

DANJON wanted to expand on the remark by Dr. Dieckvoss. The experiment was made by Baillaud and Couderc according to a plan proposed by Turner. On the same plate they exposed 10 to 20 different fields and reduced them to the same system. The results were very satisfactory, and if this is possible with a *Carte du Ciel* telescope of a $2^\circ \times 2^\circ$ field, much better results could be obtained with an instrument having a 5° field in diameter. This method might be easier and more satisfactory than using very large fields.

DIECKVOSS said that it was not necessary to assume that the plate constants remained unchanged, and that a kind of triangulation can be made from one field to the next, and in this way cover a large field of the sky. This would diminish the meridian circle work.

VASILEVSKIS remarked that it had been proposed to enlarge the field by using larger plates rather than by

using instruments of shorter focal lengths. He felt that neither Lick nor Yale with their experience with 17×17 -in. plates would be willing to go to 27×27 -in. plates. If, however, the same plate size is kept and the focal length decreased in order to get $20^\circ \times 20^\circ$ fields, then there would be many problems to solve. Besides flatness of the plates, there may be large corrections for plate tilt and distortion, which could be taken care of by using many reference stars, but this would take away the advantage of the large field.

STRAND felt that in the case of a very wide-angle camera it would be necessary to know the tangential point with very high precision. This could be done by having fiduciary marks built into the instrument.

BROUWER agreed with Dr. Vasilevskis that 17×17 -in. plates were hard enough to handle. One should not lightly consider using even larger plates.

Very Accurate Positions of Selected Stars

J. H. OORT

Sterrewacht, Leiden, Netherlands

Discussion is invited on the subject of transferring the accuracy of the fundamental system to a list of stars of particular interest.

THE possibility of improving the fundamental system to give an accuracy of $0''.001/\text{yr}$ in the proper motions has been discussed at great length. The ultimate purposes for which this great accuracy is needed, is to get a better distance scale in the universe, a better determination of the constants of galactic rotation, and better determinations of the motions of certain stars of special interest.

At the time of the Brussels meeting, Dr. Blaauw and some others drew up a list of stars which were thought to be of particular interest. The problem which one is confronted with is the transfer of the accuracy of the fundamental system to these particular stars, of which only a small number are included among the fundamental stars. The question is; what is the best way to obtain an accurate link between the fundamental system and these special stars? One possibility is to take a fairly large number of plates with an instrument like the Lick astrograph in the galactic zone between -10° and 10° galactic latitude. It would not be necessary to go beyond the 12th magnitude, but at least two exposures would be needed at each epoch.

DISCUSSION

FRICKE wished to know what types of stars should be observed.

OORT said that in the list were O- and early B-type stars, Cepheids, and supergiants.

DIECKVOSS told that they had received such a list of stars, and that they were prepared to take second epoch

plates of them as soon as the AGK3 program was completed. It would be quite a task to tie these stars into the fundamental system. The Lick astrograph would give a higher accuracy.

FRICKE felt it would be helpful to the people who have to do this work to know in advance something about these stars. In his opinion, such a program would be all right for objects which can be expected to have measurable proper motions, so this had to be studied in advance. For this reason it would be useful to have all the data which are already known about these stars to go with the list.

OORT said that for some purposes proper motions were wanted for stars too distant to have individual motions. In determining galactic rotation, stars with very small proper motions would be desirable as long as they are accurate and tied in with the fundamental system.

STRAND remarked that another group of stars for which it would be useful to get very accurate proper motions tied in with the fundamental system would be stars in galactic clusters.

DIECKVOSS said that the list included several dozens of Cepheids, and that much could be learned from observing them, because of the poor state of the knowledge of the distances and proper motions of the Cepheids.

OORT wanted to emphasize that the required accuracy should be of the same order as the accuracy of the fundamental system, which meant yearly proper mo-

tions with mean errors of the order of $\pm 0''.001$ to $\pm 0''.002$.

