If an insufficient number of stars in each quadrant is observed, the star observations can be combined into pairs, preferably one star observed in the East, the other in the West. These pairs will give rise to equations of conditions with the $\Delta\delta_\delta$ and $\Delta\phi$ as unknowns neglecting the errors depending on α. The influence of the neglected refraction correction to the observed directions has been computed in the case of Blaauw's observations (about 600 star observations in all, or 300 pairs).

It turns out that this neglect would cause systematic differences in the correction $\Delta\delta_\delta$ as follows: for zone of declinations $+60°$ to $+50°$, $+50°$ to $40°$ and so on till $-40°$ to $-50°$, the values: $-0''.13$, $-0''.15$, $-0''.17$, $-0''.17$, $-0''.19$, $-0''.19$, $-0''.22$, $-0''.18$, $-0''.20$, $-0''.17$, $-0''.15$. The error made in the correction to the adopted latitude $d\phi$ is insignificant, $-0''.02$.

In the discussion following this paper Dr Blaauw inquired about the influence of changing errors in the graduation of the circle, and Prof. Heckmann about the importance of collimation error. Dr van Herk emphasized that a change in collimation error would not affect the results. As to the importance of the first source of error, Dr van Herk stated that the division errors had been determined before the first expedition but not since then. As the circle had been changed very often during observations, the effect would at most mean slightly increased accidental errors.

9. A FUNDAMENTAL SYSTEM OF DECLINATIONS AS DERIVED BY SHAPOSHNIKOV'S METHOD

By D. D. Polozhentsev

In compiling fundamental catalogues it is common practice to derive the means from the results of the observations made at different observatories. This method, however, is far from satisfactory when the elimination of systematic errors is intended.

In 1939 V. G. Shaposhnikov (1) suggested an original method of constructing a fundamental system of declinations based upon the principle of zenith symmetry of errors in meridian observations. In accordance with this principle, the arcs of the meridian, spaced symmetrically with respect to the zenith, and equal in the declination system of the catalogue i, are also equal in reality. This equality can be expressed by the following formula:

$$\delta^i_{\phi_i+z}-\delta^i_{\phi_i}=\delta^i_{\phi_i}-\delta^i_{\phi_i-z}, \tag{1}$$

where $\delta^i_{\phi_i}$ is the declination of the zenith in latitude ϕ_i and $\delta^i_{\phi_i+z}$, $\delta^i_{\phi_i-z}$ are the declinations of the points having zenith distance north and south of the zenith at the upper culmination.

For corrections to the system of declinations, Shaposhnikov's principal formula is:

$$\Delta\delta^i_{\phi_i+z}-2\Delta\delta_{\phi_i}+\Delta\delta^i_{\phi_i-z}=0. \tag{2}$$

Applying the systematic differences between the declinations of catalogue i and those of the fundamental catalogue, one can deduce the corrections to the fundamental catalogue. Equation (2) in this case will have the form:

$$\Delta\delta_{\phi_i+z}-2\Delta\delta_{\phi_i}+\Delta\delta_{\phi_i-z}=\Delta\delta^i_{\phi_i+z}-2\Delta\delta^i_{\phi_i}+\Delta^i_{\phi_i-z} \tag{3}$$

where $\Delta\delta_\delta$ are corrections to the system of the fundamental catalogue, and $\Delta\delta^i{}_\delta$, the systematic differences between catalogue i and the fundamental one. The system derived from equations (3) has a definite solution, provided only that the corrections $\Delta\delta_\delta$ at the boundaries of the zone are known.

The construction of a fundamental system based on the zenith symmetry involves the derivation of equations (3), the assignment to these of weights according to their systematic quality, and the solution of the system thus obtained by the method of least squares. The weights are assigned, the extent to which the conditions of zenith symmetry

is met in the catalogue concerned being taken into account. In such a way the catalogues observed with vertical circles will be given larger weights, since with these instruments the principle of zenith symmetry can be observed very strictly. Unfortunately, the present uneven distribution of the observatories in latitude makes it very difficult to obtain declination corrections of equal weight, which results in the general lowering of weights, especially in the zone from 0° to −20°. The weights can be considerably increased if observations are made in latitudes south of −45°. This could be done at an observatory such as that at La-Leona (Argentina), which is now under construction ($\phi = -50°$).

