COMMISSION 8. POSITIONAL ASTRONOMY (ASTRONOMIE DE POSITION)

PRESIDENT: J.A. Hughes VICE PRESIDENT: Y. Requieme

ORGANIZING COMMITTEE: G. Billaud, G. Carrasco, W. Fricke, V.S. Gubanov, E. Høg, B.L. Klock, J.A. Lopez, Luo Ding-jiang, M. Miyamoto, L.V. Morrison, I. Nikoloff, G. Teleki, Y.S. Yatskiv

INTRODUCTION

The activities of the commission during the XIX GA are chronicled below. The Joint Meeting on HIPPARCOS (7, 8, 24, 25, 33 and 37) and those on Earth Rotation Parameters (7, 8, 19 and 31) are covered elsewhere. The reporter (and now past-president) wishes to thank the commission members who made these activities very worthwhile, and to especially acknowledge the various chairmen and secretaries. In the latter category, L.V. Morrison and C.A. Smith are particularly noteworthy.

Business Meeting, 21 November 1985, 0900-1030
Chairman: J. Hughes

The results of the commission elections were certified by the president and accepted by the members. The new officers of the commission are: President: Y. Requieme; Vice President: M. Miyamoto; Organizing Committee: P. Benevides-Soares, D.P. Duma, L. Helmer, J. Hughes, L. Lindegren, Luo Ding-jiang, F. Noel, G.I. Pinigin, L. Quijano, S. Sadzakov, H. Schwan, C.A. Smith and M. Yoshizawa.

In the absence of the chairman of the SRS committee, W. Fricke, the report of that group was read by committee member J. Hughes. The report consisted of the text of the agreements concluded at a meeting held at the Pulkovo Observatory in June, 1985. Additional members include T. Lederle, D.D. Polozhentsev, V.A. Fomin and C.A. Smith. The cited text follows.

The SRS Committee recommends:

1. That the Pulkovo Observatory and the U.S. Naval Observatory should produce a single catalog of SRS positions which should be both completed and published jointly within a reasonable time in the FK5 system.
2. That the preliminary catalog of SRS positions should be referred to the system of the FK4 catalog and later transferred to the FK5 system.
3. That work on the computation of proper motions of the SRS, already in progress at the U.S. Naval Observatory, should be completed as soon as possible after the completion of the SRS catalog.

Recommendations with regard to future work:

1. That second-epoch observations of IRS (AGK3R + SRS) should receive high priority, and that an international effort to reobserve the IRS differentially and fundamentally should be organized.
2. That observations in the southern hemisphere should be strongly encouraged.
3. That observations of IRS should be referred to the FK5 system.
4. That an *IRS Committee* should be formed.
5. That a *Supplementary List* of IRS stars be made available to observers in order to improve both the homogeneity of the areal distribution of the IRS and its spectral type distribution in selected areas of the sky.

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The report of the Astrolabe Working Group (AWG) was given by its chairman, G. Billaud. Some 22 astrolabes participated in the MERIT program. The use of laser ranging and VLBI for EOP measurements will decrease the astrolabe contribution to this work although efforts should continue, at least for the present, for rapid prediction services. Future work is likely to center on catalog observations. Such work is currently underway at twelve stations. It is believed that improved EOP observations will indirectly benefit the astrolabes by allowing much better evaluations of local effects thus improving results for star positions. Chollet has shown that humidity can cause errors of $0''.003/^{o}C$, while star colors can contribute a few $0''.01$'s. Visual astrolabes have established a precision of $0^{s}.005$ and $0''.07$ in time and latitude, while new, automatic instruments lower these numbers, and are intended for stellar observations (China, France and Japan) or solar observations (Brazil and France). The latter have a monthly precision of $0''.06$. The equinox difference, FK5-FK4, given by Fricke is confirmed to within $0^{s}.002$. Journet found $E=0^{s}.026\pm 0^{s}.005$. Studies of changes in the solar diameter showed a period of 975 days, not correlated with Wolf's number, and of interest to astrophysicists. The South American Group (Natal, Rio, Rio Grande, San Juan, San Martin and Valhinos) plans a catalog covering 0^{o} to -75^{o}. A similar northern program involving the Chinese astrolabes, plus Potsdam and Boroviec would be very desirable. Natal and Quito could link the hemispheres. The planets, Jupiter, Saturn and Uranus are observed at Santiago and San Juan; radio stars at Paris, Potsdam, San Juan and Santiago.

The report of the Working Group on Astronomical Refraction (WGAR) was given by its chairman, G. Teleki. A *Workshop on Refraction in Optical and Radio Astrometry* was held at the Pulkovo Observatory from 3 to 5 June, 1985. The LOC was chaired by I.I. Kanaev, and the SOC by Teleki. The latter will edit the proceedings which will be published as the *Belgrade Astronomical Observatory Publication, No. 35* during the first half of 1986. Some 60 participants from 7 countries together with about 50 attendees from the USSR heard 42 papers. The appearance of the *Pulkovo Tables, Fifth Edition* is of particular interest. The new treatment of chromatic effects in this work is of special interest.

