

24. PHOTOGRAPHIC ASTROMETRY (ASTROMÉTRIE PHOTOGRAPHIQUE)

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I. Introduction

The question of the title of Commission 24, obviously, offers a difficult problem as already mentioned in recent reports. Photographic Astrometry no longer describes the whole scope of the commission. This problem has continued during the last three years especially in view of the preparations for the astrometric tasks of the NASA Space Telescope and of the ESA satellite HIPPARCOS.

A review of the field of astrometry was published in *Ann.Rev.Astron.Astrophys.* (van Altena, 34.041.014). Murray edited a volume entitled "Vectorial Astrometry" (33.003.083).

Many of the activities of Commission 24 coincide with the interests of other commissions, especially with Commission 8. Surveys of new topics were made by Fredrick and Smith: "Photoelectric Astrometry" (*Instrumentation in Astronomy* 4, S.P.I.E. Proc.312, 111), Fredrick: "Methods for Photoelectric Astrometry" (S.P.I.E. Proc.331), Johnston: *Radio Interferometric Astrometry; Techniques and Results* (IAU Symp. No.109, Gainesville), McAlister: "Speckle Interferometry in Astrometry" (IAU Symp.No.109, Gainesville).

In the past three years several meetings were held which were attended by members of Commission 24 who discussed topics and problems in the fields of activities of our commission:

ESA Colloquium "Scientific Aspects of the ESA Space Astrometry

Mission HIPPARCOS", 22-23.02.1982, Strasbourg, France (31.012.011).

Workshop on "Calibration of Stellar Luminosities from Astrometric Data", 4-5.05.1983, Herstmonceux Castle, England.

IAU Colloquium No.76 "The Nearby Stars and the Stellar Luminosity Function", 13-16.06.1983, Middletown, Conn., USA (34.012.065).

IAU Symposium No.109 "Astrometric Techniques", 9-12.01.1984, Gainesville, Florida, USA.

IAU Symposium No.111 "Calibration of Fundamental Stellar Quantities", 24-29.05.1984, Como, Italy.

II. Data

TRIGONOMETRIC PARALLAXES

The new edition of the Yale Parallax Catalogue is nearing completion with an expected publication date of 1985. Van Altena gave preliminary reports at Middletown (34.002.125) and at Gainesville (IAU Symposium No.109). He also discussed the question "Can a system be defined for the new edition of the YPC ?" (37.002.086).

Trigonometric parallaxes of individual objects were published by Harrington et al. (34.111.002 - VB8, VB10), Harrington et al. (34.111.034 - LHS 292), Russell et al. (31.111.007 - Wolf 294, 39 com, Case 2, Vega), Ianna et al. (32.111.005 - HD 149499), Kiselev (32.111.018 - Vyssotsky Nos. 5, 233, 28, 29, 191), Wang (34.111.021; 37.111.018 - BD +2°348), Guinan and Ianna (33.119.013 - R CMa).

Dahn and Monet reported about CCD Astrometry at KPNO and USNO-Flagstaff (IAU Symposium No.109). They gave preliminary results from the KPNO 4m-CCD parallax program (34.111.010; 34.111.032 - VB10, LP750-28, LP750-29, LHS 205a, 1405, 1625, 1625a, 1742a, 3481, 5356, VB8 and LHS 2924).

Lists of newly measured parallaxes: Van Vleck: Upgren and Breakiron (29.111.018), Upgren et al. (31.111.005, 33.111.005, 34.111.012); USNO: Dahn et al. (31.111.006); Sproul: Lippincott (30.031.562, 33.111.012), Heintz and Borgman (Astron.J.89, 1068); McCormick: Ianna and Whitman (37.111.009); Herstmonceux: Scales and Zhao (37.111.011); Yale Southern Station: van Altena and Sawada (34.111.011).

Further observations and reductions of trigonometric parallax series are in progress at Yerkes Obs. (Vilkki), Roy. Greenwich Obs. (Murray and Argyle, plates taken with the UK Schmidt-Telescope), South African Astr.Obs.(Churms), Yale-Columbia refractor at Mt.Stromlo (Ianna and Culver, giant stars, 37.111.005, and at IAU Symposium No.111), CTIO 4m-telescope (van Altena).

Murray et al. reported on "Trigonometric parallaxes obtained with the UK Schmidt Telescope" (IAU Symposium No.109).