A practical test of the method concerned begun before the war by V. G. Shaposhnikov, has been lately completed by the present author at the Pulkovo Observatory. For determining systematic corrections of the form $\Delta\delta_\delta$ in the GC nine absolute catalogues were used, the majority of which contain stars of the Backlund-Hough list. These catalogues are: Pulkovo 1915, Nikolaiev 1915, Babelsberg 1925, Washington 1910, 1925, Cape 1900 II, Cape 1925 I, San Louis 1910 and Cordoba 1900. The comparison of declination systems of these catalogues with the GC was made by means of 1219 stars, uniformly spaced in α and δ. The declinations of stars were reduced to the epoch and equinox 1925.0 by means of the proper motions from the GC and of Newcomb's precession. The results are given in the table below. They represent a new system of declinations. This system agrees pretty well with those of FK 3 and N 30 for the northern sky, but differs systematically from the systems so far proposed for the southern sky.

Shaposhnikov's method solves directly the problem of determining the systematic errors of the form $\Delta\delta_\delta$. Moreover, it can also be used with some groups of stars with different α for deriving the errors of the form $\Delta\delta_\alpha$. Moreover, by making use of the catalogues with large differences in epochs, one can also obtain systematic errors of proper motions $\Delta\mu'_\alpha$ and $\Delta\mu'_\delta$.

The accuracy of Shaposhnikov's method, the simplicity of its principal premise—the zenith symmetry—as well as the results of the first practical attempt to apply this method, suggest the possibility of employing it for deriving the fundamental systems of declinations.

Table 1. *Corrections to the system of* GC, FK 3 *and* N 30 *for the epoch of* 1925.0, *as obtained by Shaposhnikov's method* (units 0″.01)

δ	Shap. −GC	Shap. −FK3	Shap. −N30	The mean error of corrections to GC
+80°	+ 2	− 2	0	±2
70	+ 6	− 2	+ 2	2
60	+11	+ 2	+ 5	2
50	+11	0	+ 2	3
40	+14	+ 4	+ 4	3
30	+15	+ 4	+ 5	5
20	+13	+ 2	+ 1	5
+10	+16	+ 3	+ 4	5
0	+21	+10	+13	6
−10	+11	+ 3	+ 7	7
20	+16	+10	+10	8
30	+12	− 2	+ 6	4
40	− 4	−24	−15	4
50	− 8	−23	−20	5
60	−10	−25	−20	5
70	−15	−19	−20	5
−80	− 9	−18	−12	±3

Reference

(1) V. G. Shaposhnikov, *A.J. U.S.S.R.* **16**, 3, pp. 62–74, 1939.

The later part of the joint discussion was devoted to problems from the following fields:

Traditional observations
Non-traditional observations
Re-activating work in the southern hemisphere.

Traditional Methods

Dr Atkinson made the following comments:

I should like to offer two warnings about methods of determining flexure which have been mentioned today. (*a*) If one uses a pair of collimators, one only obtains the difference between the flexures in two positions 180° apart; thus even if one arranges pairs of collimators in a large number of different positions, one can never obtain the complete flexure-function: all the even harmonics will always be missing. (*b*) If one observes stars in a mercury pool, as well as directly, one cannot obtain any component of flexure that is anti-symmetrical about the horizon, i.e. all the odd cosines and even sines of the z.d. will be missing. The use of an optical square, which (as the Astronomer Royal has stated) I have proposed, allows all harmonics to be obtained except those which are multiples of 4; by using a similar constant-deviation device set for some other angle, one can also get the 4th harmonics, etc.

Prof. Heckmann called attention to the new observatory under construction at Caracas in Venezuela (latitude +10°) where even a conventional meridian circle would be very useful.

Prof. Zverev said:

Meridian observations by absolute methods are carried out at some well-known observatories. Methods and programmes of the absolute determinations have been based on great experience, and objections to them seem to be out of place. I should like, therefore, to confine myself only to a short remark as to what stars must be included in the programmes of absolute observations.

