

24. PHOTOGRAPHIC ASTROMETRY (ASTROMETRIE PHOTOGRAPHIQUE)

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I. Introduction

One of the continuing problems facing Commission 24 is its name. It has been known and reported for some years that the present title is not suitable for reasons that are all too obvious. This problem has continued during the last three years, despite the growing development and use of non-photographic methods and techniques.

Most of the recent meeting activity in which the Commission and its membership has been involved, has centered on its shared interests with Commission 8 and with the Working Group on reference frames formed at the last General Assembly. Since its inception at that time, C. A. Murray has been appointed to represent the Commission on that group.

Meetings of interest to the Commission and its membership held during this period include the following:

IAU Symposium No. 128, "Earth's Rotation and Reference Frames for Geodesy and Geodynamics" was held at Washington in October 1986. The SOC was chaired by D. D. McCarthy and W. E. Carter was the chairman of the LOC.

IAU Symposium No. 133, "Mapping the Sky - Past Heritage and Future Directions" was held at Paris in June 1987. The meeting celebrated the centennial of the Carte du Ciel. J. A. Eddy and A. R. Uppgren served as co-chairmen of the SOC. They, S. Débarbat and H. K. Eichhorn are the editors of the proceedings. The chairman of the LOC was P. Charvin.

IAU Colloquium No. 96, "The Few Body Problem" was held at Turku in June 1987. The chairman of the SOC was V. A. Brumberg and the chairman of the LOC was M. Valtonen.

IAU Colloquium No. 97, "Wide Components in Double and Multiple Stars" was held at Brussels in June 1987. The meeting was organized by J. Dommanget who also served as chairman of the SOC. The chairman of the LOC was E. Van Dessel. The meeting was dedicated to W. J. Luyten and the proceedings are being edited by Z. Kopal.

IAU Colloquium No. 100, "Fundamentals of Astrometry" was held at Belgrade in September 1987 to celebrate the centennial of the Astronomical Observatory there. The meeting had been organized by G. Teleki. Following his very unfortunate death in February 1987, Eichhorn accepted an invitation to succeed Dr. Teleki as chairman of the SOC and I. Pakvor chaired the LOC. Eichhorn, Murray and Uppgren are editing the proceedings.

"Astrophysics of Brown Dwarfs" is the title of a meeting and its published proceedings, edited by M. C. Kafatos, R. S. Harrington and S. P. Maran. The meeting was held at Fairfax, Virginia in October, 1985.

Meetings with papers of interest held prior to the period covered by this report but published during this period include IAU Symposia Nos. 109, 111, 114 and 118 and Highlights of Astronomy 7, 1986. Each contains a number of contributions dealing with astrometric subjects.

The astrometric work on HIPPARCOS and other satellite projects is covered in detail in the report from Commission 8 and consequently will not be repeated extensively here. In brief, A. N. Argue, Chairman of HIPPARCOS Input Catalogue Subgroup 2130, reports on the link to the extragalactic reference frame. The final catalogue has an average density of 2.5 stars per square degree. A detailed account of it is being prepared for publication, edited by C. Turon and M. A. C. Perryman. E. Hog, J. Kovalevsky and Turon report on the progress since the last General Assembly. The satellite is expected to be finished in early 1988, but the launch is scheduled for 1989, for a 2.5-year mission.

Kovalevsky has reviewed the present achievements of ground-based astrometry and the prospects of stellar astrometry from space. The methods used to construct a quasi-inertial reference frame are discussed along with HIPPARCOS and its payload and detector. The establishment of an absolute reference frame and the use of VLBI observations are also described (38.041.031, 38.041.042).

D. Hoffleit is conducting research on the history of astronomy at the Yale Observatory through the directorship of Dirk Brouwer, much of which involves the history of astrometry. She is also updating the tape version of the Bright Star Catalogue with W. Warren. Several thousand corrections and additions have been made since the most recent printed version of 1982.