Astrometric perturbations, search for "unseen companions": Lippincott (30.118.008 - Zeta Her, 85 Peg; 30.118.009 - Mu Cas; 32.118.004 - 7 visual binaries; 33.118.010 - 10 double or suspected multiple systems; 34.122.081 - EV Lac; 34.118.041 - 36 UMa), Hershey and Lippincott (31.118.034 - Lalande 21185, BD+5°1668), Borgman and Lippincott (33.111.004 - White Dwarfs), Lippincott et al. (33.118.025 - BD+41°328), Harrington et al. (30.118.004 - quadruple system G107-69/70), Harrington and Kallarakal (32.111.006, abstract - G208-44, L850-62, W922, Barnard's star), McNamara (Bull.A.A.S. 16, 507 - BD+66°34). Lippincott reported on the status of the Sproul astrometric plate series on the nearest stars in the research for planetary systems (32.118.016).

Also speckle interferometry in astrometry concerns searches for unseen planetary companions (Papers presented at IAU Symposium No.109 at Gainesville by McAlister and by McCarthy). At IAU Colloquium No.76, D.W. McCarthy gave a report and a list of astrometric companions confirmed by infrared speckle interferometry (34.118.045).

Gatewood and Stein described the high precision of electronic detectors which reveal parallactic motion more quickly than previously possible (34.036.206).

An error analysis of the USNO absolute parallaxes was published by Wang (37.041.029).

Halliwel gave an abstract of an orbital and trigonometric parallax comparison (32.111.008).

In two papers Lutz et al.(30.111.011) and Hanson and Lutz (33.111.001) investigated systematic effects in trigonometric parallaxes.

NEARBY STARS

Gliese and Jahreiss are preparing a third edition of the Catalogue of Nearby Stars which will be extended to a limit of 25 pc. Basic data will include the trigonometric parallaxes of the new Yale Catalogue but again supplemented by spectroscopic and photometric distance determinations. The latter are outside the scope of Commission 24, but the calibrations of spectral type-luminosity relations and color-luminosity relations are mostly made from trigonometric parallaxes and the difficulties arising from such procedures depend on statistical problems encountered in trigonometric parallaxes (Lutz, 34.115.026).

At Gainesville (IAU Symposium No.109) Gliese read a paper on "Astrometric Desiderata for Nearby Stars".

PROPER MOTIONS

The measurement of trigonometric parallaxes includes the determination of relative proper motions in the publications cited above.

Klemola reported (IAU Symposium No.109) on "Proper Motions with respect to Galaxies". The Lick proper motion program with respect to galaxies (B.F. Jones, Klemola, Hanson) has completed second-epoch photography for 93% of the 1246 fields north of -23° declination. Hanson and Sirk have completed proper motion and position reductions from -3° to $+68^\circ$ declination. The Lick "Input Catalogue of Special Stars" (Klemola) contains over 65 000 entries.

The Yale Southern Observatory has now extended the region of overlap with the Lick proper motion survey to the $+25^\circ$ declination zone (van Altena, 72 additional fields).

Investigating the reductions of relative to absolute proper motions of stars obtained from galaxies, Patchikhin found that the accuracy of the measurements of galaxies at Pulkovo proved to be smaller than that of 15^m stars by 2.4 times (32.031.671).

Rybka gave the systematic differences between four catalogues of proper motions with respect to galaxies (Pulkovo, Tashkent, Moscow, and Goloseevo). The size of the differences depend on the stellar magnitude (31.111.009).

Rakhimov and Umarova investigated the Pulkovo Catalogue of Proper Motions of Stars relative to galaxies for determining precession corrections and inaccuracies (34.043.005; 34.111.027).

Absolute proper motions of faint blue objects near the galactic north pole were measured with reference to 45 galaxies. Plates were taken with the Tautenburg Schmidt telescope (Schilbach, 32.111.015).

Luyten has continued analysing pairs of Palomar Survey plates and published several hundred new proper motions for faint stars: Large proper motions (31.111.031); BD+12°584 (31.111.032); another 800 double stars with common proper motions (37.111.020), thus bringing the total number of his double stars (LDS) to more than 6 000. Luyten and H.S. Hughes published the "First Supplement to the NLTT Catalogue" (31.111.030) and proper motions for 374 and 280 faint stars (32.111.021, 34.111.023).

Herbig and B.F. Jones published proper motions of additional Herbig-Haro objects measured on Crossley and 120-in. plates (34.121.003).

Proper motions of ultraviolet-excess objects were determined by Noguchi et al. (32.111.014).

