

24. PHOTOGRAPHIC ASTROMETRY (ASTROMÉTRIE PHOTOGRAPHIQUE)

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1. INTRODUCTION

The review given in subsequent sections has been prepared from reports of individual astronomers and institutions. A general picture of the progress appears to be encouraging. In regard to instrumentation, the number of reflectors active in astrometry is increasing, upgrading of many older refractors has either been done or is in progress, new automatic and semi-automatic measuring machines are entering the field at an accelerated rate, older machines have been or are being upgraded, experiments are carried out for measurement directly at the telescope by utilizing photoelectric techniques, and use of high-speed computers has already become a normal routine. Summing it up, the astrometric instrumentation has entered the era of modern technology.

Astrometry itself has entered the mainstream of astronomy. Only a few decades ago it suffered a marked decline, when it was widely believed that problems of stellar luminosities, kinematics, evolution and others can be solved by means of other fields alone. With the gradual change in this attitude, the demand for astrometric results has greatly increased. In response, there is a significant increase in astrometric production. Not only most of the old trigonometric parallax programs, have been continued or revitalized, but also new programs have been started, with a particular emphasis on faint stars. Proper motion survey is going on at an increasing rate, yielding an abundance of information in regard to proper motions larger than a certain limit. After the completion of AGK3, its improvements have been made. Proper motions have been and are being measured in regions of clusters and in other selected fields. Finally, the first sets of proper motions have been measured with the reference to galaxies. The input of stellar parallaxes and proper motions in galactic research is increasing.

The optimistic picture painted above, however, is one-sided, with an important part missing. Nearly all the mentioned developments take place in the northern hemisphere. In the southern hemisphere, the work on trigonometric parallaxes has been greatly reduced in comparison with that a few decades ago. A Commission member in his correspondence believes that even if the Cape refractor is active again, the future increase of trigonometric parallaxes will still be too slow in the southern hemisphere. He feels that it will be necessary to increase our knowledge on the distances of southern dwarfs by spectroscopic and photometric means. The latter are not advisable for white dwarfs, but it might be possible to use measurements of $R-I$ and the mean relationship between M_p and $R-I$ for red dwarfs. On the other hand, there is no substitute for a direct measurement of parallaxes whenever possible. The solar neighborhood is the proper and the only domain of trigonometric parallaxes. The inevitable conclusion is that the highest priority must be assigned to re-activation and expansion of the trigonometric parallax work in the southern hemisphere by bringing additional telescopes, and particularly reflectors, into the field. Since a few years of efficient observing could yield an appreciable number of trigonometric parallaxes, some northern observatories with available means and expertise might consider expeditions to the south.

The next priority, perhaps, should go to proper motion work in the southern hemisphere. Although much has been done toward a systematic photographic coverage of the southern sky, there is still no southern counterpact to the AGK3 and to the emerging proper motions with respect

to galaxies in the northern hemisphere. Galactic research would benefit greatly from a uniform coverage of the whole sky in regard to proper motions rigorously referred to the same fundamental system as well as to galaxies.

Absolute proper motions with reference to galaxies are expected to play an increasingly important role in galactic research. Analyses of the first results indicate an existence of rotation of the local star system, that may lead to a significant revision of the adopted values for solar motion, galactic rotation and correction to precession. Although the full impact of these absolute proper motions is not expected before they are available for the whole sky, additional data in the northern part are likely to yield important new information. Consequently, a high priority must also be assigned to an accelerated determination of proper motions at the northern observatories, and it must be stressed again that the progress towards this goal should be increased at the southern observatories.

The priorities above are not mentioned to imply that other existing and active programs should be slowed down or curtailed. The demand for parallaxes and proper motions exceeds by far the supply even in the northern hemisphere. The priorities are meant to indicate the areas that cause the present imbalance in astrometric activities, and to point out the directions where additional effort must take place.