A meeting of the members of the WGAR present at Leningrad took place after the Workshop. Attending were, D. Currie, B. Garfinkel, Huang Kun-yi, I.G. Kolchinskiy, A.I. Nefed'eva, V.I. Sergienko and G. Teleki. It was agreed that closer connections between the researchers and institutions working in the field would be very useful. Specific areas of investigation and the most interested institutions were identified as: Local anomalous refraction, Irkutsk, Nanjing, Tokyo, Tomsk and Washington; Atmospheric modeling, Belgrade, Irkutsk, Leningrad, Kazan, Lvov, Moscow, Nanjing, Tokyo, Tomsk and Washington; Experimental determination of refraction effects, Irkutsk, Kazan, Kiev, Lvov; Terminology and Standards, Belgrade, Kiev. Dispersion methods were strongly endorsed. The meeting agreed that it would be advisable to continue the existing groups within the IAU and IAG. An inter-union group including astronomers, geodecists, meteorologists, physicists, et cetera, was endorsed. Finally, the year 1987 and the location of Belgrade were mentioned in the context of a special workshop on the basic questions of refraction.

The continuation of the above Working Groups and the Study Group on Horizontal Meridian Circles was approved by the commission without dissent.

Membership in the commission has become very popular. In all, 30 new members were approved. Arranged by country, they are:

Australia:	D. Harwood
Brazil:	L.B.F. Clauzet
Chile:	E. Costa

China: (Nanjing)	Hua Yingmin, Jiang Chong Guo, Li Zhifang, Li Zhigang, Lu Chun Lin, Mao Wei, Miao Yongkuon, Quian Zhi Han, Quin Zhi Han, Shen Kaizian, Shi Guagchen, Xia Yi Fei, Xie Liangyun, Xu Bangxin
Denmark:	K. Fabritius
FRG:	R. Wielen
France:	F. Crifo, A. Journet
Italy:	G. Chuimiento
Korea DPR:	Du Jin Cha
UK:	M.A.C. Perryman, C. Thoburn
USA:	S.J. Dick
Yugoslavia:	D. Durovic, N. Solaric, D. Saletic

The commission approved four consultants. They are: M. Dachich, I. Pakvor (Yugoslavia); T. Rafferty (USA); K.G. Steinert (DDR).

A discussion centering on the need for unified star lists took place. Actually, L. Morrison had broached the subject at the *Joint Discussion on Reference Frames* held on 20 November where he, together with C.A. Murray, pointed out the need for defined, faint fundamental lists, perhaps to 13th magnitude. Other lists should also be standardized or at least made known. For example, V. Abalakin proposed a list including some 42,000 IRS, 5,000 BS, 3,000 High Luminosity Stars, 2,500 Doubles and 2,000 Radio Source Reference Stars. In view of the universal need for and interest in such lists, a new *Working Group on Star Lists* was formed. Its members are: G. Carrasco, T. Corbin, L. Helmer, M. Miyamoto, D.D. Polozentsev and Y. Requieme. The latter, in his capacity as president-elect, agreed to serve as chairman of the group, at least provisionally. Additional members may be approved by the Chairman. The report of the SRS committee should be read in connection with this Working Group.

The possibility of a conflict between "astrometric" meetings proposed for 1987 in Paris and in Belgrade was discussed. It was agreed to leave the matter in the hands of the principles involved until the joint meeting with Commission 24. Some discussion of that forthcoming meeting, particularly involving joint interests, took place, but the business meeting adjourned without further action.

General Space Astrometry, 21 November 1985, 1100-1230
Chairman: R. L. Duncombe

A. and M. Meinel (read by J. Hughes) reported on their plans for *Astrometry on a Thousand Astronomical Unit (TAU) Voyage*. The technology to send a 1.5m telescope on such a long baseline parallax voyage has been examined at JPL. With an initial mass of 25,000 kg the TAU spacecraft will be deployed into LEO by the shuttle. Ion propulsion using a 1Mw nuclear electric module and 13,000 kg of Hg can attain a velocity of 100 km/sec upon leaving the planetary neighborhood, and a distance of 1,000 AU is reached in 50 years. Optical communication at 20 kb/sec can return data by using a 5w laser and a 1m communication telescope. Objects at 20th magnitude could be reached in a reasonable integration time, and it appears that centroiding diffraction limited CCD images to 30 microarcsconds is possible. An object exhibiting a parallax of 200 microarcseconds at a baseline of 200 AU is at a distance of a megaparsec, thus members of the local group are accessible. Since TAU cannot separate parallax and proper motion, a second 1.5 m telescope in LEO must provide the latter. A conference is planned for summer 1986 and Commission 8 members involved in new astrometric techniques are especially invited.

