

## COMMISSION No. 8

### POSITIONAL ASTRONOMY (ASTRONOMIE DE POSITION)

PRESIDENT : Y. Requième

VICE-PRESIDENT : M. Miyamoto

ORGANIZING COMMITTEE : P. Benevides-Soares, D.P. Duma, L. Helmer, J. Hughes, L. Lindegren, Luo Ding-Jiang, F. Noël, G.I. Pinigin, L. Quijano, S. Sadzakov, H. Schwan, C.A. Smith, M. Yoshizawa.

Prior to Commission 8 meetings the Joint Meeting "For milliarcsecond or better accuracy" was held on August 3 including Commissions 4, 7, 8, 19, 24, 31 and 40. (Chairman : K. Seidelmann). The proceedings will be published elsewhere.

#### **Business meeting, 4 August 1988**

**Chairman : Y. Requième**

The President welcomed members in attendance and asked for a moment of silence in memory of four Commission members : W. Fricke, J. Larink, W.H. Robertson, G. Teleki who passed away since the last General Assembly.

The Commission unanimously approved the election of the new President, M. Miyamoto, and Vice-President, L.V. Morrison. The results of the election of the new Organizing Committee were also accepted. The members of the O.C. are : P. Benevides, D.P. Duma, L. Helmer, J. Hughes, Hu Ning-Sheng, J. Kovalevsky, L. Lindegren, F. Noël, G. Pinigin, Y. Requième (ex-officio), H. Schwan, C.A. Smith, M. Yoshizawa.

The following were approved as new members of the Commission : M. Lattanzi, J. Muiños, K. Nakajima, I. Pakvor, M. Soma, C. Turon-Lacarrière, F. Van Leeuwen. In the following days, M. Catalan, M. Lehman, G. Pizzichini, T.A. Spelstra and G. Westerhout applied for membership and were announced to the General Secretary.

Since the last General Assembly S. Lautsen, W. Gliese and T. Dambara have resigned.

The list of consultants was reviewed and approved : C. Cole, M. Dachich, K.R. Joschi, G. Kaplan, T. Rafferty and K. Steinert.

#### SRS Committee

The final report of the SRS Committee prepared by J. Hughes, D.D. Polojentsev, C.A. Smith and L. Yagudin was presented by C.A. Smith. The work on the compilation of the Southern Reference Star catalog undertaken jointly by the Pulkovo and the U.S. Naval Observatory is completed. A catalog of 20 488 positions, referred without proper motions to the FK4 system and the equinox and equator of B1950.0 at the mean epoch of observation, has been produced. This catalog has also been transformed to the FK5-J2000 basis and is available with approximate, preliminary proper motions for the convenience of the user.

The final SRS catalog was compiled from a combination of the Pulkovo and Washington preliminary catalogs with equal weights. However regional deviations between these catalogs led to bring the Pulkovo right ascension system closer to the FK4 system by reducing it to the Washington right ascension system. The declination systems of the preliminary SRS catalogs were in excellent systematic agreement.

The average mean error of the right ascensions at the mean epoch of observation is 0.07 arcsec. The corresponding value for the declinations is 0.10 arcsec. Preparation of a full description of the compilation procedures is in progress. It will be included with the publication of the S.R.S. catalog data.

On behalf of the astrometric community the President thanked the members of the S.R.S. Committee for efficient work and declared the activities of this Committee closed.

#### Star List Working Group

Members are G. Carrasco, T.E. Corbin, L. Helmer, M. Miyamoto, D.D. Polojentsev and Y. Requième. Two new members were proposed : S. Roeser and Luo Ding-Jiang. T.E. Corbin was proposed and accepted to act as chairman of this W.G.

During the last triennium the Pulkovo Observatory proposed the observation of 6 000 bright stars, 2 500 double stars and 1 500 reference stars near radiosources.

The urgent need of a re-observation of the I.R.S. was once more stressed. It was noted that 97 % of the I.R.S. stars have been accepted in the Hipparcos Input Catalog (including the supplement proposed by T.E. Corbin).

L. Helmer and L.V. Morrison have prepared a candidate list for a faint extension of the fundamental reference frame, to be observed by automatic meridian circles (or possibly astrolabes).