2. INSTRUMENTATION

A new one-meter Baker modified Cassegrain-Schmidt astrometric telescope has been installed at the Fan Mt. observing station of the Leander McCormick Observatory. Installation was completed in August 1972. The telescope is undergoing tests and it features a totally computer-controlled system. It is intended that 25×25 cm plates will be used in the beginning and work will concentrate on stars of 12–15 mag. for parallax work, clusters will be taken for proper motion work, and other astrometric work will be initiated. The scale is $15'' \text{ mm}^{-1}$ and the telescope has a one-degree usable circular field. A roller drive of the system was designed by C. W. Jones at the request of the observatory, and subsequently it has been used successfully elsewhere.

Murray reports that tests on the astrometric performance of the Wynne corrector at the prime focus of the Isaac Newton Telescope at Herstmonceux have been successful, and a small parallax program to be outlined below has been started.

Modernization of the 30-in. Thaw long-focus photographic refractor of Allegheny Observatory of the University of Pittsburgh is under way. Electric controls and automatic guider are to be installed. The stability of the 36-in. Lick refractor has been significantly improved by proper tightening of bolts in its base, and particularly by installations of a gravity pre-load on the worm-gear and of a compressed air pre-load on the declination tangent arm; Melsheimer of Lick Observatory has been responsible for the upgrading. Instrumentation developed for the Yerkes Observatory astrometric programs include an automatic guiding camera for the 40-in. refractor and a photoelectric parallax scanner designed to determine parallactic shifts at the telescope. These instruments are discussed more completely in the report of Commission 9.

An automatic guider has been developed by Robinson and Ricketts of Lick Observatory for the 20-in. Astrograph. The guider uses an image dissector tube as a sensing element, and produces signals which drive relays in parallel with the manual guide buttons. Preliminary tests carried out by Klemola produced satisfactory photographs. A new moving-wire guiding eyepiece incorporating a step-motor has been developed and constructed for observing of fast-moving objects with the 20-in. Astrograph.

Lacroute proposed at Hamburg, in March 1972, the application of marks on curved plates to improve the reduction of the Schmidt plates in astrometry.

A GALAXY machine similar to that at Edinburgh has been installed at Herstmonceux. A second-generation automatic measuring machine incorporating massive granite parts, an on-line mini-computer, and laser interferometry has been delivered to U.S. Naval Observatory and is currently undergoing tests. A new Grant 10×10 -in. semi-automatic measuring machine has been installed at Leander McCormick Observatory and is being used to measure parallax and proper motion plates.

In addition a fully automated measuring machine has been obtained from the U.S. Army Topographic Command and is being modified for use on the astrometric programs of McCormick Observatory. A photoelectric device employing a Ronchi ruling has been used successfully on the 26-in. refractor and has been measuring positions to $2\ \mu\text{m}$. It is believed that some improvements will bring the accuracy to better than one micron. In the spring of 1971 the Sproul Observatory acquired a Grant twoscrew measuring machine. It was tested by Hershey, and since September 1971, the machine has been in almost continuous operation; some 4500 plates were measured during seven month's operation. One setting of the Grant machine is more accurate than four settings by bisection on the old machines. The probable errors of unit weight in the parallax solution range from 60% to 80% of the values from the old machines. The measuring speed has been increased by a factor of 5 to 10 over the manual methods.

The Lick-Gaertner automatic measuring system is being significantly upgraded. Much of the control circuitry is being replaced and an on-line computer will be added. The computer selected, a PDP 8I, is identical to the two already in use at Lick Observatory, and much of the previous developmental work will be applied to the upgrading. An IBM compatible magnetic tape unit will eliminate the need for punched cards. A major increase in efficiency and reliability in measurement is expected. The project is being supported by the National Science Foundation, with Vasilevskis and Robinson as principal investigators. At the U.S. Naval Observatory the performance and reliability of the Strand Automatic Measuring Machine has been improved over the report period. The accuracy of a single setting on a photographic stellar image of good quality is typically between 0.6 to 1.0 μm . At Yale University Observatory redeterminations of the errors of the two-screw Mann measuring engine have been made.

At Sproul Observatory an underground fire- and waterproof vault was constructed during the summer of 1970. It now holds the Sproul plate collection of over 100000 plates which in recent years increased by up to 8000 plates per year.