R.D. Reasenberg gave a presentation on *Optical Interferometry in Space* pointing out that although interferometers are more complex than telescopes, they are useful for astrometry since, for instruments of comparable size, an interferometer is

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orders of magnitude faster for most scientific objectives. POINTS (Precision Optical INTerferometry in Space) is a design concept for an articulated, space-based, dual astrometric interferometer having two 2 m baselines and four 25 cm telescopes capable of measuring the angular separation (of about 90°) of a pair of tenth magnitude stars to 5 μas in about 10 minutes. This would allow about 60 measurements per day. The problem of systematic error is addressed by using stable materials and by means of realtime metrology and post analysis of data including bias estimation. The latter, depending upon 360° closure, has been investigated by covariance studies which show that no special observing schedule is required and several biases per day can be estimated with only a small increase in the statistical uncertainty in star coordinates. Other covariance studies show that with redundant observations, the separation of all pairs of stars (including those pairs not directly observed) becomes well determined; the grid becomes rigid. A set of 300 stars and 5 QSO's could be redundantly observed in a month. If such a sequence were repeated 40 times in 10 years, positions, proper motions, and parallaxes typically would be determined to 0.6 μas, 0.4 μas/year and 0.4 μas, respectively. As a result of aberration, these coordinates would be known to better than a milliarcsec in the frame of the earth's orbit. Additional objects would then be observed with respect to these 300 stars thus thousands of additional objects could be investigated with accuracies only slightly reduced. A POINTS mission would support a diverse set of scientific objectives. These include a second-order deflection test of general relativity and a deep search for other planetary systems. However, the most important results of such a mission are likely to come from lines of investigation not yet considered including serendipitous discoveries.

W. Van Altena reported that the Space Telescope Astrometry Team plans to observe Hyades cluster members and field subdwarfs with the Fine Guidance Sensors to determine the stars' trigonometric parallaxes and improve the Pop I and II distance scales. They expect that both distance scales will be defined to approximately 0.01 -0.02 magnitude in the distance modulus. Observations with the Planetary Camera are also planned for six globular clusters to determine their internal velocity dispersions.

L.W. Fredricks indicated that the Hubble Space Telescope Astrometry Team has drawn up a list of 19 objects without parallaxes and hopefully within 200 parsecs of the sun. Redundancy was desired so the list concentrates on five planetary nebulae, 2 dwarf novae, four old novae, Feige 24, and seven T Tauri stars. The latter will yield distances to their nebulae as well. Special filters have been inserted. The passband starts above the OII lines and cuts off before the H-alpha line.

P.K. Seidelmann talked about the Hubble Space Telescope, which is to be launched in 1986, and carry a Widefield/Planetary Camera, which will have fields of view of 2'.63 and 68". For astrometric observations, methods of centroiding, plate solutions, calibration procedures and achievable accuracies must be considered. The Widefield/Planetary Camera Investigation Definition Team plans to include in its guaranteed time observations for low-mass companion studies, searches for and observation of faint satellites of the outer planets, search for satellites of asteroids, studies of the rings and shepherd satellites, study of the orbit and colors of Pluto and Charon, and motions within planetary nebulae.

T.B.H. Kuiper described work carried out with S.P. Synnott and E.F. Tubbs. Synthesis of large telescope apertures in space at submillimeter wavelengths is feasible with current or near-term technology if the instantaneous vector between two spacecraft can be established in a stable coordinate system. A technique by Kuiper et al., *Radio Science* in press, 1985 has been developed in which clustered star trackers can be used to determine the direction of any visible point source with respect to the stars of the HIPPARCOS catalogue. The accuracy of the determination will be limited by the catalogue accuracy (approx. 2 millarcsec), degrading with time due to the uncertainties in the proper motions (approx. 2 milliarcsec/year). A reflight

of the HIPPARCOS mission is thus of great importance to our ability to produce high resolution submillimeter images of astronomical sources. Several submillimeter missions are planned between 1995 and 2010, including FIRST (Far InfraRed Space Telescope, by ESA) and LDR (Large Deployable Reflector, by NASA), as well as possible Spartan and Explorer class precursors. This approach to interferometry should be evaluated for the possibility of combining two or more of these spacecraft, after they have fulfilled their primary missions, to perform aperture synthesis. Such a mission would yield valuable experience for future missions, such as SAMSE and TRIO. The design of currently planned missions would be affected by an intent to do interferometry and this should therefore be determined in the next few years.

J. Hughes described an Astrometry Satellite proposed by a group headed by D. York (Chicago) of which the former is a member. Based upon a 1 to 1.5m class, compound, reflecting telescope, the primary mission of this satellite is the determination of relative positions to 10^{-4} arcsecond with a limiting magnitude of 19.5. This, together with a field of about 20 arcminutes in diameter, ensures that over most of the sky at least one QSO appears in each field. If the roll angle can be monitored by precision gyros even a single QSO could suffice for accurately referring the measures to the rest frame defined by such objects, although in many, or most, cases multiple QSO's will be in each field. It was remarked parenthetically that such gyros could also generate a global reference system, albeit at a somewhat reduced accuracy, say 0".01. The detector is a combination of a Ronchi ruling and a CCD. The parallaxes and inertial proper motions to be obtained from these measurements open up many, many scientific possibilities including much improved distance scale calibrations, the determination of the relative motions of globular clusters, and the measurement of the motions of the galaxies in the local group.

Observing Programs I, 22 November, 0900 - 1030
Chairman: L. Helmer

M. Miyamoto reported on the observing programs planned for the Tokyo Photoelectric Meridian Circle. With a scan time of about 30s per star and an average of 150 clear nights per year, it is possible to carry out 350,000 observations of stars brighter than 11.0 magnitude in 5 years. With 3 observations per star, this will give positions of about 100,000 stars to an accuracy of around 0".1. The Tokyo PMC program will include 100,000 stars in the AGK3 and Yale catalogues in the declination range -30° to $+90^{\circ}$. This will include about 20,000 IRS stars which will be observed with higher weight. Proper motions will be determined with an accuracy of 0".003/yr. The program also includes observations of the Sun, major and minor planets.