The progress of fundamental astrometry depends on the development of the new methods of determining the equinox and the equator corrections by means of the observations of minor planets as well as on the employment of extragalactic nebulae for determining the proper motions of stars. Astrometrical observations of these objects are made with reference to faint stars. Hence, it is advisable that not only bright but also faint stars $7^{m}\cdot5$–$8^{m}\cdot5$ vis. be included in the programmes of the absolute observations.

Observations of this kind require careful investigations of the instrument and the study of its stability. This work involves much time and labour. That is why a large list of stars is not suitable for such observations. I consider that a list of about 1000–1100 stars is quite enough for absolute observations at one observatory. The working list of stars for absolute observations at Pulkovo contains about 550 bright Struve stars and as many stars from FKSZ. However, the fundamental catalogue of bright stars must contain not less than 3000–3500 stars. Therefore differential meridian observations of some thousand fundamental stars with the same or other instruments are necessary. The observations of FK3 Supp. stars must also be carried out by differential method at many observatories.

I welcome the extension of the KSZ list for the southern hemisphere as far as the South Pole which has been undertaken at the Cape observatory. The doubling of the number of stars suggested by Dr Stoy is in agreement with the decision taken for the northern hemisphere (I mean the recommendation to observe the stars by two lists—Scott's and KSZ).

Prof. Kopff made the following remark with reference to the N30 catalogue: If the 1930 positions are on the whole free from systematic errors, but the 1900 positions are not, then the 1960 positions have systematic errors of the same order as the 1900 positions.

Dr Stoy asked for information on the relative importance of minor planet observations for determination of the equator point. Dr Brouwer stated that both photographic and meridian observations are equally useful, and that the solutions of the orbits give corrections to the equator point. It is highly desirable to include minor planets in meridian circle fundamental programmes.

Non-traditional Methods

Prof. Heckmann suggested that the following contributions be included under this heading:

The report by M. Guinot made at the meeting of Commission 8 on the performance of the impersonal astrolabe of Danjon.

Absolute determination from azimuth observations by G. van Herk.

Atkinson's mirror transit circle.

Brouwer's photographic method.

Dr Stoy inquired about the plans at the Ottawa Observatory concerning the construction of a new type of transit circle. Sir Harold Spencer Jones reported that the plans are proceeding satisfactorily.