3. PARALLAXES

A new program is being planned for parallax measurement of faint stars, at the lower end of the main sequence, with the new 60-in. mirror of the L. Figl Observatory, as reported by Meurers. Murray reports that about 20 stars with photographic magnitudes between 16 and 18.8 are being observed for parallax on the Isaac Newton Telescope. These have been selected from Luyten's list of low luminosity stars, and also his 48-in. Schmidt proper motion survey north of $+75^\circ$, this region of the sky being particularly convenient for observation at Herstmonceux. In addition, a field near M67 which contains four possible nearby red dwarfs is also being observed. It is hoped that sufficient plates on two fields will have been obtained by early in 1973 to enable preliminary parallaxes to be measured. This program is being carried out under the direction of B. F. Jones.

Thomas reports that more than half the 100 stars which have been on the Herstmonceux parallax program since 1959 are now ready for measurement. A further 80 stars, including 16 of van Altena's Hyades stars, have been added to the program, which it is estimated will be completed by 1976. The results of the first 22 fields are in press. A further 12 fields are currently being measured and reduced. Accuracy is significantly better than that achieved at Greenwich with the same telescope. Agreement with some recent Van Vleck parallaxes is good. An important systematic difference has been found between parallaxes determined separately from right ascension and declination measures. Thermally-induced distortions of the optics of the telescope seem likely to be responsible, and these are currently being investigated.

Wagman reports that 27 parallax series, many with 50 or more plates and measures in both coordinates, have been computed at Allegheny Observatory since the last report. Results are being prepared for publication. Barnard's star was studied by Gatewood using 241 Allegheny and Van Vleck plates extending over 55 yr. No convincing evidence for a perturbation was found. The SAMM measuring engine of the U.S. Naval Observatory is being used for some measuring. Gatewood finds that the use of this machine with his method of reduction increases the accuracy of Allegheny

parallaxes by a factor of 1.7. The remeasurement and reduction of earlier published parallax series is contemplated.

Churms reports that the Cape parallax observing program consists of 249 stars. Of these 163 are south of the equator, have no previous Cape determination, and are listed in *Royal Observatory Annals*, No. 5; 20 are from Parenago's list (*Trans. IAU*, **10**, 367, 1960); 16 are from the lists of Fundamental Data for Southern Stars, by Evans *et al.* (*M.N.R.A.S.*, **117**, 534; **119**, 638; *R.O. Bull.*, **48**, 85, 110), and the remaining stars were put on at various times for other reasons e.g. suspected white dwarfs, suspected astrometric binaries or at the request of other astronomers. Sufficient plates have been obtained to date to remove 48 stars from the above list. These plates are now being measured.

The parallax program at the 36-in. Lick refractor continued under Vasilevskis' supervision, with most of the observing being done by E. A. Harlan. The plate measurement is being carried out mostly by C. A. Wirtanen. Nearly 2000 plates of 77 fields have been measured so far. Various approaches in methods and analysis of errors have been made, and almost all the measurements have been reduced.

Fredrick reports that more than 13000 parallax plates have been taken at Leander McCormick Observatory during the past triennium. Thirty-one percent of these plates were taken on the Hyades cluster alone which is receiving great attention at this observatory. Of 25 parallaxes obtained in 1971–72, only Ross 986 appears to have a non-linear proper motion.

Van de Kamp, Heintz and Lippincott have revised and amended the astrometric program at Sproul Observatory. The program now contains some 600 objects, single double and multiple. A few stars are being discontinued which show no signs of perturbations after a 30-yr interval. Others are being continued only during the midnight hours, where the parallax has already been well determined. A number of stars distributed over the sky are continued for parallax to check on telescope behavior. Some 150 new stars have been added, which are nearby but have poorly determined parallaxes. Most of the more distant double stars are kept on the program for mass ratio determination. Astrometric results on double stars are reported to Commission 26. Some 30 new parallaxes from long interval series have been determined in the last three years.

Strand reports that the U.S. Naval Observatory Program of determining the trigonometric parallaxes and proper motions of low luminosity stars has been continued using the 61-in. astrometric reflector at Flagstaff, Arizona. Approximately 24000 plates have been obtained since the start of the program in 1964 and about 9000 since the last report. Two catalogues containing astrometric and photometric results for 209 stars have been published (*USNO Pub.*, **20**, Parts 3 and 6, 1970 and 72). A third catalogue is in preparation. Several stars of special interest have been discussed individually in literature. The current program consists of approximately 315 stars with emphasis upon intrinsically faint degenerates.