#### Horizontal Meridian Circle Study Group

No member of this group was participating in the General Assembly. So the President reviewed briefly progress reported by the members : axial automatic meridian circles under development at Nikolaev and Kiev (Pinigin et al., Lazarenko et al.), regular observations of the Pulkovo automatic horizontal meridian circle (Naumov, Gumerov and Pinigin), construction of a new automatic horizontal instrument at Pulkovo from an agreement between Pulkovo, Kiev, Nikolaev and Kazan. Furthermore the construction of the Danish-Chinese horizontal glass meridian circle is progressing satisfactorily.

#### Working Group on Astronomical Refraction

J. Hughes was confirmed as chairman. The important event of this triennium was the International Workshop on Astronomical Refraction held at Belgrade on September 1987 in memoriam to George Teleki where met 75 participants. (Publication of the Belgrade Astronomical Observatory.) The main topics were : refraction corrections in radioastronomy, ray tracing, meteorological information, refraction tables, measurements of refraction and flexure, corrections for ionosphere on VLBI observations, and terrestrial measurements. J. Hughes also stressed development of the two colour methods, studies on chromatic refraction and clarification of the concept of local pure refraction. At last he presented some figures showing the importance of the local refraction around the U.S. Naval Observatory.

#### Astrolabe Working Group

The report on activities was presented by S. Débarbat, interim chairman, on behalf of G. Billaud.

Most of the existing astrolabes in the world have actively participated in the MERIT campaign for the astronomical determination of the Earth rotation parameters by star observations relative to the local vertical. They were shown to be among the best classical instruments for such determinations.

Due to the changes which occurred at the beginning of this year for ERP, a large number of astrolabes have moved their activities to catalog observations (Argentina, Brasil, Chile, China, Spain). The results of these individual catalogs will have to be compared with the Hipparcos Output Catalog. Such a comparison will allow the determination of the systematic errors before a new "Catalogue Général d'Astrolabes" (CGA) is established. This new CGA will be of higher quality ; it will be possible to use it to improve the proper motions and ensure the durability of the Hipparcos reference system.

Furthermore the combination of results from solar and stellar observations will, in the future, permit absolute catalogs to be formed in right ascension.

In order to extend the benefit of the Hipparcos results and, perhaps, in some cases, to improve them, the quality of the astrolabes must be increased as much as possible and this will be done if they are completely automated. Two large photoelectric astrolabes (26 cm) are in the process of final adjustment in China and in France, the CERGA photoelectric astrolabe is now in full automatic operation.

Important projects were stressed :

- a) Close cooperation of the different astrolabes in order to obtain the best from their zonal observations (including Sun, planets and radiostar measurements).
- b) Organization of one or two chains of measures to connect the northern and southern hemispheres (for exemple China, Latin America, Europe).

After the official report S. Débarbat read a few personal words of G. Billaud : "In reason of my imminent retirement, I decided to resign from chairmanship of the Astrolabe Working Group. But I would not forget to express thanks to all those who, during the last fifteen years, have collaborated with the W.G. For my part I have had the uncommon pleasure of performing a task which I greatly enjoyed with persons whom I highly esteemed".

H. Schwan emphasized that the astrolabe catalogs have been integrated in the FK5 with a very high weight.

In the following day members of the W.G. participated in a meeting initiated by S. Débarbat. F. Chollet (France) was designated as the new chairman and the general organization of the W.G. was discussed.

#### Discussion of Resolutions

The recommendations included in the report of the W.G. on Reference Frames (given during the Joint Meeting JCM1 on August 3) were proposed as resolutions by J. Hughes and discussed one after the other. The different resolutions were adopted with modifications. A. Murray and Y. Requième met afterwards with K. Seidelmann in order to reconcile the modifications suggested by the involved commissions before final adoption by the Resolution Committee.

A proposal of joint resolution with Commission 12, recommending that long-term ground-based astrometric observations of the Sun by transit instruments and astrolabes should be associated with programs of solar diameter monitoring, was accepted by our Commission but finally rejected by Commission 12.