II. Trigonometric Parallaxes and Nearby Stars

The fourth edition of the General Catalogue of Trigonometric Stellar Parallaxes is nearing completion. W. F. van Altena gave a status report on it at IAU Symposium No. 133. R. B. Hanson, T. E. Lutz and van Altena are analyzing the contents to refine the luminosity calibration of field subdwarf stars.

Lists of newly determined trigonometric parallaxes were reported from several observatories. Among them are Lick, where Hanson, A. R. Klemola and S. Vasilevskis have redetermined the Lick parallaxes for about 125 stars, McCormick, where P. A. Ianna is continuing observations on Vyssotsky stars, subdwarfs and binaries (40.111.005) and the U. S. Naval where Harrington and his colleagues have published a seventh list of faint stars (39.111.005). At Sproul, W. D. Heintz has measured parallaxes and mass ratios (38.111.001, 42.041.016) and at Van Vleck, Uppgren and his colleagues have published a seventeenth list, the first to include PDS measures of subdwarfs among other stars (39.111.016). From Yale, van Altena reports that about 5100 stars brighter than the 21st magnitude at regions at a galactic latitude of 16° have been determined using the 4m reflector at Kitt Peak. Similar observations are being obtained near the South Galactic Pole with the Cerro Tololo 4m reflector. Two papers were published of Yerkes parallaxes, one by van Altena et al. (41.111.018) and the other by E. U. Vilkki et al. (42.111.018). An experimental parallax program with the 0.4m refractor of the Shanghai Observatory is now in progress. Results have been published by J.-j. Wang et al. (40.111.022).

Parallaxes of individual objects have been obtained by Heintz at the Sproul Observatory of HR 4550 (38.111.014) and by D. Monet and C. C. Dahn at the U. S. Naval Observatory of IHS 2924 (39.111.027).

Murray and his colleagues have conducted a survey of parallaxes, proper motions and photometry of several thousand stars near the South Galactic Pole, using the UK Schmidt telescope. The observed parallactic motion is used to

estimate the proper motion zero point and to calibrate the trigonometric parallaxes. A number of other kinematical results have been derived from the data (42.111.014, 42.111.015).

At the Van Vleck Observatory, Uggren and his associates completed two sets of measures of stars in 13 fields in the central region of the Hyades cluster. The measures of 25 members and 260 field stars were made by hand and on the Yale PDS Microdensitometer. The parallaxes of members agree with the currently accepted cluster distance. The external mean errors from the PDS measures are only about half those from the hand measures. This implies that about 3/4 of the total variance of the hand measures lies in the measuring uncertainties.

During the period under review, W. Gliese and H. Jahreiss continued the compilation for the Third Catalogue of Nearby Stars, which will be extended to 25 pc from the Sun. Trigonometric Parallaxes are adopted from the new edition of the Yale Parallax Catalogue, and spectral class-luminosity and color-luminosity relations are calibrated from them. At least 3000 systems with about 3500 individual stars are expected to be included in the catalogue. The Malmquist and Lutz-Kelker corrections are being applied to the absolute magnitudes determined from B-V, R-I and other colors (38.115.014, 39.115.021, 40.041.013, 40.115.012, 41.041.071).

E. W. Weis completed his photometric survey of all NLTT stars in the Northern Hemisphere brighter than about 14.5 with color class m and no previous parallax (41.111.014). Of about 2000 stars covered, some 300 appear to be closer than 25 pc, but only about ten appear to be within ten pc and none within five pc of the Sun.

III. Proper Motions and Positions

W. J. Luyten, in collaboration with G. Hill and S. Morris of the Dominion Astrophysical Observatory, has published two further catalogues of proper motions and approximate colors for 13700 faint stars in the Pleiades and Hyades regions with mean errors of 0".007/yr. This raises the total number of published proper motions in these regions to 24000 stars. The data are determined from plates taken with the Mt. Palomar 1.2m Schmidt telescope (39.111.025, 41.111.027).