Upgren reports that parallax observations continued on the 20-in. refractor and measurements on the Mann measuring machine at Van Vleck Observatory. Interest centered on 20 dwarf members of Hyades and the nearby field dwarfs from Vyssotsky's lists. A seventh parallax list was published by Mesrobian, Griess and Titter (*Astron. J.*, **77**, 392, 1972) and an eighth list has been completed by Titter, Mesrobian and Upgren. The latter contains parallax and proper motion results for about 25 stars and the formerly derived parallaxes, proper motions and some orbital information for three binaries; it was found that a suspected perturbation of a fourth star, Ross 413, was spurious. α and Proxima Centauri triple system is being investigated from Yale and Cape plates. The earlier analyses made at Van Vleck Observatory by Gasteyer will be re-evaluated from a much larger number of plates and reference stars, referring both α and Proxima Centauri to a common frame of reference. Plates were measured at Van Vleck and also on the automatic measuring machine at the U.S. Naval Observatory. Griess remeasured 16 parallax series of bright A-stars of the Yale Observatory, in order to check these stars which appear subluminous on the basis of previous parallaxes, mainly from the Yale Observatory. The revised parallaxes do not support the existence of the subluminous group. In a continuation of the study of external errors in trigonometric parallaxes, Upgren has been able to separate the scatter in absolute magnitudes of late-type dwarfs

due to observational errors from those due to the intrinsic scatter of the lower main sequence.

The present Yerkes Observatory parallax program was started by van Altena in 1966 with two principal goals: (1) the determination of accurate parallaxes for a group of stars that were too faint to be observed by conventional methods, and (2) the development of observing, measuring and reduction techniques to substantially increase the accuracy of trigonometric parallaxes. Observations for an initial group of 57 stars have been essentially completed, the results for eight of them have been published (06.111.004) and measurements for 14 more have been made. A comparison with previously published parallaxes determined with the 40-in. refractor shows that the new parallaxes are approximately four times more accurate than the older ones. The stars currently being observed include 30 subdwarfs, 25 white dwarfs and 16 Hyades members. The goals of this program are to investigate the following problems: (1) the helium content of the Population II subdwarfs; (2) the Pop. II distance scale from main sequence fitting of globular clusters to the subdwarf sequence; (3) the luminosities and radii of DA white dwarfs, which fall on a very narrow sequence around $\log g = 8$ in the two-color Strömrgren diagram; and (4) the Population I distance scale from trigonometric parallaxes of Hyades members.

At Pulkovo Observatory Schacht has determined the trigonometric parallax of ADS 7251 (05.111.004), Kiselev and Sumzina for LP 9-231 (03.111.004), and Kanaev and Sokolova of six stars (*Astr. Tsirkuliar*, No. 705, 7, 1972). The Pulkovo 26-in. refractor has been used in this work.

Gliese has investigated the systematic effects of the accidental errors of trigonometric parallaxes in statistical investigations and the systematic differences between the series of certain observatories (*Q.J.R.A.S.*, 13, 138, 1972). A very preliminary value for reduction from the Allegheny parallax system to a 'true' system is $+0^{\circ}002 \pm 0^{\circ}0014$ (s.d.). More reliable results are expected from further data, particularly from the parallaxes determined with the USNO 61-in. astrometric reflector, and also from data on Hyades.