Y. Requième and C. Turon reported on the Hipparcos Input Catalog which will be published by 1990 with in addition a complementary catalog containing the proposed stars not accepted for the Hipparcos mission for different technical reasons. Concerning the Input Catalog it was stressed that the number of accepted faint stars  $11 < V < 13$  is only 1 600, showing the interest of the faint reference frame proposed by L. Helmer for ground-based observations. As to the complementary catalog, about 20 000 stars have an high astrometric interest (IRS, planetary and lunar occultations, minor planet crossing points) and 32 000 are high priority stars of astrophysical interest (variable stars, O-B stars, F stars for galactic structure, red dwarfs, halo stars). After calibration of the instrumental errors of the automatic meridian circles and astrolabes by using the Hipparcos Output Catalog, an accuracy of 0.02"-0.04" is expected for these ground-based instruments which could be used for observation of this complementary catalog. Using old catalogs including Astrographic Catalog proper motions could be derived with an accuracy of 0.003"/year.

**Astrolabes, 5 August 1988**  
**Chairman : H. Schwan**

P. Benevides reviewed the method of Krejcin for obtaining absolute declinations at two different zenith distances at a given site. In collaboration with L.B.F. Clauzet he applied that method to 3 years of observations made with the Valinhos astrolabe for zenith distances 30° and 45°. Absolute corrections to the declinations of 28 FK4 stars were given with a mean error of 0.30". Uncertainties are due, to a large extent, to remaining magnitude and color effects. A full pupil photoelectric astrolabe could yield in principle 3 to 4 times better accuracy.

F. Chollet described the modified astrolabe of Paris Observatory and its current program. The stability and the possibilities of the instrument have been improved, especially by using a Zerodur prism ; it is possible to observe stars (limiting magnitude 6.5), planets and the Sun in a declination zone up to 120°. The same type of instrument is under development at Santiago, but could be also installed in the long term in Turkey, Algeria and possibly Morocco.

Some last results of the Danjon astrolabe at Santiago were given by F. Noël. Observations of Mars, Jupiter, Saturn and Uranus are in progress. For Uranus an offset between the astrolabe and the ephemerides of roughly -0.3" was found in right ascension. (A quite similar value was obtained at Bordeaux.) Observations of  $\alpha$ SCO-A and 9 SGR were also presented. The Santiago astrolabe will be modified : the quartz prism will be replaced by cervit angles in order to stabilize the instrumental zenith distance and to make possible observations at  $z = 30^\circ$  and  $z = 60^\circ$ .

A. Poma reviewed the Cagliari and Merate astrolabe catalogs. Both programs consist of 11 groups with 237 FK4 stars at Cagliari and 198 at Merate. The average error of the residuals (after applying the group corrections) is about 0.05"-0.08". Preliminary results show no significant magnitude and spectral type correction.

S. Débarbat presented a paper of F. Laclare on the astrolabe observations of the Sun. Using different reflecting prisms on a more elaborated astrolabe, observations at 10 different zenith distances are now possible. The mean error is 0.3" to 0.4" according to the zenith distance. In addition the diameter of the Sun is regularly measured (up to 40 determinations per day) ; the mean value obtained by Laclare from 2 700 measurements (1975-1987) is 959.45". Journet obtained with the same instrument from 1 200 measurements 959.03" (1984-1987). Variations of the diameter were clearly detected with periodicity of 10 years, 970 days, 330, 220, 75 and 50 days. A new prototype of automatic solar astrolabe is in service at CERGA, with CCD measurements and Zerodur reflecting prism of variable angle. Astrolabe observers are encouraged to modify theirs instruments to monitor the solar diameter variations.

**Galactic reference frame and catalogs, 5 August 1988**  
**Chairman : M. Miyamoto**

H. Schwan reported on the "basic FK5" and its extension to new bright and faint fundamental stars. A tape version of the basic FK5, giving mean positions, proper motions, mean epochs and mean errors for the classical 1 535 fundamental stars, has been generated and is distributed on request. The printed version of the catalog is in preparation. Systematic and individual corrections to the FK4 have been derived.

Mean positions and proper motions for the bright FK4 Sup. stars (5.5 to 7.0) were derived at Heidelberg on the basis of about 125 catalogs of observations made since 1900. The precision of the proper motion (0.15"/cy and 0.18"/cy in right ascension and declination) is comparable to the FK4 one. A tape version for this "Bright extension" (980 FK4 Sup. stars in the FK5 system) has been generated and is also available on request.

The extension of the FK5 to fainter magnitudes is being made jointly with the U.S. Naval Observatory. Within his work of determining proper motions for all the IRS stars, T. Corbin is selecting about 2 000 new faint fundamental stars in the magnitude range 6.5 to 9.5. The selection in the AGK3R stars has been completed, the work on the southern part (SRS) is in progress.

