

und zwei südlichen Katalogen mit dem PGC zur Zeit der mittleren Epoche kombiniert. Schliesslich wurde der FK 3 übernommen.

Das Berliner *Astronomische Jahrbuch* hatte während dieser ganzen Zeit an einer Kontinuität festgehalten: erst Fundamental-Katalog von Auwers (FC), daraus weiterentwickelt den Neuen Fundamentalkatalog (NFK) und daraus den FK 3, der selbstverständlich weiterer Verbesserungen bedarf.

Das Astronomische Rechen-Institut in Heidelberg betrachtet es als seine wichtigste Aufgabe, für die weitere Verbesserung des FK 3 in naher Zeit zu sorgen, wofür schon neue Beobachtungen in grosser Zahl vorliegen. Für die Rektaszensionen bedeutet die Einführung der Quarzuhren einen wesentlichen Fortschritt. Daran schliesst sich der in Heidelberg zu bearbeitende FK 3 Supp an (*Astr. Nachr.* Bd. 281, Heft 1). In dieses System ist auch der FK schwacher Sterne (*faint fundamentals*) einzugliedern. Dringend erwünscht ist es, dass möglichst bald eine einheitliche Festsetzung der Sterne des gesamten Fundamentalkatalogs erfolgt, um der durch die Zeitumstände hervorgerufenen Zersplitterung einen Einhalt zu bereiten, und zu vermeiden, dass Positions-Beobachtungen unbenutzt bleiben.

IV. Vierte Frage: Wie soll der gesamte FK veröffentlicht werden?

(13) Die Antwort scheint mir einfach. Für alle helleren Sterne (bis 6.5 oder 7 mg.), die für die verschiedensten Zwecke benutzt werden, sind die Örter für den Anfang jedes Jahres zu veröffentlichen, ausserdem Ephemeriden für eine möglichst grosse Zahl dieser Sterne. Für die schwächeren Sterne genügt es, ihrer Verwendung entsprechend, die mittleren Örter für einzelne Äquinoktien zu geben. Hilfsmittel zur Berechnung scheinbarer Örter sind für alle Sterne bereitzustellen.

In reply to a question from Dr Jackson, M. Watts replied that the *Fundamental Catalogue* N 30 will appear very shortly.

Dr A. Wilkens suggested determining the positions of the faint stars (to 11^m.0) in direct reference to fundamental stars, using an ordinary visual refractor as meridian circle. For reducing the influence of flexure the observations must be made in narrow zones not wider than 5°. In the discussion of this suggestion Dr Jackson and Prof. Zverev expressed their doubts concerning the practicability of the method outlined.

3. ON THE BERGEDORF CATALOGUE OF FAINT STARS

By J. LARINK, Hamburg-Bergedorf

In his introduction to the *General Catalogue* Boss reports on the outlook for positional astronomy at the end of the nineteenth century with these words:

Towards the end of the nineteenth century it became increasingly and discouragingly apparent that the outlook for positional astronomy was sorry indeed unless new developments were forthcoming. An immense amount of raw material had been produced, with no apparent market.

As you all know, the considerations which are expressed in these words led Boss, father and son, to the derivation of the famous *Preliminary General Catalogue* and later on to the *General Catalogue*.

In the last decades a new branch of positional astronomy has developed. In the hands of Schlesinger and others astronomical photography on large fields became a powerful instrument for astrometric purposes and it has been shown that the weight of one single photographic position of a star, derived with a modern wide-angle camera and reduced with the help of a good system of reference stars, is three or four times as great as the weight of one single modern meridian circle observation. The immediate consequence

of this fact cannot be overestimated. In the first place the meridian circle may be used for fundamental observations in the old sense, where up to now we have not been able to do without it, though certain work in fundamental astronomy may be done by other instruments even now, as for instance the work of the Leiden astronomers and the work with the photographic zenith tube has shown. The meridian circle may also be used for observing a good system of reference stars. The measuring of the places of the great bulk of stars should certainly and will certainly be done photographically.

Of the two steps necessary for practical reasons for building up the system of reference stars for the photographic plate, the fundamental observations do not belong to the topics of our symposium, at least not directly. It is the differential observations of the reference stars proper with which we have to deal.

These remarks are by no means original but have been emphasized by many colleagues in recent years and it seems to me very remarkable that during the last years they have developed independently in different places.

Some optimistic colleagues had expressed the hope that Boss's *General Catalogue* itself could be used as a reference system for a longer period of time. However, I can show you here a part of a GC star-map which we made at Bergedorf some years ago. The stars are given in four steps of magnitudes. In our considerations only the green and red points, viz. stars from 8^m to 9^m and stars fainter than 9^m play a role. A short inspection will show you that the distribution of these faint stars is purely due to the accidents of observation and is very uneven. Many of the faint stars are components of double stars. Of course the use of diffraction gratings would improve the situation, as brighter stars could be used to fill up the gaps, but one may doubt, whether a perfect system of reference stars for photographic plates could be made in this way, apart from the fact that the exactness of the star places of the GC is deteriorating with the passage of time.