4. PROPER MOTIONS

Luyten reports that all 153 pairs of plates from the Palomar Schmidt Proper Motion Survey which had been hand-blinded have now been completely measured. Data for 68000 stars have been published; this includes the entire area north of $+70^{\circ}$, as well as that between $+57^{\circ}$ and $+70^{\circ}$ of declination, and 5^{h} and 20^{h} of right ascension. The data for the last remaining 7000 stars will be published in 1973. The automated-computerized plate scanner and measuring machine, funded by the National Aeronautics and Space Administration, and constructed by Control Data Corporation, became fully operative in 1971. To date 225 pairs of plates have been processed, and computer printouts are available giving data for 120000 stars with motions larger than $0^{\circ}1$ annually, and between the magnitudes (red) 11 and 19. Several lists giving data, including also photographic magnitudes and colors for more than 6500 stars, mainly with motions larger than $0^{\circ}2$ annually, have been published. The brighter stars with larger motions are expected to appear also in the Lowell Proper Motion Survey. A beginning has been made with the compilation of a final catalogue of all motions larger than $0^{\circ}2$ annually, and as a sample the section containing data for 2100 such stars north of $+70^{\circ}$ has been published. It is hoped that other astronomers will freely comment on this and make suggestions such as to render the final catalogue as useful as possible, when it is ultimately published in full.

Giclas reports that the Lowell proper motion survey with the 13-in. astrograph of stars between magnitudes 8 and 17 with motions larger than $0^{\circ}26 \text{ yr}^{-1}$ has been completed for the northern hemisphere and a summary catalogue published (05.112.012). The survey is being continued into the southern hemisphere, but to a lower limiting motion of $0^{\circ}20 \text{ yr}^{-1}$ because of the longer epoch now existing between plates. Four regions covering 550 square degrees around the South Galactic Pole have been completed and published in *Lowell Obs. Bull.*, 158. Supplementary lists of very blue, white dwarf suspects, and very red stars with motions less than $0^{\circ}20 \text{ yr}^{-1}$ found during the course of the survey are now regularly included with each region, together with finding charts.

Goyal reports that 64 regions common to Potsdam Photographische Himmelskarte and Paris Astrographic Catalogue in $+34^{\circ}$ and 35° zones have been compared by him and Khandelwal to

obtain stars having large proper motions. The total number of large proper motion stars listed is 2825 (04.112.013–014; 06.112.018). These large proper motions gave a solar apex quite close to the accepted value. The investigations into star streaming and ellipsoidal hypothesis have been completed. It is intended to derive some kind of distributions of these large proper motions and stars in general.

At Strasbourg Observatory, Lacroute and Valbousquet have made a new reduction of the AGK-3 measures given by Dieckvoss; overlapping of plates was used in reductions (06.031.080). Positions, proper motions and estimated random errors were derived for each star. Results are on a magnetic tape.

Murray reports that astrometric observations for the repetition of the old Radcliffe and Greenwich plates of the Northern Kapteyn Selected Areas, on the 26-in. refractor at Herstmonceux, are now 90% complete. Some 1500 astrometric plates, and also about 500 photometric plates, will be measured on GALAXY at the Royal Greenwich Observatory. Extensive computer programs for the data handling and the analysis for this project are in an advanced stage of preparation. As a preliminary study, plates on SA 54 have been measured on GALAXY at Edinburgh. Initially the proper motions will be referred to the FK4 system through AGK3 stars, but ultimately it is planned that special measures of some 30–40 stars in fields away from the galactic plane will be made at Lick, to enable direct reference to the system of external galaxies. Proper motions of about 20 of the faint M stars found by Sanduleak, in the northern galactic cap, have been measured on plates taken at Mount Wilson, and at Greenwich and Herstmonceux. It appears that these are all dwarf stars and it is suggested by analysis of this material that the local space density of such stars is very high.

Gliese also points out that an unexpectedly large number of faint very red stars has been found in the northern and southern galactic polar regions; they seem to be nearby dwarfs according to their proper motions. His investigations on kinematics of a sample of these stars near the south galactic pole has been completed. There are difficulties in derivation of reliable statistical parallaxes for them. Although there is an abundance of proper motion data, nearly nothing is known about their radial velocities, velocity dispersions and the solar velocity relative to these stars. Moreover, the red dwarfs have to be subdivided into the kinematically differing groups of dM and dMe stars.

At Pulkovo Observatory Gorel has derived proper motions of 12590 stars in the zone $+25^\circ$ to -20° from comparison of AGK3R, KSZ, AGK2, Yale Zone Catalogues and AGK1 (*Trudy Pulkovo*, 80, 5, 1972). Bronnikova has measured proper motions of 4211 stars relative to reference stars of magnitude 13.2 in four areas of Taurus. Photographs taken with the Pulkovo Normal Astrograph were used; epoch difference was 57–60 yr (*Trudy Pulkovo*, 78, 99, 1971).