T.E. Corbin presented a progress report on the compilation of the SRS proper motion catalog (after the completion of the final SRS position catalog). Since the poor observational histories of these stars made it impossible to compile a system south of  $-30^\circ$  from catalogs referred directly to the FK4, the Greenwich transit circle series was used in the north to study the behavior of magnitude equation with declination. No significant variation was found for the traveling wire micrometers whereas this was not true for the fixed wire variety. Next a system of mean positions and motions, with good results north of  $-30^\circ$ , was formed by combining data from catalogs observed with screens. The magnitude equation study was then used to bring the Cape observations made after 1915 into this system to extend south of  $-30^\circ$  with a total of 3 890 stars. The mean errors of the proper motions in this extended system are  $\pm 0.35$ "/cy and  $\pm 0.38$ "/cy in right ascension and declination. Currently this system is being used to reduce the Cordoba and La Plata series, and finally all other southern catalogs that can contribute to the SRS proper motions.

L. Helmer presented a candidate catalog for faint extension to the fundamental reference frame, which could be most useful for photographic work. The faint stars ( $m_v = 11.5 - 12.0$ ) have been selected at Copenhagen University Observatory with a mean density of one per square degree from three zones of the Astrogaphic Catalog : 1 488 in the Greenwich zone, 9 180 in the French zone and 1 630 in the Vatican zone. In the Northern remaining zones, selection is in progress. In addition 6 452 faint AGK3 stars have been selected. The positions are brought on the FK5 system and proper motions are derived where possible. The candidate list is proposed for reobserving on automatic meridian circles.

R. Wielen described the work started at Heidelberg (A.R.I.) to collect all available astrometric data on positions and proper motions of stars in a computerized data bank, called ARIGPH. All relevant astrometric observations since Bradley (1750) will be put into machine-readable form and reduced to a common system (FK5, then Hipparcos). From this unprecedented data base the A.R.I. intends to derive positions and proper motions in a way which makes best use of all the observational information obtained over more than 200 years. The final catalog, called ARIGC, should have utmost accuracy for all sufficiently well-observed stars.

M. Yoshizawa presented the second annual catalog Tokyo PMC 86 (3 873 stars observed at least two times) based on the FK5 system. The construction of the catalog was made in the classical night-to-night reduction mode and also in a global adjustment mode. The systematic trends obtained from the observed (O-C)'s for the FK5 stars confirm that a systematic error  $\Delta\delta\delta$  of about 0.1 arcsec still exists in the new basic FK5 (as already found at Bordeaux and La Palma) in the zone  $+40^\circ < \delta < +60^\circ$ .

P. Benevides described an iterative solution of singular least squares problems. With R. Teixeira he applied the overlapping method to the differential reduction of right ascensions obtained by meridian circles. The algorithm was shown to display linear convergence, even if the original coefficient matrix is rank deficient, when the final limit will be dependent on the starting iterate. The corresponding procedure for any general least-squares problem was outlined.

**Common interests of Commissions 8 and 24, 6 August 1988**  
**Chairmen : A. Uppgren and Y. Requième**

Y. Requième introduced a general discussion regarding the names and objectives of the Commissions 8 and 24. The present name of Commission 8 "Positional Astronomy" appears somewhat vague and could be depreciated by other colleagues insofar as it does not reflect clearly the main scientific objective of our commission which is in fact the construction of a galactic reference system. Taking into account the importance given to the problems of frames during the last general assemblies, it was suggested to change for "Stellar (or galactic) reference frame". It was also agreed that Commission 24 should change its name, but the only proposal was "Astrometry", which appeared too strongly similar to "Positional Astronomy". At this point, A. Murray raised the question of a possible merging of our both commissions. After a long discussion Y. Requième called for an informal vote, and the proposal was rejected by 19 votes to 15 and 7 abstentions (many other members did not express their opinion). Finally a consensus was not found about renaming of the commissions.

Furthermore it was pointed out that Commissions 19 and 31 were very active in the domain of the reference frames and could integrate it in their own objectives. M. Feissel confirmed that the subject had been discussed in their last meeting. As a matter of fact the extragalactic reference frame is become one of the main objectives of the Commission 19 but the whole domain of Reference systems is not well covered by any commission. The idea of a permanent Joint Working Group appears as the best solution. Finally it was recommended that "the Working Group on Reference Systems (WGRS) be continued as an intercommission project and that it concern itself with nutation, astronomical constants, origins, reference frames and time" (see Resolution C2).