Of course there is a great number of faint stars in the old AG catalogues, but they do not satisfy our modern aims. You all know the very interesting procedure of Schlesinger who replaced the positions of the reference stars in the *Carte du Ciel* by modern positions, so getting photographic star places which are by far superior to the old *Carte du Ciel* positions. In Bergedorf, after some previous trials in the zone of AG catalogue Berlin B, Dr Heckmann and his collaborators are preparing the reduction of this zone of the 'Carte du Ciel' on a larger scale.

Similar considerations led Dr Kopff to ask for a catalogue of faint stars. Since we have a great number of faint stars in the old AG zones, and since these old positions have greater accidental errors than modern meridian circle positions and besides this are subject to systematic errors, in the first place to an error in magnitude, one should expect that by combining some newer star catalogues and extrapolating to the epoch of the old AG zones one could make the old material homogeneous and could arrive at proper motions which may not be very exact for the single star but would fulfil the requirements of stellar statistics.

These considerations of Kopff given in his Darwin-Lecture before the Royal Astronomical Society in 1935 were the starting point for my work on the positions and proper motions of faint stars. Since we at Bergedorf have a meridian circle with 19 cm. ($7\frac{1}{2}$ in.) aperture, and since I have made many thousands of observations of the faint Polarissima BD + 89° 1, whose magnitude is $10^{m.6}$, I tried to go down in magnitude as far as possible. So I was able to use the faintest stars of the well-known catalogue Bonn X (Küstner 1900). Küstner observed with the 6-inch Bonn meridian circle with gratings, but did not use the impersonal micrometer. With the help of Küstner 1900, AGK 2 and our new observations we could hope to get good positions of faint stars for 1900 (Küstner), 1930 (AGK 2) and 1950, the epoch of our own observations.

The number of 3000 stars was the proposal of Kopff. I thought a number of four observations for each star necessary, since four observations with the meridian circle have the same weight as a single photographic observation. So I did not dare to surpass this number of 3000 stars, though certainly a greater number would have been more profitable in several respects. I shall come back to this matter later. But let me remind

you at first that Küstner 1900 has stars between the equator and $+50^\circ$, which corresponds to the zenith of Bonn. This part of the celestial sphere is nearly two-thirds of the hemisphere, and since I wanted to go to -5° in declination to have a good overlap in the case of a similar catalogue for the southern hemisphere I had to take about 2000 stars from Küstner 1900. Küstner has nearly 4000 stars of magnitudes fainter than $8^m.0$, which magnitude I took as an upper limit, and so I had to take one-half of these stars. The remainder of the stars, about 1000 between $+50^\circ$ and the north pole and 300 between the equator and -5° , I took from the catalogue Bo xx and from AGK 2 A, the Küstner-König list of stars. The catalogue Bo xx (Mönnichmeyer-Hopmann) has been observed while Küstner was still director of Bonn Observatory. There is a difference between Bo x and Bo xx in the observing method, viz. the use of the impersonal micrometer in Bonn xx, and in the epoch, which is 1900 in Bonn x and 1915 in Bonn xx. But this difference is not so serious, since gratings have been used in both cases.

As Dr Zverev has remarked, the distribution of the stars into a network of optimal uniformity on the sphere is a rather difficult and tedious task, if you want to fulfil some rather stringent conditions: stars fainter than $8^m.0$, no double stars whose visual or photographic observation would be difficult, small or, better still, imperceptible proper motions. Whether the distribution of the stars is uniform enough you may judge for yourself from the original drawings. An example is given in the photostatic copy of the star list.

The principal advantage of the catalogue seems to be the fact that the observations *have* been made, and they have been made not only in Bergedorf by Dr Kox and myself but also in Heidelberg by Dr Bohrmann, Dr Groeneveld and Dr Klauder. Both observatories have finished the observations with the exception of some controls which will be made as we hope in the coming weeks. Since we have the intention of condensing the observations of Bergedorf and Heidelberg into one catalogue we hope that some years hence a catalogue of very faint stars will appear, each star being observed at least eight times. While this work of observing and reducing the stars is going on I have received financial help for an assistant who is deriving the proper motions of the stars, which generally are small as I have said, but which notwithstanding must be known in order to make the catalogue useful for a longer interval of time.

On the other side a good deal of criticism may be said against the catalogue.