Deutsch reports that the second-epoch photography of fields with galaxies, in accordance with the Pulkovo program, was continued at Pulkovo, Moscow and Tashkent. At Pulkovo, plates taken from 1949 to 1958 serve for the first epoch, after the epoch difference reaches at least 20 yr. Proper motions of stars down to magnitude 17 are determined. At Moscow and Tashkent the new plates are compared with those taken before the war, as has been done earlier by Fatchikhin at Pulkovo (03.112.114, 116; *Astron. Tsirkuliar*, No. 668, 1972). From plates obtained at Pulkovo, Bolbochanu has determined and investigated proper motions of stars down to magnitude 15 with reference to 92 galaxies in the special SA 32 near the galactic pole. On El Roble Mountain in Chile, first-epoch photography of 164 fields with galaxies has been completed by using the Maksutov two-meniscus telescope. In accordance with the Pulkovo program, plates were taken with long (30 min) and short (1–3 min) exposures. This material will serve for future determination of absolute proper motions of stars down to magnitude 19 in the southern hemisphere. A complete photographic coverage of the southern sky in blue and yellow light has been started with the same instrument. This work is being carried out jointly by the Soviet and Chilean astronomers.

Klemola and Wirtanen continued the work of the Lick proper motion program under the supervision of Vasilevskis. The pilot program was completed and a catalogue of proper motions of 8790 stars with reference to galaxies (06.112.005) and of 41 RR Lyrae variables (05.112.009) were published. Studies of solar motion and galactic rotation (05.155.013), and of correction to precession

(06.043.001) were carried out. These results, particularly for correction to precession, are in serious disagreement with the conventional ones. The pilot program was followed by a second phase of the Lick program, and the total number of fields for which blue and yellow pairs of plates have been taken exceeds 270. About 20 fields have been surveyed but none have been measured pending completion of modifications to the Lick-Gaertner automatic measuring machine. A total of about 30000 stars of various kinds, so far lying mostly outside the Milky Way, have been selected by Klemola from the literature, together with a similar number of stars from the AGK3. Stars from the U.S. Naval Observatory by Blanco *et al.* were selected for photometric standards.

Wesselink reports on the Yale-Columbia Southern program for determination of proper motions with reference to galaxies. The plate taking for the first epoch is making good progress at Leoncito, Argentina. Only 85 fields still have to be observed, and it is expected that this work will be finished before the end of 1973. The use of the Yale-Columbia astrograph in the interim period between the first and second epoch has not yet been decided. Apart from photometric programs it has been suggested to use the astrograph for the determination of relative proper motions in galactic clusters, for which important program the telescope would be eminently suitable.

Fredrick reports that under the direction of Blaauw, very accurate proper motions are being remeasured for the stars in the McCormick regions (*McCormick Pub.*, 7 and 10) as part of a study of the kinematics of intermediate age stars. One hundred regions including 1687 stars between magnitudes 8 and 12 have been finished; the relative proper motions are determined from an average of 16 plates covering 50 yr with probable errors of $\pm 0.001 \text{ yr.}^{-1}$. Most of these regions are near the galactic poles, and over half are centered on FK4 stars which makes reduction to the fundamental system possible.

Clube reports that the absolute proper motions, reduced statistically, of 355 variable stars have been obtained. These comprise mostly RR Lyrae (06.122.059), semi-regular and Mira variables occurring in the Greenwich, Vatican, Oxford and Cape zones and which are identified in the Groningen program.