Together with H. Hughes, Luyten has continued the analysis of proper motions from Schmidt plates and they have published motions for 350 additional faint stars found on the Mt. Palomar Schmidt plates and 270 stars found on the ESO Schmidt plates. Luyten has also published two lists giving data for 927 more double stars with common proper motion.

The second-epoch observations at El Leoncito, Argentina, for the Southern Proper Motion Survey was started by T. Girard, C. E. Lopez and van Altena. The results are referred to faint galaxies and the average epoch difference is 20 years, which will yield an accuracy of 0".005/yr for the average star.

At the Yale Observatory, van Altena and his colleagues obtained proper motions of stars in open clusters. Together with L. A. Marschall he completed a proper motion membership study of Tr 37. He and J.-F. Lee, J. T. Lee, P. K. Lu and Uggren completed an investigation of the internal motions of the Orion Nebula Cluster. They found the internal velocity distribution for stars brighter than magnitude 12.5 to be 1.46 ± 0.13 km/sec, with no evidence for anisotropy in the velocities or equipartition of energy, as is to be expected for a very young cluster. Probabilities of membership for stars in NGC 188 are being derived from the proper motions by Y.-W. Lee and van Altena. Astrometric calibration fields have been established for the field of this cluster and for Omega Centauri for the focal plane of the Space Telescope. Both fields of view have flat field

rectangular positions accurate to about $0''.01$.

At the Lick Observatory, B. F. Jones and M. Walker continued a program of measuring proper motions for membership and internal motions in young clusters. They have completed a study of the Orion cluster region, which includes more than 1000 stars within $15'$ of the cluster center. They also find isotropic velocity dispersions of about 2 km/sec in each coordinate. Klemola continues an astrometric survey of the SMC halo field around NGC 121 and has begun a similar study of the LMC around NGC 2257 in order to isolate red giants for further observation. A major objective is the determination of the absolute motion of the Magellanic Clouds. Klemola has also started an astrometric and photometric survey of the extended Pleiades field in order to isolate faint K and M type members for subsequent astrophysical study.

Second-epoch photography for the Lick Northern Proper Motion (NPM) program is now complete for 97% of the 1246 fields north of declination -23° . Plate measurement is complete north of -3° for the sky outside the Milky Way and reductions are complete for the 600 fields between -3° and $+68^\circ$.

Proper motions and photometry have been determined by K. Cudworth and his associates at the Yerkes Observatory for the globular clusters M 71 (39.154.003), M 22 (42.154.019) and M 2 and the Ursa Minor dwarf spheroidal galaxy. In each of the globular clusters, the internal proper motion dispersion and the membership has been derived, and for the latter two, the distance as well, from a combination of the data with radial velocities.

At the Bonn Observatory, Relative proper motions were derived in the regions of the globular cluster M 12 by H.-J. Tucholke and M. Geffert (38.154.073) and more recently in the open clusters M 16 (42.153.021) by Tucholke, Geffert and P.S. The and the Pleiades by Geffert. The absolute space motions of the globular clusters NGC 4147 and NGC 6218 have also been derived.

Optical positions and identifications of QSO's and other radio sources were undertaken at Bonn (38.041.048), Yerkes (41.159.086) and Hamburg where Ch. de Vegt reports that work on optical positions of radio sources has continued with precise positions for about 100 sources in the Northern Hemisphere determined. H. G. Walter and R. M. West (41.041.009) also determined optical positions from Schmidt plates relative to reference stars in the Perth 70 Catalogue.

Position and proper motion studies also continued at Bonn by P. Brosche and H. Schwan (38.111.019, 41.043.018) who studied motions of FK4 stars. They found that the motions of young stars from fundamental catalogues reveal a breaking wave in the velocity field along the local spiral arm and they have discussed the consequences of this result.

At Hamburg, de Vegt et al. continued work on the CPC2, and at Brussels, Dommanget has improved the Catalogue of the Components of Double and Multiple Stars (CCDM). Some 20000 accurate positions of components of systems have been introduced into the CCDM.