Seven scientific papers were presented after that discussion. As they rather related to the Commission 24 objectives, the abstracts are to be found in the report of that commission.

**Link between reference frames, 8 August 1988**  
**Chairman : J. Hughes**

K. Johnston presented a joint five year program to establish a radio-optical reference frame based upon extragalactic radiosources. The primary catalog includes 400 well distributed objects with no extended radio and optical structure ( $z > 0.8$ ), observations were started in 1987. The radiopositions are obtained by VLBI Mark III S/X measurements. The expected accuracy is 1-3 mas for  $\delta > -30^\circ$  and 10 mas for  $\delta < -30^\circ$ . The optical positions will be obtained from astrographs (Hamburg, USNO) and prime focus plates on 4 m class telescopes. In addition J. Russell detailed the recent radio observations of the N.R.L. aimed at establishing a global radio reference frame.

C. Ma reported on the GSFC catalog, including 182 extragalactic radiosources. Positions were obtained with formal errors less than 1 mas from 237 681 pairs of Mark III VLBI group delay and phase delay rate observations divided into 600 data sets from 1979 to 1988. The sources are distributed fairly evenly above  $-30^\circ$  with 68 sources in the Southern hemisphere. Analysis under different conditions and external compa-

of La Palma (latitude N 28°75'). Since then 3 annual catalogs containing 35 000 stars and 5 000 observations of solar system objects have been published. The continuing program is divided into 5 parts :

- a) Optical reference frame  
FK5, IRS (+90 to -45), faint extension ( $V = 11-12$ , 1 star per square degree, see report of L. Helmer above), 1 500 Hipparcos stars, PZT zones. About 65 % of the IRS has been completed and observation of the faint extension has just started.
- b) Linking optical and radio reference frames  
Faint reference stars in extragalactic radio fields (about half complete), radio-stars and Hipparcos link stars in extragalactic fields.
- c) Stellar kinematics  
Six lists of about 20 000 stars, selected by spectral type and luminosity class for improvement of proper motions.
- d) Solar system  
Mars, Callisto (+ Europa in future), Titan (+ Iapetus), Uranus, Neptune (+ Triton), (Pluto), 59 minor planets in Hipparcos list.
- e) Monitoring variable stars  
RS CVn, etc.

G. Kaplan presented the program to be observed by the Mount Wilson optical interferometer (see below J. Hughes et al.).

M. Miyamoto (with M. Soma) talked on a proposal of faint minor planets for improving the fundamental reference system. In a problem to link the stellar reference frame (FK5) with the dynamical one, they have simulated the accuracy in deriving the equinox correction  $\Delta E$ , the equator correction  $\Delta D$ , the obliquity correction  $\Delta \epsilon$ , and the longitude correction  $\Delta \lambda$  from the observations of some minor planets. The orbital calculations of these minor planets are based on the planetary ephemeris DE200.

If they rely upon the meridian observation for the brightest four minor planets, it takes over 15 years to determine the equinox correction  $\Delta E$ , for example, with the accuracy of  $\pm 0.05''$  level. On the other hand, it is shown that if they can observe the faint three minor planets (Nos. 1620, 2100 and 3103) with the orbital period shorter than 2 years by a combination of the meridian observation with the photographic astrometry, then the accuracy of the determination of  $\Delta E$  attains  $\pm 0.04''$  level within the observational period of 3 years. Thus, the combination of the meridian observation with the photographic astrometry for faint minor planets with short orbital periods would increase remarkably the observational efficiency.

A paper of D.P. Duma and Yu. N. Ivaschenko was read by Ya. Yatskiv, describing a method for determining the relative orientation between radio and optical reference frames on the basis of non-synchronous observations of artificial satellites in both radio and optical wavelength ranges. For its realization it is sufficient to observe an artificial satellite with respect to both systems during the same period of time. If the instrumental errors of the observations are negligible, it is possible, after having calculated the orbital elements of the satellite, to obtain the three angles P, Q and R of the relative orientation between the radio and optical systems. Positions of a geostationary satellite with a special photo-cassette mounted on a Zeiss double wide-angle astrograph ( $F = 2$  m,  $d = 40$  cm) and time registration ( $\pm 2.5$  ms) have been obtained with a precision of  $\pm 0.3''$ . Taking that error on the satellite positions and a number of positions equal to 72, the corresponding errors on P, Q, R are respectively  $0.07''$ ,  $0.06''$  and  $0.10''$ .