At Sternberg Astronomical Institute Karimova and Pavlovskaya have derived absolute proper motions of 407 Am and Ap stars (*Trudy Sternberg*, 42, 65, 1972) and of 111 O-stars (*Soobshch. Sternb.*, No. 176, 3, 1972). In both cases all the available sources of stellar positions were used. At Pulkovo Observatory Sokolova has determined absolute proper motions, reduced statistically, of four novae from photographs taken with the Pulkovo Normal Astrograph; epoch difference 25–69 yr (05.112.003). Deutsch and Orlova have carried out a statistical investigation on motions and distances of planetary nebulae (05.133.025). Zhukov at Pulkovo (05.112.007) and Primkalov at Tashkent (05.112.014) have also determined proper motions of individual stars, of two R5 stars and of CY Lyrae, respectively. At Abastumani Khatsov has determined accurate positions of 42 novae (06.124.003).

Dieckvoss reports that in the circular field of 10° diam around α Persei, positions of 4832 stars were measured on 22 plates of the Bergedorf Schmidt telescope, taken by Lübeck in 1966. The criterion for including a star in the list was the occurrence of at least twice on the relevant plates of the Astrographic Catalogue, Catania and Helsingfors zones. A total of 817 'cluster stars', according to their proper motions, yielded an expansion coefficient of $+0.015$ with a root mean square error of 0.022 in units of 10^{-6} yr^{-1} after correcting for a radial velocity of -1.6 km s^{-1} and a distance of 165 pars.

Meurer reports on investigation of systematic effects in artificial two-dimensional velocity field based on generating random numbers, with the conclusion that accidental expansion-phenomena of associations are possible. Further investigations in Selected Areas along the galactic equator led to similar conclusions.

At Lick Observatory Cudworth is carrying out a study of planetary nebulae, based on their proper motions from plates taken with the 36-in. refractor. Hanson is investigating Hayades from astrometric measurements, with a particular effort to refer proper motions to the frame of galaxies. While at Lick, Jones measured relative proper motions in Praesepe with high enough precision to detect internal motions. The cluster shows a more isotropic velocity distribution than Pleiades.

Relative proper motions were obtained for nearly 2000 stars in the region of Pleiades from Lick Carnegie Astrograph and Palomar Schmidt plates. These were used for a membership study, the main result being that the Pleiades lower main sequence is fainter than that of the Hyades and the sequence formed by nearby stars. In collaboration with van Altena the absolute proper motion of Pleiades was determined with respect to galaxies, and membership studies were made of open clusters NGC 2420, 6530 and 7062 from plates taken with the Yerkes 40-in. refractor. After moving to Herstmonceux, Jones continued his studies of open clusters, and in particular, the proper motions in Pleiades were used for a kinematic study of field M dwarfs found by McCarthy and Treanor, with results supporting the suggestion of Murray and Sanduleak that there is an unexpectedly high density of these stars near the sun.

Van Altena reports that research on star clusters at Yerkes Observatory has concentrated on determination of membership and physical characteristics of clusters of astrophysical interest and measurement of internal motions in some nearer clusters. Since 1970 membership determinations based on proper motions have been published for nine clusters (IC 4665, NGC 6611, 6633, 6811, 6819, 6823, 6838, 6913, and 7092), in addition to the three clusters investigated jointly with Jones and reported above. Also, in addition to Praesepe, internal motions were determined by Jones for Pleiades. The research on clusters has utilized the large collection of old photographic plates taken with the 40-in. refractor. Persons participating in this research are Sanders, van Altena, Erickson and Kamp.

De Vegt reports that investigation on absolute proper motions of 30 open clusters was started at Hamburg Observatory in 1970. Remeasurement of the original Carte du Ciel plates of Vatican zone have been finished and positions in the FK4 system derived for the clusters NGC 457, 581, 1502, 7160, 7380, IC 1805, 1848. New epoch plates will be taken with the 24-in. refractor. Reference star positions for the small refractor field will be provided by a newly developed zone astrograph ($D=213$ mm, $f=2060$ mm) which is scheduled to be in operation by the end of 1972.