Cudworth gave a report "Astrometry of Star Clusters" (IAU Symposium No.109). Such observations and measurements of proper motions have been done at several observatories. Some of the Commission members have reported their work to IAU Commission 37 (van Altena), others informed Commission 24 on proper motion work in globular clusters, open clusters and nearby galaxies: B.F. Jones and Cudworth have published a study of Praesepe membership (33.153.008). Currently under study at Yerkes Observatory are the globular clusters M71, M22, M13, Pal.11, 47 Tuc, NGC6712, the old open clusters NGC2158 and NGC6791, and the UMi dwarf spheroidal galaxy. A several-year project obtaining proper motions, photometry and spectra for large samples of stars to $V=16.5$ at intermediate galactic latitudes is

initiated (Cudworth, Kron, Rybski); Adler and Ianna: Membership in the open cluster NGC2287 (37.153.078); Brosche and Geffert: NGC5466 (32.154.016; 34.154.034) and Brosche et al. (34.154.095); Brosche et al. determined the absolute motion of NGC4147.

Stock reports on the activities in Venezuela: Positions and proper motions for the Coma cluster and for Tr 10 have been published (Cova, 32.111.012), NGC129 and IC752 are ready for publication and δ Per is being measured. The plates were taken with the CIDA refractor.

A catalogue of 7120 proper motions for faint stars in the region of the Hyades was published by Luyten et al. (32.111.019) and another similar list of 6300 such motions is in press.

A catalogue of relative proper motions and photographic UBV magnitudes in the region of the sky with the open star cluster NGC7092 (M39) was published at Leningrad by Platajs (34.002.037).

PHOTOGRAPHIC POSITIONS AND CATALOGUES

The last of the southern Yale Zone Catalogues was published as "Catalogue of Positions and Proper Motions of Stars between declinations -60° and -70° " (Fallon, Hoffleit, 37.002.073). It includes 14597 stars.

King and Lomb produced the Sydney Southern Star Catalogue (37.002.068 - SSSC) which gives 26926 positions in the zone -51° to $-63^\circ 5'$, available in a tape version. Plates have been taken from -36° to the South Pole.

Nicholson et al. published the first volume of the Second Cape Photographic Catalogue 1950.0, CPC2 as provisional catalogue of positions of stars in the Cape zone -40° to -52° (37.002.024). It contains 51018 stars, printed in microfiche and available also on magnetic tape. A total of 5820 plates covering the whole southern hemisphere was taken at Cape 1962-1972 and measured on GALAXY at Herstmonceux. A new block adjustment program version which can handle very large global plate overlap patterns is under development. This system will be used for the final reduction of the whole CPC2 (de Vegt).

The Pulkovo Bolivian Expedition (26.041.025) has taken already 1650 plates of the southern sky; measuring work is continued (Kanaev).

Murray gave a report on Astrometry with Schmidt telescopes (37.041.035).

In September 1983 the "VI Lohrmann-Kolloquium Geodätische Astrometrie" was held; five papers on new results using the 2m-Schmidt at Tautenburg, GDR for photographic astrometry were read (in press: Mitt. Lohrmann-Obs., Stange).

At IAU Symposium No.109 Stock presented a paper on "Astrometric positions from objective prism plates".

Stock and Cova published a catalogue of 2911 stars of the Carte du Ciel (equ. 1950.0, epoch 1901.1: $11^{\text{h}}39^{\text{m}}$ to $12^{\text{h}}30^{\text{m}}$, $+26^\circ$ to $+32^\circ$) using recently developed block adjustment methods (33.041.036).

RADIO SOURCES

The Working Group on Optical/Radio Astrometric Sources for the Establishment of an Inertial Reference Frame has produced an Interim Progress Report (Argue and de Vegt, Abh. Hamburger Sternw., Band 10, 101-176, 1982) and summarized the first step of this progress publishing a list of suitable objects for future work: A catalogue of 234 strong compact extragalactic radio sources for the construction of an extragalactic radio/optical reference system (Argue et al., 37.043.001).

Optical positions of radio sources were reported by West and Walter resp.: Walter and West (30.141.121, 32.141.014), Harrington et al. (34.041.005), Clements and Argyle (Monthly Notices Roy. Astron. Soc. 209, 1, 1984), Brosche and Geffert (30.141.126), Geffert and Richtler (33.041.003). Plates for sources were taken with the double refractor at Bonn (Brosche), with the Mexican 2.12m telescope (Lentes) and at Kazan (Rizvanov).

SOLAR SYSTEM OBJECTS

Plates for determining positions of Solar system objects (minor planets, comets, major planets and their satellites) were taken at Zelenchuk Mountain Station of the Kazan University, at Engelhardt Observatory (Rizvanov), at the Zvenigorod Tracking Station of the Astron. Council of the USSR Acad. of Sciences (Lozinsky), at San Fernando (Quijano), and at Bucharest (Bocşa).