At Strasbourg, A. Fresneau compiled a survey of the Zones from $+1^\circ$ to $+31^\circ$ of the Astrographic Catalogue for about a million stars. Stars brighter than magnitude 11.5 can readily be detected with precision $+0''.006/\text{yr}$ (39.111.020). Klemola and his colleagues at Lick constructed star positions in the fields of Uranus and Neptune for the Voyager spacecraft encounters with these planets, and along part of the inbound trajectory of Comet Halley.

Measurement was completed of plates taken for the Zodiacal Zone Catalogue at Yale and at the U.S. Naval Observatory with the 0.2m astrograph. This project

includes all SAO stars within 16° of the Ecliptic with epochs around 1980 but with proper motions. The catalogue should be complete by the end of 1987. Observations of the northern section of their astrographic catalogue were completed and the telescope was relocated at the site on Black Birch Mountain near Blenheim, New Zealand. Measurement of the northern plates has commenced on the Starscan measuring machine in Washington.

At the Kazan Observatory, N. Rizvanov reports on a photographic survey of northern stars and an astrographic catalogue of stars in both hemispheres.

A precise position was determined by Girard, Lopez and van Altena for SN1987A from plates of the 0.5m double astrograph at El Leoncito. It is found to lie very close to Star 1 in the complex image of Sk -69*202.

IV. Instrumentation, Techniques and Reduction Methods

Brosche and his associates at Bonn have investigated the accuracies of measuring machines and of plates of the Astrographic Catalogue.

First astrometric tests at Hamburg have been performed with the new PDS 1010G by de Vegt et al. A HP dual axis laser interferometer has been obtained and is being adapted to it. The visual F422 Mann-Comparator was converted to a semi-automatic measuring machine using a Hamamatsu CCD-camera. First results have shown that 0.5-micron accuracy will be possible for plate measurements. Design studies are begun for a new granite-based measuring machine with several camera detectors. Also at Hamburg, optical design studies for a new type of astrometric telescope of aperture 1.5m are in progress. It is expected that the system will be capable of positioning stars to magnitude 17 to a few hundredths of an arcsecond. Reductions are also being improved. A new block adjustment program is being finished and work on transformations of the principal photographic catalogues to the FK5 system has been started.

D. Jones reports that the 1.0m Kapteyn telescope at La Palma, in the Canary Islands is in routine use for astrometry. The highly corrected Harmer-Wynne f/8 arrangement with a 1.5° field is used on most nights. A search for common proper motion companions to nearby stars and precise positions of radio sources are among the programs in progress. A Cassegrain focus of f/15 is also used for a parallax program with the CCD camera. Jones also reports that astrometry at Herstmonceux has ceased but old plates are repeated if they show stars on one of the La Palma programs.

A new tailpiece/autoguider was installed on the Mt. Stromlo telescope and a similar system is being installed on the 1.0m reflector of the McCormick Observatory.

Dommanget has pursued his research into Schmidt plate reduction methods, taking into account the bending of a glass plate in a plate holder. Measures have been made of a network registered on a plate in bended and unbended positions.

Rizvanov reports on improvements in methods of observation, measurement and reduction (40.002.133).

At the Shanghai Observatory, Wang has published (42.036.144) an iteration procedure using Murray and Corben's method for the reduction of trigonometric parallax data.

Eichhorn has developed formulae which derive corrections to spherical coordinates of stars directly, without the use of the standard coordinates explicitly other than as auxiliary quantities. The formulae are needed to perform

an overlap solution in an extended area (40.041.024).

An expression has been developed by H. Smith for the probability density of the true parallax of a star, given its apparent magnitude and measured trigonometric parallax and the absolute magnitude distribution of its type. This allows the calculation of the most probable parallax which may differ from the weighted mean. This has implications for the compilation of a catalogue of nearby stars (40.111.020).

V. Acknowledgment

I am very grateful to all who responded to my request for information on which this report was based.

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President of the Commission