At Sternberg Astronomical Institute Artiukhina and Kalinina have determined relative proper motions of 2964 stars to magnitude 12.8 in the region of M 39 (04.112.006). Cluster membership is indicated. At Pulkovo Observatory Koroleva has determined proper motions of 2036 stars in the region of NGC 6866 (05.112.006) then in NGC 6866 and 7789 (06.153.024), and subsequently in extended surroundings of NGC 6866 (*Astron. Zh.*, 49, 786, 1972), where 92 members of the cluster were found in its 'corona'. Zhukov derived absolute proper motions, reduced statistically, of the globular clusters M3 and M5 (*Trudy Pulkovo*, 78, 160, 1971). Deutsch has developed and tried a method to determine secular parallaxes of field stars, if relative proper motions of open clusters are measured and their photometric distances are known (05.111.007). At Tashkent Latypov worked on NGC 457, 663, 1039, 2682, 6633, 6694, 6705, 6709, 6755 and 6940 (*Tsirkuliar Tashkent*, No. 34, 1972).

Proper motions, membership and stellar content of NGC 188 have been determined by Uppgren, Mesrobian and Kerridge at Van Vleck Observatory. A total of 228 stars were measured on plates taken with the 30-in. Thaw refractor of Allegheny Observatory. Absolute proper motion of the cluster, reduced statistically, was also derived.

Wood reports that Robertson is working on proper motions in the open cluster NGC 6025 and expects to go on to further work on the clusters which are situated in the Sydney zone of the astrographic catalogue where there are old epoch plates. Sims is working on the proper motions of variable stars in the Sydney astrographic zone.

5. MISCELLANEA

Kox (deceased 1971) and Günther have derived definite plate constants for the Astrographic Catalogue zones north of $+32^\circ$ by means of reference star positions and proper motions in AGK3. In the course of this work systematic errors depending on the reference star coordinates and diameters were determined. Reports as well as the plate constants have been published (03.041.007; 05.041.006; 04.041.025; *Astron. and Astroph. Suppl.*, 6, 201, 1972). The plate constants on punched

cards may be obtained on request from Dr A. Günther, Rechenzentrum der Universität Hamburg, D-2000 Hamburg 13, Rothenbaumchaussee 81.

A reduction of the Astrographic Catalogue for all stars between $+31^\circ$ and -2° of declination is well under way by Lacroute and Valbousquet at Strasbourg, in collaboration with the Paris, Bordeaux and Toulouse Observatories. The system of reference is AGK2-3. They hope to improve the results by using some information deduced from the overlapping of plates, as outlined in *Astron. and Astroph.*, **17**, 296, 1972.

Herget reports on improvement of the plate constants for the Bordeaux zone of the Astrographic Catalogue, which is subject to improved positions of reference stars and to elimination of typographical errors. A list of the latter was published earlier (*Astron. J.* **72**, 575, 1967), and 87 additional errors have been found. For improvement of positions of reference stars a number of catalogues, including AGK3, have been combined in forming a 'general catalogue' of the reference stars. Plate overlaps have also been utilized. The results will appear in the next Publication of the Cincinnati Observatory.

Hoffleit reports that for lack of funds Yale University Observatory is at a temporary standstill in regard to astrometric measures for the zone catalogues. Several proposals for funds are pending to complete the work on the -60° to -70° zone and for starting work with the El Leoncito plates. The measurements of the -60° to -70° zone had been turned over to the Army Map Service as they contracted to do the reductions, but none were ever carried out. Late in the spring of 1972 the measurements were returned to Yale. A little work has been resumed, mainly re-orientation on what has been done before. Since 1970 when the -40° to -50° zone was published, a catalogue of preliminary results for the south polar cap, -70° to -90° , has been published by Lü (06.041.030).

Information on the Cape Photographic Survey and the Sydney zones is given in reports of Commission 8.

Uppgren reports on studies of K and M dwarfs. The published dwarf star catalogue (*Astron. J.*, **77**, 486, 1972) contains many new stars within 20 pc of the Sun, and it extends the coverage of the Vyssotsky's dwarf K and M star catalogues of the McCormick Observatory to most of the southern sky. Some recent unpublished parallax and proper motion results increase substantially the number of dwarf stars for which space motions are known. Lü and Uppgren have shown that there are many pairs with parallel space motions amongst nearby K and M dwarfs.

Clube has made investigations on derivation of statistical parallaxes, and on stellar kinematics from FK4 and Lick proper motions. Details of these investigations, as well as of those by others on topics of galactic research involving proper motions and parallaxes are given in reports of Commission 33.

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