M. Yoshizawa reported on solar observations made with the Tokyo PMC since December 1984. The first and second limbs of the Sun are scanned with 3 pinholes 3" in diameter. The goodness-of-fit to the observations varies from around 2".0 in winter to 1".3 in summer, of which the image motion contributes about 1". Fourteen scans with 3 pinholes, taking 200s, gives an expected accuracy of 0".3. In fact, an accuracy of 0".4 was obtained, with a mean correction of -3".7 to the solar radius. The definition of the solar limb is, of course, dependent on wavelength. The standard deviations in RA, DEC and radius were $0^{s}.022$, 0".62 and 0".38, respectively.

G. Teleki reviewed present and future programs in Belgrade. The Meridian Circle (Askania 190/2578 mm, visual) presently observes a program of double stars, stars around radio sources, and the Sun, Mercury, Venus and Mars (daytime observations). The future program may also include IRS stars. The Transit Instrument (Askania 190/2578 mm, vacuum meridian marks) is undergoing a program of modernization. The future program will include the Sun and planets. The Vertical Circle (Askania 190/2578 mm, visual) carries out observations of Mars (rms error 0".55), Jupiter (0".65), Saturn (0".57), Uranus (0".73) and Neptune (0".64). The future program will include the Sun and inner planets. The Zenith Telescope (Askania 110/1287 mm, visual) continues its program of star observations.

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S. Debarbat described the Paris astrolabe program. The long series of observations of fundamental stars continues. Among these stars is the radio star β Persei which has been observed on a regular basis for 10 years. These observations showed a systematic drift with respect to the FK4 proper motion. The observations will be continued and compared with the radio positions. The correction for the "phase effect" of planets, calculated by Chollet, has been used at the Bureau des Longitudes for the HIPPARCOS asteroid model, and will be employed at JPL. Chollet started making observations of the Sun with a modified astrolabe (in 1984), following the results obtained with the CERGA astrolabe which appear to show a fluctuation in the diameter of 0".5 over 3 years.

V. Abalakin (for D. Polozhentsev) reported on the organization of meridian observations of the IRS in the USSR. Meridian circles at Pulkovo, Odessa and Nikolaev have been equipped with photoelectric micrometers and some have been moved to high altitude sites. About 5 or 6 instruments will begin observing the IRS between -20° and $+90^{\circ}$ in 1986. An IAU Resolution stressing the importance of the IRS is desirable.

C. Smith reported on the programs of the Flagstaff Transit Circle. In the period June 1983 to 1985, the positions of 362 reference stars for Halley's comet with m_V between 5.9 and 9.0, and spectral types B to M, were observed. The internal mean errors in RA and DEC were 0".08. Future programs will include radio stars (those measured with the VLA will have high priority), AGK3R stars within 6° of selected quasars, and non-AGK3R stars within $0^{\circ}.5$ of quasars.

Observing Programs II, 22 November 1985, 1100 - 1230
Chairman: H. Schwan

R. Stone reported on the USNO New Zealand program. The USNO 7-inch automated transit circle has been relocated to New Zealand and has become operational. The USNO double 8-inch astrograph has completed its northern hemisphere program and is currently enroute to New Zealand. In July 1985 the transit circle started a comprehensive observational program including an evaluation of its errors and an investigation of various instrumental effects. Preliminary results from collated data give standard deviations of $0^{s}.014 \cos\delta$, 0".17, and $0^{m}.06$ in α, δ and V respectively. These are averages from all zenith distances. The limiting magnitudes for night and daytime stellar observations are about $11^{m}.5$ and $4^{m}.5$, and the instrumental constants are found to be very stable with respect to time. Solar observations are beginning.

Y. Requieme considered the question of faint star lists for automatic meridian circles. The latter are now able to determine positions of faint stars up to B=13 practically without magnitude error. It would now be possible to construct a secondary reference frame with 11<B<13 for the needs of photographic astrometry. Other valuable programmes concern local frames and extragalactic objects and selected areas for galactic research. Furthermore, about 200,000 stars have been proposed for the HIPPARCOS mission, but 100,000 will not be included in the input catalogue. The faintest stars of these latter stars, of high astrophysical interest, could make up a priority complementary program for meridian circles, but the HIPPARCOS Input Catalogue Consortium plans to release the list only by the end of 1989.

Hu Ningsheng described work by Mao Wei and Guo Xinyian of the Yunnan Observatory concerning the use of a CCD to set up an inertial coordinate system. The method involves the measurement of the absolute proper motions of fundamental reference stars with respect to extragalactic systems. The residual rotation of the fundamental system is then calculated from these motions. Since the field observed by a CCD is quite small, overlapping techniques were described to link adjacent areas of the sky. The method compares very favorably with photographic techniques.

Meridian observations of the Sun and planets at the Kislovodsk Station of the Pulkovo Observatory were described by K.G. Gnevysheva, A.V. Devyatkin and G.S. Kossin in a report read by Ya. Yatskiv. The Kislovodsk location (ϕ=44°, h=2100m) has proved to be an excellent site for a daytime observing program. The Struve-Ertel vertical circle started regular observations of the declinations of the Sun, Mercury and Venus in 1984. The standard deviations of one observation of these objects are, 0".51, 0".31 and 0".35 respectively. For day stars the figure is 0".35.