The first point is that I did not select the stars with respect to the spectral types. It would have been very difficult to get the necessary number of very faint stars if I had considered this criterion. Now Dr Vyssotski has been kind enough to send me the McCormick spectra of my stars and a rough count shows that there are about 68% of the stars belonging to A, F or G and 31% to K or M, while for instance Dr Zverev's plan foresees a distribution of spectra that is 37% for A, F and G and 63% for K and M. This advantage of Dr Zverev's catalogue is for a part at least counterbalanced by the fact that his limiting magnitude is about one magnitude brighter than mine.

On the other hand, and this may be the second point for criticism, the faintest stars of my catalogue are too faint for smaller meridian circles, and I even had to replace about 30 stars of my original list by brighter stars. Incidentally Dr Bohrmann with his $6\frac{1}{2}$ -inch instrument at Heidelberg was able to observe all the stars which are retained in the definitive star list, so proving the superiority of the Königstuhl observatory to our place.

The main criticism may be against the small number of stars. One may doubt whether the number is sufficient to make the old AG-catalogues homogeneous in the sense of Dr Kopff. The number is insufficient for photographic purposes, since even for Schlesinger's largest plates of 14×10 degrees about 22 stars are available while Schlesinger has worked with about 50 stars. Even if in the future new types of instruments and plates should be invented which would allow the use of a smaller number of unknowns in the least-square calculations for the plate constants it seems unlikely that their number could be brought down to about 20 in the case of the plates of 14×10 degrees.

I therefore frankly admit that a greater number of stars is necessary and I want to state here that we at our observatory are prepared to co-operate in any observing

programme which leads to a reliable system of reference stars for photographic plates. I hope that our symposium may lead to such a co-operation and I want to bring to your consideration some points which in my opinion should not be overlooked:

1. The first point is the number of the stars. In order to simplify I calculate them roughly for the whole sphere in my considerations. I get the following numbers in the star lists which have already been published:

Author	Number	Magnitude
Küstner-König	26,000	5·0–10·5
Zverev	20,000	7·5– 9·2
Larink	6,000	8·0–10·5

Let us accept the area of 10×10 degrees as the ideal plate for the near future. This is $1/400$ of the whole sphere. For this area 65 stars would follow from the Küstner-König list, 50 from Zverev's list, while Schlesinger himself wanted 50 stars for his greatest plates of 14×10 degrees. So in my opinion both lists, Küstner-König and Zverev, contain more stars than are necessary. If we consider 30 stars with first-class positions as necessary and sufficient a catalogue of about 12,000 stars would follow. I am convinced that this diminution of the original Zverev numbers will improve the quality of the definitive catalogue. It would give us the possibility of taking out of Zverev's catalogue the blue stars, or at least most of them.

2. From the beginning the programme should comprise the whole celestial sphere down to the south pole. It seems to me better for the future of astronomical work to select stars for the new programme which up to now are not in one single meridian circle catalogue but which fulfil the condition of even distribution, than to take stars from older catalogues and to reject the condition of uniformity of the network of stars. I am sure that the new programme will attract the meridian circle observers and will help to avoid the splitting of our rather small means on the northern and our extremely small means on the southern hemisphere.

3. In thirty years experience I have found that the so-called 'Küstner series,' series of differential observations which contrary to the old zone observations extend over stars of all declinations, are far superior to pure zone observations. Now since the new programme will certainly comprise so many stars that one single observatory is unable to execute it in a reasonable time, the shares of the different observatories should comprehend stars of all declinations, as far as they can be observed with the necessary accuracy, that means all the stars which are not too near to the horizon.

4. This programme will also satisfy our future efforts for connecting our fundamental system to the system of the faint extra-galactic nebulae. One of the reasons which in my own list led me to the faintest stars which I was able to observe was the hope of connecting these stars directly with the faint nebulae say of the 14th magnitude. After some provisional photographic observations of my own and after having inspected the wonderful photographs of Dr Shane at the Lick Observatory I now am convinced that this is impossible and that a further step from our stars of magnitude 9 down to the stars of magnitude 11 to 13 must be done by means of photography. These very faint stars, as I should like to call them, may be selected according to the distribution of the nebulae on the sphere, but the very faint stars themselves need the uniform net of reference stars which we are going to work out here in our symposium.

The Chairman raised the question of the optimum size of the plates and stated that about 1930 Prof. Schlesinger had told him that he would prefer plates $5^\circ \times 5^\circ$ in size to larger ones if he could get the necessary meridian observations of comparison stars. Prof. Brouwer stated that at a later stage, Prof. Schlesinger became convinced that larger plates were quite satisfactory.

Nemiro: Although Larink's catalogue is very useful for modern astrometry, it may not yet be convenient enough for photographic work because of the insufficient number of stars.