VASILEVSKIS said that in addition to the regular Lick proper motion program there are other proper motion programs already in progress at Lick. One program deals with Selected Areas taken on 10- \times 10-in. plates. A second program is to determine proper motions of all clusters within one kiloparsec with apparent diameters 20' or more. A number of plates have been taken of each cluster to bridge a very wide range of magnitudes in case they are needed. When the regular Lick proper motion program is completed stars can be selected to serve as reference stars for the determination of absolute proper motions of these clusters. The program mentioned by Dr. Oort could be undertaken without great difficulties because the 20-in. astrograph is rather idle at the moment. Since only the 12th magnitude is wanted the exposures would be short. Many of the stars which are wanted will be measured in the regular program, but in the region of -10° to 10° galactic latitude the star density is very high and many stars might have to be omitted. In conclusion, he would like to know whether, if a photo-visual lens was obtained, this would be more preferable for this work than the photographic lens.

OORT felt that the photo-visual system would be the best. Some stars on the program are blue, and since so many of the reference stars are yellow this would be the best way to reduce the color effect. Dr. Vasilevskis had said that they already had taken some early plates which might be used for this purpose. This would depend upon whether the fundamental stars would be measurable on the plates, because otherwise, there would be a second link between these stars and the proper motion stars. Moreover, one or two exposures would not give the sufficient accuracy for this purpose which requires at least 10 exposures at each epoch.

LUYTEN would like to suggest another program for the Lick astrograph. For the Hyades, proper motions are needed for members down to the 17th magnitude. Their proper motions are so large that within a 10-year interval good proper motions can be obtained. About a dozen fields would be required with only a few plates of each field.

VASILEVSKIS replied that the first plates of the Hyades were taken in 1948 and a second epoch plate was taken in 1958. With the new blink comparator just received, a search will be made for faint Hyades members.

FRICKE said that Dr. Brouwer and he were willing to work out a detailed plan for the construction of a revised General Catalogue (GC). In view of the importance of the special stars which have been discussed special attention should be given to finding out how many could be included in this catalogue.

GRATTON pointed out that there are several fields for which plates have been taken in large numbers at many observatories. For example, the Pleiades in the northern hemisphere and fields in the Magellanic Clouds

and around Eta Carinae in the southern hemisphere. Perhaps it would be worthwhile to undertake a special investigation of these plates.

OORT agreed that this ought to be done because these regions are some of the most interesting known, and there is a good chance that, for instance, rapidly moving stars such as were found in the Orion region may be found.

STOY said that he understood that the problem, in the first place was to get accurate positions at a given epoch. He felt that the logical instrument for this would be the normal astrograph as used in the catalogue work. He therefore suggested that when observations were made for the catalogue these objects should be measured along with the reference stars.

OORT preferred to use the Lick instrument because the larger focal length would give greater accuracy. Efforts should also be made to have a greater number of exposures. Any attempt to strengthen the positions for these stars would be welcome, but the requirement of tying them into the fundamental system in the most direct way must be fulfilled.

STOY said that a direct tie into the fundamental system would be obtained if the stars in question were measured at the same time as the reference stars.

SCOTT expressed interest in the discussion of tying these stars into the fundamental system by photographic means. He believed that it had been agreed upon at the Brussels meeting, that the meridian circles should observe the Blaauw and the Parenago lists. The stars on the Blaauw list have been observed and efforts are being made to observe the stars in the Parenago list not included in the Blaauw list. There is a problem of congestion in both lists which makes it almost impossible to even cover 30 minutes in right ascension. He believed that on the Blaauw list about 80 to 90 nights were spent in one place, and the same applies to the Parenago list. Lists of this kind are a great concern to the meridian observers because usually all stars are completed for many hours of right ascension, and there is still a large number of stars to be measured in a small region near $5^{\text{h}}30^{\text{m}}$. If it was perhaps possible to observe a selection of stars sufficient to tie the remainder into the fundamental system, this would relieve the meridian observer from the problem of congestion.