A paper by A. S. Karin, N.F. Minyajlo and V.L. Voronkevich of the Main Astronomical Observatory at Goloseevo, Kiev (also read by Yatskiv) concerns the accuracy of observations of the Sun and major planets. A data bank exists involving some 18 years of observations and three optical methods. Extensive analyses were carried out to determine random, systematic and total error estimates. Comparisons were made of six series of observations each from the Nikolaev Transit Instrument and Vertical Circle and the Washington Transit Circle. Extensive estimations of the errors of recent observations (published 1981-84) were also given.

A progress report on the *Belgrade Catalog of Absolute RA's of Bright Polar Stars* was given by I. Pakvor, Belgrade Observatory, Yugoslavia. He indiated that the observations of absolute RA's of bright polar stars from the list of 308 stars in the declination zone +65° to +90° with the Large Transit Instrument (LTI) of the Belgrade Observatory were finished early in 1983. This is the first absolute RA catalog observed by the LTI of Belgrade Observatory. These observations involve the first use of vacuum meridian marks for determining the values of differential azimuth and collimation errors. The annual variations of these constants were given. Reductions are in progress and the chain method is in use.

Common Interests of Commissions 8 & 24, 25 November 1985, 1100 - 1230
Chairmen: W. Gliese and J. Hughes

The chairmen made brief introductory remarks emphasizing the need for close cooperation between the two commissions and pointing out that indeed many astronomers have dual memberships.

The discussion regarding the two "astrometric" meetings proposed for 1987 was continued. As a result of communications between the proposers, namely S. Debarbat (Paris) and G. Teleki (Belgrade), it was determined that the subject matter for these two meetings is distinct. The Paris meeting will have an Historical/Scientific thrust, concentrating on the heritage of the past including large scale catalogs as well as future directions. The Belgrade meeting, commemorating the 100th anniversary of the Belgrade Observatory, will concentrate on Fundamentals of Astrometry and indeed is so named. Current plans call for a spring 1987 meeting in Paris sponsored by Commissions 24 and 41; and a fall 1987 meeting in Belgrade sponsored by Commissions 8 and 19. Given the many new developments and initiatives in astrometry, it was held that these meetings are each appropriate, distinct and desirable.

The members of Commisssion 8 present voted without dissent to accept the two *Joint Discussion* I resolutions as written, and to forward them to the Resolutions Committee for submission to the GA. It was noted that Commissions 4 and 20 had deleted the section of the resolution on reference frames dealing with the duties of commissions, but Commission 8 members present did not accept this deletion. Members of Commission 24 had previously adopted the same position as Commission 8 in the matter. A resolution, proposed to Commission 8 by J. Kovalevsky and R. Reasenberg, concerning space and interferometric observations, was approved and forwarded to the Resolutions Committee. (**NB** See the list of resolutions as adopted by the GA.)

A discussion took place regarding the names and "duties" of the Commissions (8 and 24). It was generally agreed that both commissions should change their names. It

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was also apparent that it was good to discuss the matter jointly. Beyond this, however, a concensus did not emerge. Several suggestions and comments were made, many meeting with general approval, but no single idea was received with enthusiasm. It was finally noted by one of the chairmen (JH) that if the JDI resolution was adopted by the GA as written, i.e., as approved by Commissions 7, 8, 19, 24, 31, 33 and 40, and not as amended by commissions 4 and 20, then a forum would exist to discuss the matter in a much broader context. On this note the meeting adjourned.

Instrumentation and Techniques, 27 November 1985, 0900 - 1030
Chairman: C.A. Smith

A new Slit Micrometer for the CAMC on La Palma was described by L. Helmer. Its purpose is to achieve higher accuracy, a fainter limiting magnitude and to require less service. The slit plate is equipped with a linear encoder having a resolution, in x, of 1/4 micron, and the mounting is more rigid. Efficiency is maximized and a cooled, fixed Ga-As photocathode is introduced. Accuracy is expected to be better than 0".15 in both coordinates and the limiting magnitude should reach 14.5 to 15.

M. Yoshizawa of the Tokyo PMC reported that regular measurements of the instrumental constants have been made since May 1983. In addition to measuring the constants each day at midnight (24^h JST), several programs of more intensive measurements were also performed. Each program consists of continuous measurements lasting 2 to 5 days with a 0.5 to 1 hour interval between successive measurements. The standard deviation of a single measurement is typically about 0".05. The diurnal and annual variations of the constants are studied as a function of temperature or its rate of change with time. It was found that an optimal procedure to obtain the invididual constants during a tour of observations is to (1) measure the relative azimuth and the zero point of the divided circle once per 2 hours (or once per 1^oK change), (2) measure the level and collimation errors at least once per 6 hours (or once per 3^oK change), (3) measure the flexure at least once per day, and (4) measure the seasonal variation of the pivots and division errors of the circle. In the daytime, an increase in the frequency of measurement is strongly recommended.

