	$0''.02 \text{ deg}^{-3}$	
Color-magnification error	$\leqslant 1\mu$ for the whole field and spectral range	
Light-concentration	90% light intensity inside a circle with 20μ diam.	
Filter size	$240 \times 240 \times 6$ mm, Schott OG 515 interchangeable	
Distance to focal plane	17 mm	
Field distortion due to filter	irregular field errors $\leqslant 0.3\mu$ in the whole field	

2. Guiding telescope	
Aperture	190 mm
Focal length	2580 mm
Pointing micrometer setting range	$50' \times 50'$
Setting accuracy	$\pm 1''$ in the whole field

Because a considerable improvement of the colour- and field-corrections as compared with the AG-objective was required, a five-element objective (Figure 1) has been designed using new types of glass for the inner lenses. The focal curve of the objective is shown in Figure 2. A maximum focus deviation of ± 0.1 mm is achieved

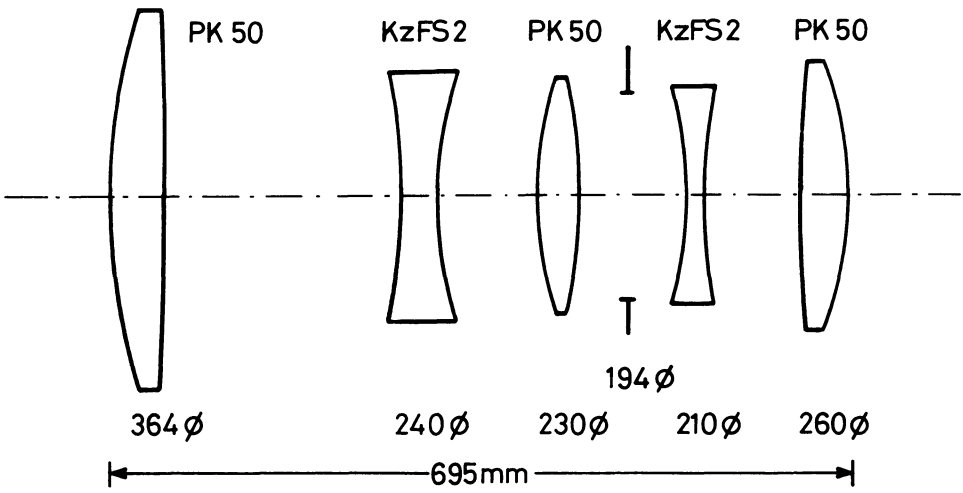

Fig. 1. Five-lens objective of the zone-astrograph.

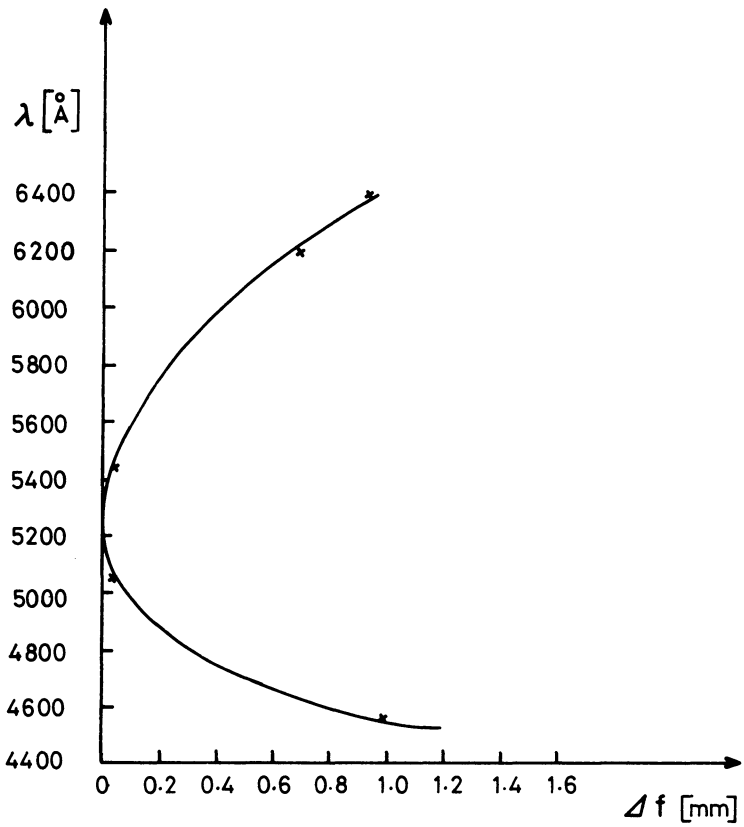

Fig. 2. Focal curve of the zone-astrograph.

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in the desired spectral range 5300–5800 Å, which is about the Rayleigh tolerance. The short wavelength cut-off is provided by an OG 515 (Schott) filter which is plane-parallel within 2″. It is planned to replace this filter by an interference filter, designed for the already quoted spectral bandpass. So one would become independent of the long-wave length cut-off of the photoemulsion. At present technical difficulties have to be overcome in the performance of multi-layer filters of this large size.

The astrograph has a plane plate frame which is rigidly connected in the focal plane to the tube and defines the instrumental tangential plane. During exposure the emulsion side of the plate is pressed against the plate frame by springs. Four adjustable fiducial marks are exposed on the margin of the plate by means of a small optical imaging system. The fiducial marks give then the relation to the intersection of the optical axis with the focal plane.