VASILEVSKIS said that he was surprised to find that the two star lists were meant for meridian circle observations. Of course the basis for positions and proper motions depends upon such observations to establish the fundamental system. On the other hand, the positions can be obtained individually, relative to some given reference frame, with much higher accuracy and more economically by photographic means. For this reason he felt the stars on the two lists should mainly be observed photographically, but in close cooperation with the meridian circle observers so that the stars can be tied in as rigorously as possible to the fundamental system.

VYSSOTSKY remarked that even with a long focus refractor, such as the McCormick Observatory telescope with a field of only $40' \times 60'$, quite accurate proper motions could be obtained for Cepheids reduced to the AGK2 system from a time interval of 60 years. Motions of Cepheids as faint as the 9th magnitude could be obtained in this way. Since two first epoch plates were taken for each Cepheid about 25 to 30 years ago it is within the span of human life to obtain proper motions for these objects. Sometime ago the McCormick observers had been urged to finish at least the proper motions for the brighter Cepheids, but it was found that a time interval of at least 60 years would be needed.

He questioned that the time interval would be any shorter with the Lick astrograph because the motions are so terribly small.

STOY wanted to know if the problem was to get the positions of these objects in the fundamental system, or whether it was a question of getting proper motions relative to the background stars. He believed that Dr. Oort thought of the latter.

OORT replied that this was correct. He felt that the plan of Dr. Vyssotsky was important and should be completed. However, the problem was to have a sufficient number of reference stars on the plates. If the proper motions of the Cepheids are wanted, there should either be enough reference stars to average out the individual motions or there should be reference stars for which positions and proper motions are so accurately known in the fundamental system, that they can be eliminated.

VYSSOTSKY said that most of the Cepheids were in the Milky Way and that there would be between 12 and 16 AGK stars on each plate and any number of faint stars for obtaining the plate constants. How accurate the AGK2 system is will not be known until the AGK3 has been studied.

OORT pointed out that if there were 12 stars on the plates with proper motions having mean errors of $\pm 0''.008/\text{yr}$, this would still leave a mean error of $\pm 0''.002$ for the average motion of the comparison stars, and that would be too large. The solution would be to

improve the proper motions of the reference stars by the method he had outlined.

SCHILT said that in discussing high accuracy for individual stars, he would like to call attention to the comparatively few supergiant stars of about 5th magnitude for which proper motions are known with a probable error of $\pm 0''.002/\text{yr}$. If a normal absolute magnitude is assumed, then the probable error corresponds to ± 1 km/sec, which is the same accuracy with which radial velocities can be measured. If proper motions are to be obtained for stars which in terms of distance modulus are 5 magnitudes further away then $\pm 0''.002/\text{yr}$ would correspond to ± 10 km/sec.

The stars for which the proper motions are known or can be obtained with a probable error $\pm 0''.002$, are restricted to only a part of the hemisphere, and there is not a single star in the southern part of the galaxy. It is for this reason that he thought that the bright stars, particularly in the southern hemisphere, would contribute more to the knowledge of accurate stellar velocities than the fainter stars. While he did not wish to hold back any special program which had been in progress for a quarter century or more, he did wish to emphasize that for the closer stars there was a possibility of getting all three velocity components with an accuracy of about 1 km/sec.

OORT felt that most of the stars Dr. Schilt was thinking about could be included in the list of special objects, or, in any case, the two projects could be pursued simultaneously.

SCHILT remarked that this would be a mixture of two projects. He was talking about meridian or astrolabe observations for his stars, while Blaauw's list refers to photographic methods.

OORT disagreed because it had first been proposed to observe the stars on Blaauw's list with the meridian circles, but as Mr. Scott had remarked and others had indicated, the photographic method would be more suitable for getting accurate proper motions.

STOY reported that the stars of 5th magnitude and brighter were continuously on the Cape programs and accurate proper motions would be obtained. Only time could solve Dr. Schilt's problem.