Another paper was read on proper motions of double stars determined at Belgrade. S. Sadzakov and M. Dacich have observed with the Askania meridian circle 1 611 double stars not suitable for any photographic or photoelectric observations (small separation). Using the AGK2 as first epoch, proper motions were derived.

rison indicate that the reference frame defined by the radio source catalog should be reliable at the 1 mas level.

A preliminary comparison of the optical and radio reference frames based upon VLA and optical positions of 40 radiostars (mainly in the Northern hemisphere) was given by De Vegt. Optical positions are photographic and based upon AGK3RN and SRS catalogs which have been transformed to FK5 using the tables as provided by ARI. Most positions agree within 0.1 arcsec, regional deviations of the same amplitude are indicated.

A paper of Luo Ding-Jiang and Peng Yizhi was read reporting the measurements of 24 radiostars by the Beijing photoelectric astrolabe Mark II with a mean precision of 0.05". This observing program will be continued, not only at Beijing but also at Shaanxi, Shanghai and Yunnan.

L.V. Morrison showed that the optical reference systems of the Carlsberg automatic meridian circle and the Bordeaux meridian circle were very similar and were in fact a smoothed version of the FK5. Comparison of 19 CAMC and 17 Bordeaux optical positions of radiostars (obtained in these systems) with VLA and VLBI radio positions showed clearly that 54 CAM has an offset in R.A. of 0.5 arcsec. There is no clear evidence of any other offsets greater than 0.2 arcsec.

#### Observing programs, 8 August 1988 Chairman : P. Benevides

T.E. Corbin presented the Pole-to-pole observing program involving the USNO's Six-Inch transit circle (Washington) and Seven-Inch transit circle (Black Birch, NZ) commenced in the Northern hemisphere in September 1985 and in the Southern hemisphere in June 1987. The program is being conducted in both fundamental and differential modes. The differential observing involves IRS (AGK3R + SRS stars) each night in zones 15° to 25° wide with FK5 stars extending 5° beyond each zone's boundaries. The fundamental observations involve observing each night : FK5 stars in Kustner lists, radio stars, Solar system objects and a fundamental azimuth during the period from the autumnal equinox to the vernal equinox. The day observations include : the Sun, Mercury, Venus, day stars to  $m=3.1$  with the Six-Inch and to  $m=5.2$  with the Seven-Inch and daytime azimuth stars with the Seven-Inch. Most Seven-Inch day tours have sufficient data to be reduced independently thus giving an unprecedented direct link between the daytime Solar system objects and the stellar frame. Mars is observed day or night with both instruments. Thus far 45 000 observations of IRS have been made with the Six-Inch and 12 000 observations with the Seven-Inch. The two instruments together have also made the following : 64 000 observations of FK5 stars, 6 500 observations of day stars and 4 700 observations of Solar system objects. The mean errors of a single fundamental observation are :  $\pm 0.21''$  in RA and  $\pm 0.22''$  in Dec for the Six-Inch and  $\pm 0.20''$  in RA and  $\pm 0.25''$  in Dec for the Seven-Inch. The higher value for the Seven-Inch declinations reflects the fact that the instrument is at a new site and some atmospheric parameters have not yet been modeled. In addition, a definitive value of the flexure has not been adopted. The differential observations of the IRS show external mean errors of  $\pm 0.15''$  in RA and  $\pm 0.16''$  in Dec for the Six-Inch. The Seven-Inch does not yet have sufficient IRS data to determine this quantity. The Eight Inch transit circle in Flagstaff has for the past five years participated in special differential programs such as the Halley Reference Stars, the Radio Source Reference Stars, Radio Stars and requests for observations of objects of astrophysical interest. This instrument will cease operation on September 1, 1988 and the USNO's participation in the observation of the primary RSRS will be terminated.

L.V. Morrison (with L. Helmer and M. Catalan) reported about the observational program of the Carlsberg automatic meridian circle commenced in May 1984 on the island

**Space and ground-based instrumentation, 8 August 1988**  
**Chairman : L.V. Morrison**

P. Hemenway reviewed the principles of the interferometric fine guidance sensors of the Hubble Space Telescope. The standard astrometric modes of position, moving target and transfer position were presented. The overall verification plan, from the engineering "orbital verification" (2 months) through "science verification" (calibration of parameters such as field distortions) and the initial "guaranteed time observations" (5 months) as well as the planned astrometric tests, were described.