III. Astrographic Catalogues

We should call attention to the recent revival in Astrographic Catalogue work which was discussed at a meeting of the Réunion Scientifique du Conseil Scientifique du Centre de Données Stellaires at Grasse, France, 10-11.05.1984. For details and desiderata for the future see Bull. d'Inf. du CDS 27, 1984.

IV. Satellite Based Astrometry

A detailed description of the HIPPARCOS-TYCHO project for the period 1981-1984 is given by Høg in a report to Commission 8. It includes the work in progress concerning the Input catalogue preparations (Turon, Ref.: Turon-Lacarrieu 34.051.044; Turon and Réquième at IAU Symposium No.109; Turon at IAU Coll.No.78).

The work of the HIPPARCOS Input Catalogue Sub-Group of Double Stars is reported by Dommanget. A specific Catalogue of the Components of Double and Multiple Systems (C.C.D.M.) giving positions to an accuracy of $\pm 1''$ and all needed identifications is in work; several papers have been published by Bacchus (34.002.115, 37.118.038), Dommanget (34.002.016), Nys (34.002.011, 34.002.116, 37.002.028), Soulié (34.118.016, 37.118.036).

Linking the HIPPARCOS system to an extragalactic frame by observations of radio stars and of stars in the neighborhood of radio sources is within the scope of the Working Group on Optical/Radio Astrometric Sources (Argue, IAU Symp. No.109; see also Walter, 34.041.038).

Duncombe and Hemenway reported at IAU Symp. No.109 about "The use of the Space Telescope to tie the HIPPARCOS reference frame to an extragalactic reference frame".

V. Instrumentation and Techniques

The 1m Telescope at the Roque de los Muchachos Observatory on La Palma is now being commissioned. This telescope is to be known as the "J.C. Kapteyn Telescope". Time on this telescope has been assigned to a team led by D.H.P. Jones to carry out a five-year astrometric programme, including trigonometric parallaxes, radio source positions and proper motions of cataclysmic variables.

Ianna reported on astrometric applications of the PDS 1010A microdensitometer (Astronomical Photography 1984, Occasional Reports of the Royal Observatory, Edinburgh, ed. Sim and Ishida).

The PDS 2020G Microdensitometer of the Yale Observatory has been fitted by van Altena with a Hewlett-Packard dual axis laser transducer system and is now routinely producing astrometric positions whose accuracy appears to be limited only by the photographic emulsion and the telescope optics.

At Yale a theoretical analysis of the positional and photometric properties of photographic emulsions by J.F. Lee has shown that the IIIa-J emulsions should be capable of producing positional accuracies of $\pm 0.2\mu\text{m}$ (Astron.J.88, 1683, 1983).

During the last few years special investigations were made in reduction and handling plates of the 2-m-Schmidt at Tautenburg by Böhme, Sandig, and Schilbach (29.041.051) and Böhme (29.041.014).

Stock has developed an automatic program which efficiently reduces simultaneously a system of overlapping plates. It can also be used to reduce existing catalogues like the CdC no matter whether these are given in x and y coordinates or in equatorial coordinates. He also developed an automatic program intended particularly for comet or asteroid positions. It can start out with only two identified stars and will automatically search for all additional reference stars on the plate. These programs have been presented at the IHW meeting at Munich in June, 1984 and will be published as part of the proceedings.

Due to the decision of the New South Wales Government, research at Sydney Observatory has been terminated. The astrographic telescope and other astrometric equipment will be transferred to Macquarie University in Sydney (Lomb)

The growth of the city around the observatory (Observatorio de Marina de San Fernando) is seriously disturbing the work; the 2nd epoch of the Pulkovo program of Extragalactic Nebulae is abandoned (Quijano).

Funding of the GALAXY machine at Herstmonceux ceased in March 1984 (Murray).

VI. Reduction Methods

Eichhorn and Standish derived a transformation which reduces the most general class of least-squares problems to the classical standard case (29.021.007). Eichhorn gives an algorithm to avoid underestimation of internal errors of estimated parameters (34.021.037). Eichhorn developed rigorous formulae for the dependence of the location and velocity of stars on these values themselves, and also for computing parallaxes rigorously from non-uniform proper motions (30.008.026;34.111.024).

VII. Machine-readable Data

Machine-readable astrometric data are available at Centre de Données Stellaires, Strasbourg, France (Bull. d'Information du CDS) and at Astron. Data Center of the NASA Space Flight Center (NSSDC/WDC-A-R&S), Greenbelt, Maryland, USA.

VIII. Acknowledgements

I am very grateful to all who have assisted by submitting information on their activities. I am deeply indebted to the Vice-President A.R. Uppgren for reading and supplementing this report.

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President of the Commission