Miyamoto described an annual variation of the graduation error of the Tokyo PMC. He stated that the fully automated meridian instrument enabled the determination of the graduation error of the circle within a few days. Frequent measurements of the error shows its annual change. The amplitude of the change in the circle error amounts to about 0".05 (the corresponding value in the diameter error is about 0".3), which may cause, in compiling an absolute catalogue, a systematic declination error depending on right ascension. In the classical graduated circle, the amount of the change is expected to be much larger, in general.

V. Abalakin read several reports starting with a description of the first version of the Axial Meridian Circle (AMC) being developed at Pulkovo by G.I. Pinigin, A.V. Sergeev and O.E. Shornikov. This instrument consists of a single, fixed horizontal telescope with the tube lying East/West. An optical device mounted in front of the telescope objective transfers the image of a transiting star into the telescope and permits the observation of a distant prime vertical mark. Thus one can directly measure the distance between the observed star and the mark. Provision is also made for auto-collimation measurements with the eyepiece micrometer. Among the advantages of such an instrument is freedom from errors caused by variation of the position of the eyepiece micrometer due to, e.g., pivot errors, temperature deformations, tube flexure, etc. The horizontal light path is minimized and circle errors do not double. It is believed that by careful use of appropriate materials the systematic errors will be about 0".02 - 0".03 in both coordinates.

A *Catalog of Absolute Declinations of Stars* as compiled from PVC Observations in the Southern Hemisphere by V.A. Naumov and A.A. Naumova was discussed by Abalakin. It contains 698 FK4, 691 PFKSZ and 35 GC stars, and is the result of observations

made at the Cerro Calan Observatory (Santiago) by five observers using the Zverev photographic vertical circle (PVC) during 1965-66. The reductions and scale derivation were described. Corrections for flexure, diameter errors and a dependence of zenith distance on photographic emulsion were determined and applied. The standard deviation is given by $(S.D.)^2 = (0''.27)^2 + (0''.20 \tan z)^2$.

The first observational results with the Sukharev Horizontal Meridian Circle (HMC) at Pulkovo were described in a paper writted by R.I. Gumerov, V.B. Kapkov, T.R. Kirian and G.I. Pinigin. Extensive measurements of circle diameter errors were made giving corrections with an accuracy of 0''.02. The circle is monitored by special rosette measurements of 6^o diameter errors. The reduction of 1300 observations (1981-83) of the declinations of 300 FK4 stars is completed and the error of one observation is 0''.20 sec z. The instrument appears stable with time and temperature and measures of the same star using the north and south tubes indicate that mirror deformations are small.

J.A. Hughes reported on the progress being made in the construction of the Mark III optical, phase coherent interferometer. A group, led by M. Shao, and involving SAO, MIT, NRL and USNO, is engaged in this effort. Construction on a site at Mt. Wilson Observatory is essentially complete. The instrument will use a 20m N/S baseline and somewhat shorter N/E and S/E baselines. The optical delay lines were designed and constructed at SAO and MIT, the siderostats at USNO. Tests of these and other components together with the associated software are underway. It is anticipated that first fringe tracking will occur in mid-1986. Preliminary stellar data from the Mark II instrument have been reduced and give a precision of about 1 arcsecond in large angle measurements. This was strictly a proof of principal effort however, and the refinements being incorporated in the Mark III will improve results by orders of magnitude.

T.J. Rafferty talked on the subject of *The Circle Scanning Systems and Glass Circles of the U.S. Naval Observatory*. Since 1970 the observatory has operated four different types of electronic circle scanning devices to determine the pointing position of its three transit circles. Most of the systems used a moving slide micrometer with a photoelectric diode as the detector. (Currently a CCD scanner, with no moving parts, is being tested.) During the same period, the observatory has replaced its engraved metal circles with glass circles. The improved precision of these devices, besides decreasing the error of measurements made with the transit circles, has revealed new areas of concern. Short term changes in the circles, apparently caused by temperature, have been found. (One of the circles shows such a large change over a short period that modelling is being used to apply diameter corrections.) Changes to a circle when it is rotated have also appeared and a new approach for monitoring and determining the diameter corrections has been developed.

Catalogs I, 27 November 1985, 1400 - 1530
Chairman: Y. Requieme

H. Schwan gave a survey concerning the process of improving a fundamental catalogue. Completed tasks are the derivation of corrections to the constants of general precession and the determination of the FK5 equinox and equator. The selection of new fundamental stars and the improvement of the individual and systematic accuracy are in progress. A description of the observational material and the new methods developed for the improvement of the FK4 and the preliminary FK5 system was presented. The basic FK5, providing improved positions and proper motions of the traditional fundamental stars, will be available in the course of 1986.

L. Helmer reported that the *Carlsberg Meridian Catalogue No. 1* has now been published. It contains the positions, in the FK4 system for the equinox J2000.0, and the proper motions and magnitudes, of 5,292 stars north of -45^o. These include 2,369 AGK3R, 1,296 SRS, 227 PZT and 838 faint reference stars around radio sources. The zenith

mean errors are: 0".193, 0".184, and $0^m.054$ in α, δ and V respectively. The mean error of a proper motion is typically 0".003/year and the limiting magnitude is 13.5. The catalogue also contains 857 observations of solar system objects. The total number of observations is 35,100 plus planets and FK4 stars (12,000 obs.), all obtained in the first eight months of 1984.