A. and M. Meinel reported on the project "Thousand Astronomical Unit mission" (TAU). The JPL study of an astrometric spacecraft mission that would provide a baseline of 1 000 AU (TAU) after a cruise of 50 years is continuing under JPL and NASA support. This study has identified 1) the need for earlier astrometric satellites, and 2) the need for a QSO reference system. The earlier missions would be desirable both to extend the current range of parallaxes and to demonstrate the several orders of magnitude improved precision of new techniques. If TAU were limited to current astrometric precision of 1 mas, a baseline of 1 000 AU would yield precision parallaxes out to 50 to 100 kpc. Improvement to 1.0 arcsec (potentially possible with a space interferometer) would permit parallax measurements from Earth-orbiting satellites to be increased to distances of 100 to 200 kpc. With this same precision TAU could yield parallaxes to distances of 50 to 100 Mpc. The JPL study emphasizes the need for increased funding for development and demonstration of advanced astrometric techniques.

J. Kovalevsky presented a progress report on the Hipparcos European satellite to be launched by June 1989. Environmental tests of the flight model satellite are now achieved and have confirmed that the initial accuracy specifications will be kept. The satellite is currently in storage configuration until reactivation commences by the end of this year. The different steps of the data processing and sphere reconstruction were detailed. The results obtained from simulations by both consortia FAST and NDAC are convergent. Furthermore work of the TYCHO Consortium is progressing satisfactorily.

J. Hughes described progress in the design of the USNO Astrometric optical interferometer. The main objectives are limiting magnitude at least equal to 10 (brighter quasars as an ultimate goal), multiple baselines (at least two, orthogonal, 15-20 m), real-time metrology, two-colour work, sky coverage 120°. The preliminary design includes :

- a) 1.25m siderostats with air-bearings and laser metrology on pier invar reference ;
- b) Beam collapsers (1 m, F/2 parabolas) tilted, giving output beams 7-10 cm ;
- c) Vacuum pipe from piers to delay lines and for delay line themselves ;
- d) Dispersed fringe detector : fiber optic lines from the combined beams to the spectrometer associated with a PAPA photon camera.

L. Helmer presented the first results obtained with the new moving slit micrometer mounted on the Carlsberg automatic meridian circle at La Palma in March 1988. The micrometer has been used during three months on an enhanced observing program including some very faint stars of magnitude 13.0 - 15.0. The preliminary results show that the positional accuracy has been improved by about 0.06 second of arc, giving a zenith mean error of  $\pm 0.12''$  in both right ascension and declination. The limiting magnitude of the instrument was proved to be 15.0.

G. Carrasco described the modernization of the Repsold meridian circle at Cerro-Calán. The construction of an electronic chronograph, a new system of contact and the automatic drive of the observations, for the improvement of the RA observations, are already finished. For the Dec. observations, the automatic reading of the micrometer screw was completed and the installation of eight Reticon RL512G for the circle reading is in progress. The registration of the meteorological parameters and the setting

of the telescope will be automatized, using a microcomputer. The re-observation of the Santiago 67 catalog are started.

A paper of G.I. Pinigin was presented by V. Abalakin on the capabilities of a meridian circle with the horizontal design (HMC). The Pulkovo HMC, in regular operation since 1986, is equipped with automatic setting (accuracy 2" obtained in 15 seconds) and automatic divided circle readings (0.02" with 4 microscopes in 12 seconds). The star transits are measured by active slit micrometers mounted on the fixed collimators. The two-side metallic mirror is monolithic with the rotation axis, giving very small flexure and collimation variation (pivot error 0.1  $\mu$ ). The vertical temperature gradient in the horizontal tubes was eliminated by forced ventilation between the inner and outer tubes. Seasonal and other azimuth variations did not exceed 0.4" for two years. The standard errors are  $\pm 0^s.011$  sec  $\delta$  in RA and  $\pm 0^s.20$  sec  $z$  in Dec. up to  $m = 11$ . The second generation HMC will have an improved mirror and horizontal tubes with increased focal length, aiming to obtain star coordinates with an accuracy of 0.02"- 0.03" up to  $m = 12-13$ .