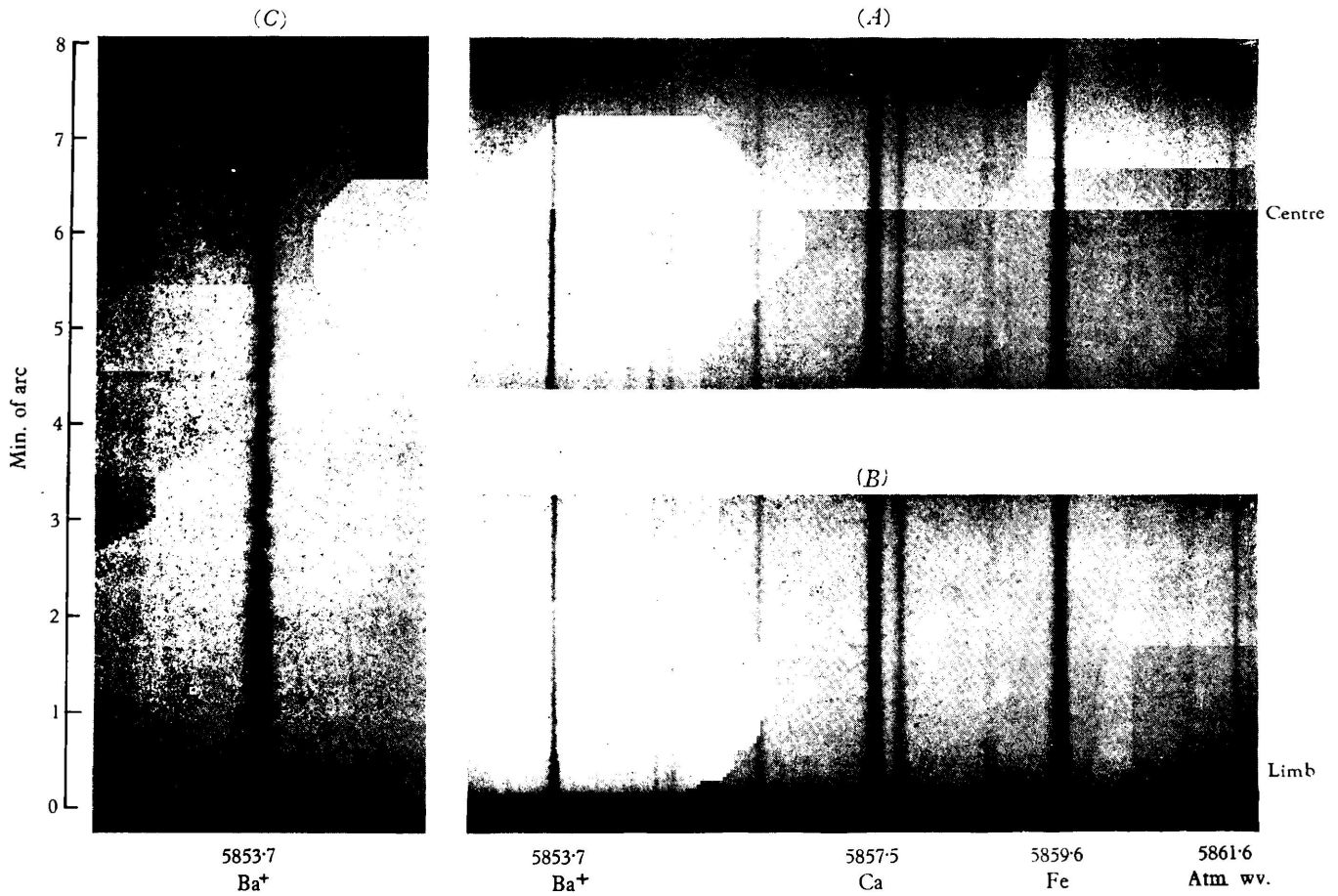
Re-activating work in the Southern Hemisphere

Dr Itzigson reported that an observatory at La Leona (latitude $-50°$) in Southern Argentina is under construction and will probably be ready before the next meeting. In connexion with the inactivity of the observatory at Santiago in Chile and partly at La Plata in Argentine, Prof. Heckmann raised the question whether or not contributions to meridian work could be made by these observatories during a limited period of time. He mentioned that the Bonn meridian circle could be moved to the southern hemisphere. Prof. Lacroute confirmed that M. Schmidt from the Strasbourg Observatory will undertake the re-activating work for the Repsold meridian circle at Quito in Equador.

Prof. Zverev made the following comment:

One cannot accept the fact that no regular meridian observations are carried out in Australia now. Formerly, such observations were made with success in Melbourne, Sydney and Perth. The catalogues of these observatories played an important part in astrometry. It seems of paramount importance that regular meridian observations be undertaken at least at one of the Australian observatories. Commission 8 must contribute to this enterprise.

In conclusion, Prof. Heckmann suggested that Prof. Zverev as chairman of Commission 8 make contact with the observatories mentioned to inquire if they are willing to co-operate in future meridian programmes.



Solar Turbulence

As evidenced by the detailed structure of Fraunhofer lines (McMath-Hulbert Observatory, University of Michigan, Pontiac, Michigan). The spectra of the individual granules or complexes of granules are clearly shown, with their individual Doppler shifts, reaching a maximum of 1–2 km./sec. These displacements increase from the centre towards the limb; over the last few minutes of arc the broadening of the lines appears.

Primary solar image 137 mm. diam.; film Eastman Royal Pan.; slit width, 125μ; slit length, 50 mm.; Babcock grating, 15,000 lines/in., 6 × 8 in., 5th order; developed 5 min., D 19; seeing 4 on scale of 10.

(*A*) Two exposures at the centre of the solar disk, each $\frac{1}{2}$ of the slit length. Top: 11.40 U.T., 20 sec. Bottom: 11.41 U.T., 40 sec.

(*B*) Radial slit intersecting the east limb 24° S. of equator. 11.43 U.T., 45 sec.

(*C*) Enlargement of Ba+ 5853·7 from limb exposure.

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