First results from the Tokyo PMC were described by M. Yoshizawa and M. Miyamoto. More than 10,000 observations of FK4 and other stars have been made with the Tokyo PMC in the period Nov. 1983 to Sep. 1985. The scanning time for one observation is 2 min. The reduction of part of those observations (Dec. 1984 to Sep. 1985) was made relative to the FK4 system. The mean error of a single 2 min. observation is given by: $\epsilon(\alpha) \cos \delta = 0^s.009$ (sec z ** $\beta 1$) and $\epsilon(\delta) = 0".14$ (sec z ** $\beta 2$), where $\beta 1$ and $\beta 2$ vary between 0.5 and 1.0. Preliminary results of an analysis of the declination dependence of the (O-C's) was also presented.

The *General Catalog of Faint Fundamental Stars* (FKSZ) has been compiled, according to a report by A.N. Kuryanova, D.D. Polozhentsev, A.D. Polozhentsev, Ya.S. Yatskiv and M.S. Zverev, as part of the KSZ-program (Zverev, 1951). Positions and proper motions are given for epochs near 1962 and 1947, respectively, of 931 faint stars ($7.3 < m < 8.4$) for both hemispheres. Seventeen catalogues in RA and 15 catalogues in DEC as well as the AGK3R and SRS programs contributed. The system is the FK4, the equinox and epoch 1950.0. The mean error of the mean positions is 0".050 in RA and 0".074 in DEC. The mean errors of the proper motions are 0".26 and 0".32 per century, respectively. The method of improving the proper motions and how the PFKSZ catalogue for the southern hemisphere was compiled were described.

A program of observations of 3 to 5 reference stars in the magnitude range of 7 to 9 in the vicinity of 87 radio sources was described by A.S. Kharin, P.F. Lazorenko and I.I. Kumkova and read by Ya. Yatskiv. This list contains 315 stars from $+90^\circ$ to -40°. Observations to -15° have been made at Goloseevo (VC) and at Kiev State University and Beograd (MC's). Up to 10 meridian instruments (Soviet Union) will be used in this program which will be referred to the system of FK4 (FK5). Meridian circles at Washington, Greenwich, Bordeaux, Tokyo, Uccle, Perth, and the Canary Islands are invited to participate. Star lists are available.

A *Belgrade Catalogue of 308 Polar Star Declinations* by M. Mijatou, G. Teleki and D.J. Bozhichkovich from observations with the Askania 190/2578 mm vertical circle was described by Teleki. A quasi-absolute method was used with observations from both instrumental positions. Each star was observed at least four times at both upper and lower culmination. The total number of observations per star is about 10. The internal accuracy was 0".33 and 0".39 for upper and lower culminations, respectively. Results will be sent to the Astronomisches Rechen-Institut and the Kiev University Observatory in December 1985, and will be published in 1986.

A paper on *The Problem of Classifying Modern Methods for the Determination of Right Ascensions* by S.A. Tolchelnikova-Murri, Pulkovo Observatory, was also read by Teleki. Several methods intended for the improvement of the right ascension system of FK4 were discussed. Suggestions were made to overcome difficulties in two commonly used methods of determining the absolute azimuth of a meridian circle.

The *Declinations and Proper Motions of 36 Belgrade Zenith Stars* as determined by R. Grujich and G. Teleki of the Astronomical Observatory, Belgrade, Yugoslavia, using the 111/1287 mm Askania ZT from 1960 to 1982 were reported by the latter author. Stars were observed from 18 to 189 times. Declinations and proper motions were computed using three models of the variation of latitude. The most accurate results were obtained using unsmoothed measurements of the variation of latitude made in Belgrade. The mean error in DEC is 0".27, and in the proper motion, 0".006 per year. Due to instrumental modifications and procedural changes a considerable improvement in accuracy has occurred. In the period 1960.0 to 1968.5, the mean

error was 0".294, while for the period 1969 to 1982, the mean error was 0".220.

The *Preliminary Results of Observations of Double Stars and Stars Near Radio Sources* made by S. Sadzakov and M. Dachich with the Belgrade Meridian Circle were described. Observations involve a list of 2,322 double stars in four zones from +60° to -20° with FK4 stars. The standard deviation in RA is 0^s.021, and in DEC is 0".31. Observations of 285 stars in the vicinity of 78 radio sources are also in progress in the zone +90° to -30°. There are 3 to 5 stars for each source. This program is about 60% completed; 2,452 transits registered. The double star program is 90% completed; 7,622 transits. The double star program should be completed in 1986 and the radio source program in 1987. Kustner series are regularly observed. About 20 series are observed per year, so that instrumental parameters are well known.

An analysis of systematic deviations of the well known *GCLS and AGK3 Catalogues* from 20 catalogues obtained from latitude observations was carried out by S. Sadzakov, Belgrade. Comparisons were made between the GCLS and AGK3 declinations and those in the individual latitude catalogues, at the epoch of the individual catalogs, with the GCLS transferred to the system of FK4. The differences were represented by 3rd order Fourier expansions in the right ascension. Tables of results were given.