The whole objective can be tilted and shifted parallel independently relative to the plate frame by a special mounting. Adjusting of the tangential point and tilt of the optical axis is performed by a small adjusting telescope, mounted perpendicularly on a plane base plate. This telescope is equipped in addition with a special autocollimation eye piece and can be attached to the plate frame with proper orientation to the fiducial marks. Reflected images from several surfaces of the objective lenses are used to monitor the tilt of the objective. In addition, the adjusting telescope can be focussed on a small cross, placed in the middle of the last surface of the objective. With this equipment, tilt of the objective and location of the tangential point can be adjusted within an accuracy of 10″.

Both coordinate-axes are provided with encoders which give a resolution of 1 s and 10″ in R.A. and Decl., respectively. Hour angle and declination are displayed continuously. The polar axis of the mounting can be adjusted to any latitude between 24° and 56°. As a transportation of the whole instrument can be provided without difficulties, a temporary change to suitable observing sites for a performance of large observational programs is feasible.

4. Details of the 4-Fold Coverage

The northern hemisphere will be covered by the proposed 4-fold net down to $-2^{\circ}5$ Decl. with about 4000 plates. In practice this overlap pattern would consist of two superposed nets, each similar to the AGK2 plate arrangement (see Figure 3). For one of these nets, the same plate-centers as in the case of the AGK2 will be adopted. An exposure time of 10 min will be suggested to cover the desired magnitude range and a coarse grating will be used instead of taking double exposures. Following the practice of the AGK3 work, the plates will be taken alternately with the camera west and east of its pier, in this way the influence of possible colour-magnitude errors of the objective could be eliminated. The whole observing program could be finished in about two years. With a Galaxy-type measuring machine about the same time is needed to perform the measurement of all plates.

The new zone astrograph, which is at present in its test-phase in Hamburg and

will then be used for a proper motion program of open clusters (de Vegt, 1973), would be available about 1975 for a large scale observing program of this kind. As a suitable observing site the new Observatory of the Max-Planck-Institute for Astronomy in Spain is being discussed. In that case, an extension to $-30°$ Decl. in-

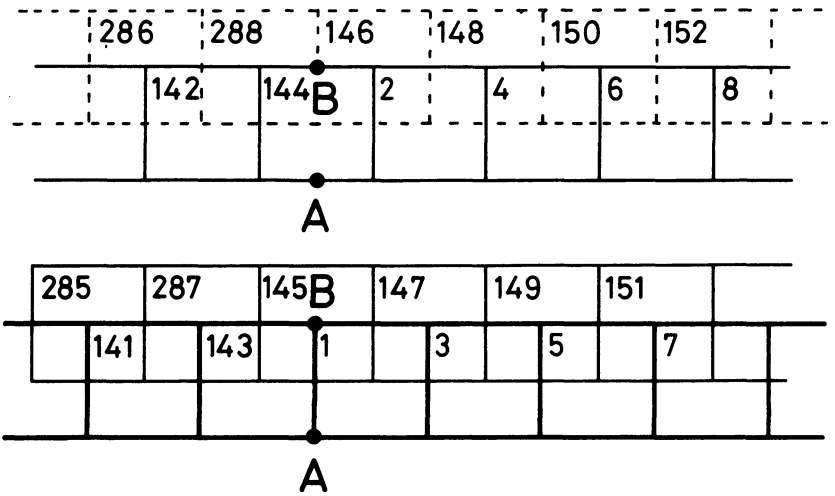

Fig. 3. Plate arrangement for the fourfold coverage. Both nets have to be superposed on points AB.

cluding the whole zodiacal zone, which seems to be of increased importance to further investigations of the lunar orbit, could be considered. At the same time, a generous overlap with the recently finished coverage of the southern hemisphere is then obtained which allows a detailed investigation of systematic deviations of both nets.

5. Reference Star System and Photographic Accuracy

In contrast to the present situation on the southern hemisphere, no new reference star positions for the assumed epoch 1975 of the photographic coverage are available. Recently a pilot program has been started at the USNO (Corbin, 1972) to provide proper motions for the AGK3R stars from available transit-circle observations. Further on in connexion with the question of incorporating fainter stars into the proposed FK5 (Fricke, 1972), the same problem will be considered. It is therefore assumed to use the AGK3R catalogue, updated to 1975, as a suitable reference system. The final accuracy of the AGK3R stars at that epoch depends, however, strongly on the observational history of each star. Some preliminary computations, based on Corbin's material, have shown that at least an accuracy of $\sigma = 0''.18$ (m.e.) for the desired epoch should be reached. With an average number of 23 reference stars per plate and adopting $\sigma = 0''.19$ for the photographic measurements, an accuracy of $\sigma = 0''.11$ for the final catalogue positions is expected, using blockadjustment methods for the reductions.

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Combining this 4-fold coverage with the newly reduced AGK2 positions, proper motions with an expected accuracy of at least $\sigma = 0''.005/a$ will be obtained for all stars of the northern hemisphere down to $m_{pg} = 12$.

The extension of present catalogues, as the AGK3, to those fainter magnitudes will provide more representative samples for all investigations concerning the kinematical properties of different stellar groups. Further on, stellar positions and proper motions in this magnitude range will be of increasing importance as a second-order reference system for the evaluation of optical positions of radio sources.

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DISCUSSION

Dieckvoss stressed, that during the plate measurement automatically magnitude- and colour equivalents will be obtained (AGK2: blue, new coverage: yellow). Thus the value of the derived proper motion data will be greatly improved for all purposes of kinematical studies.