Catalogs II, 27 November 1985, 1600 - 1730
Chairman: M. Miyamoto

C.A. Smith (Washington) reported on behalf of himself and L. Yagudin (Pulkovo) on the excellent progess made in the collaboration of the U.S. Naval and Pulkovo observatories on the compilation of the SRS catalog. The complete data base of SRS observations became available for the first time in 1984. About 482,000 observations of approximately 20,000 SRS and 900 FK4 stars from 12 transit circles are included. In many cases a further reduction to the system of the FK4 catalog beyond that already achieved by the individual participants was necessary. Preliminary mean errors of the mean positions in each coordinate are about 0.1 arcsec at the mean epoch of observation. An exchange of data bases between the U.S. Naval and Pulkovo observatories has been effected. Intercomparison of the two data bases has been completed, and has shown deficiencies in both which have since been overcome. The final stages of the collaboration will involve comparisons of outliers, of reductions to the FK4 system, of the two preliminary unweighted systems, and of the two weighted systems. If both the agreement between the Pulkovo and U.S. Naval observatories' systems and the distribution of differences for individual SRS are satisfactory, it is anticipated that an unweighted mean of the results from the two compilations will be recommended for general use.

G. Billaud described the results obtained with the CERGA Photoelectric Astrolabe while J. Kovalevsky described the work in progress at CERGA with the solar astrolabe by F. Laclare and A. Journet. Since 1983, the instrument observes the Sun at 8 different zenith distances between 30° and 60°. Normal points over one month of observation give an rms of 0".05 on the radius of the Sun. Corrections to the equinox that can be derived from these observations have an rms of 0".01.

F. Noel, on behalf of L.B.F. Clauzet (Brasil), described the basis for cooperative efforts towards a southern hemisphere astrolabe catalog involving instruments at Natal, Rio de Janeiro and Valinhos, in Brasil; San Juan, San Martin and Rio Grande, in Argentina; and Santiago, Chile. The catalog will cover 0° to -75° with Natal allowing a connection with the northern hemisphere. Recommendations agreed to at the *IV Regional Latin American Astronomical Meeting*, (Rio de Janeiro 12/84) were given regarding observation and reduction procedures, star lists and constants. Also, stations must ultimately be prepared to re-reduce data to the FK5 system, and observe planets and radio stars. Solar observations at Valinhos and Rio de

Janeiro must be continued. Agreements are sought to facilitate exchanges of personnel, and a working meeting is envisioned for 1986 in Brasil to finalize the procedures for the compilation of the general catalog which will contain some 1,000 stars.

A paper by Luo Ding-jiang (Beijing) concerning planned Photoelectric Astrolabe Observations was read. The international character of star catalogues was stressed, and determinations of the systematic errors of the FK4 by various instruments were compared. The main characteristics of the Mark III Photoelectric Astrolabe were listed including its 260/5000 mm optical system, the on-line PDP 11/23, and a photon counting technique reaching to 11-12 mag. Major planets are observable and almucantars at zenith distances of 30, 45 and/or 55 degrees are available. The many contributions which such an instrument can make were detailed including the improvement of the fundamental systems, extension of the same to fainter stars and various programs involving the optical counterparts of radio sources, radio stars and so on. Preliminary study has shown that two stations at $+40^{\circ}$ and $+25^{\circ}$ plus one or more in the southern hemisphere (including an assumed site near -42°) could produce 10,000 star positions as the first step of a complete program.

The work involved in determining *The Positions and Proper Motions of 4949 Geodetical Stars* pole to pole by E.V. Khrutskaya was described by V. Abalakin. The compilation of this catalog involved material from 17 catalogs in RA and 12 in DEC. The mean epochs are respectively 1967.74 and 1968.16. The number of catalogs contributing to a compiled position varies from 3 to 11. Weighted values of the observationally determined zonal systematic errors of the FK4 were determined. The catalog is given in the system of the FK4 and in the system of the FK4 as corrected by the weighted systematic error $\Delta\alpha(\delta)$. This will facilitate its use pending the arrival of the FK5. Errors are $0^{s}.003$ and $0''.10$ in RA and DEC, while the corresponding errors in the centennial proper motions are $0^{s}.008$ and $0''.11$ respectively. The new proper motions for the bright stars were used in statistical investigations which gave:

$$\Delta p = 1''.10 \pm 0''.07; \quad \Delta E = 1''.21 \pm 0''.07;$$

$$A/47.4 = 0''.34 \pm 0''.03; \quad B/47.4 = -0''.20 \pm 0''.02;$$

and a solar apex at:

$$A = 271^{\circ}.2 \pm 3^{\circ}.8, \quad D = 33^{\circ}.8 \pm 3^{\circ}.2$$

J. Dickey reported on work by her colleagues, O.J. Sovers, J.L. Fanselow, R.N. Treuhaft, K.M. Liewer, A.E. Niell and C.J. Jacobs on the *JPL 1985-1 Celestial Radio Reference Frame*. Dual frequency, VLBI observations during the past seven years have yielded an extragalactic radio source catalog containing 137 sources uniformly distributed north of -40° declination. The positional uncertainties are of the order of a few milliarcseconds, and 38 sources have declination uncertainties smaller than 1 mas. Positions of sources that are also monitored by the East Coast VLBI group agree well with their results. The VLBI solution also indicates a need for slight revisions of the IAU 1980 precession and nutation constants.

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