

## COMMISSION 8: ASTROMETRY (ASTROMETRIE)

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### 1. Introduction

Current Commission 8 is a merger of the former Commission 8, Positional Astronomy, and Commission 24, Photographic Astrometry (XXIV General Assembly of the IAU in 2000; Manchester, UK). The scope of scientific interests of 210 Commission members is as follows:

- instrumentation and reduction techniques (astrometric and photometric), including digitization and image reconstruction
- various ground-based observing programs (on positions and proper motions, parallaxes, binary stars, asteroids, etc.), astrometric catalogues, and compilations of databases
- reference system: maintenance and extension of the extragalactic reference frame and Hipparcos reference frame; links between various reference frames
- space astrometry including the post-Hipparcos global space astrometry and photometry: forthcoming space missions GAIA, DIVA, FAME; narrow-field space astrometry with SIM
- applications of astrometric parameters for astrophysical and kinematic studies, such as studies of open and globular clusters, galactic rotation, solar motion, kinematics of various stellar populations, galactic evolution, the Magellanic Clouds, high redshift QSOs, multi-wavelength cross-identifications, etc.
- relativistic astrometry, including gravitational lensing, time scale etc.

The research activities of Commission 8 during July 1, 1999-June 30, 2002 are presented in this report.

### 2. Scientific Highlights

In the wake of success of the Hipparcos mission – first space astrometric satellite – and the release of the Hipparcos and Tycho Catalogues, many astronomers are involved in the preparation of second-generation astrometric satellites to achieve the micro-arcsecond precision. In the last three years a great progress has been made in such active space astrometry programmes as DIVA, GAIA, SIM and FAME.

At the same time it is necessary to continue ground-based observations of a wide variety of objects such as the low-luminosity stars (M, L, and T dwarfs, white dwarfs, and brown dwarf candidates), the optical counterparts of radio extragalactic sources, many of which are too faint to be observed with the planned space instrumentation. Another class of objects include double and multiple stars with longer periods than the limited lifetime of a space

mission. The observations of planetary satellites, asteroids and comets – especially the Near-Earth Objects (NEO) have received a strong support at both, international and national levels and are very well coordinated. The studies of cluster kinematics and dynamics greatly benefit from accurate proper motions of a large number of stars. Under the auspices of the IAU working group "The Future Development of Ground-Based Astrometry", this kind of research is well organized and already has yielded several large catalogues, e.g., preliminary UCAC1 catalog, double star catalogues, etc.

### 3. Instrumentation and Reduction Methods

ARGENTINA. López at San Juan reports that in collaboration with Spain the San Fernando automatic meridian circle (CMASF) located at El Leoncito was equipped with a CCD camera in December 1999 and the observations of the southern sky survey in the range  $+10^\circ > \delta > -60^\circ$  were begun. At present, 30% of the survey has been completed. In parallel to the survey, some zones containing astronomical and astrophysically interesting objects have been observed. A regular campaign of observations of planets, their natural satellites, and minor planets has started in 2001. The photoelectric astrolabe (PA II) is continuing observations. The satellite laser ranging facility provided by the Chinese institutions will start observations by the end of 2002. In collaboration with Yale University a new system of two CCD cameras was put on the double astrograph at El Leoncito in March 2000 to resume the observation of the second epoch of SPM and began a NEO follow-up program. Up to now, more than two thousand positions of minor planets (NEOs and main belt objects) and comets have been reported to the Minor Planet Center (López 2000, 2001, 2002). In order to be able to observe fainter asteroids, the 2.15-m telescope has also been used.

The digitization of AC and other plates (exposed between 1910 and 1930) at Córdoba and La Plata observatories is now being developed.

Numerical simulations of the block adjustment method using small CCD fields from a long focus reflector show that without any kind of instrumental errors, the errors in measured positions introduced by the method do not exceed 0.1 mas. The positional accuracy in a 25' square field covered by 16 CCD frames is expected to be 0".12 with moderate optical distortion. The proper-motion accuracy is expected to be  $\sim 4 - 5$  mas/yr by combining recent positional observations accurate to 0".2 and those from the CdC plates accurate to 0".3 (Bustos Fierro et al. 2000).

BRAZIL. Andrei at Rio de Janeiro reports that astrometric observations have been made with the following 5 instruments: 0.60m and 1.60m telescopes for ICRF quasars and local reference frame stars, and to establish the UCAC-S catalogue orientation relative to the ICRS; CCD meridian circle for proper motion programmes, astrometric quasars, radio stars, open clusters, and low extinction regions in the direction of the Galactic center; photoelectric astrolabe for selected stars and Solar astrolabes for monitoring variations of the Solar diameter. A coronagraph for planetary observations and a new instrument for monitoring the solar diameter variations are being developed in cooperation with the CERGA (France).

CHINA(PR). Jin at Shanghai reports that some instrumental improvements have been implemented on the Low latitude meridian circle such as a reticon for reading the circle, axial and azimuthal collimators, electronic level, PC control of observations. The science grade CCD detector will be installed soon (Yang et al. 2000). The average precision of observations recorded in 2000 is  $\pm 50$  mas in RA and  $\pm 49$  mas in Dec (Wang et al. 2002). Two out of four Chinese photoelectric astrolabes are continuously working at Yunnan Observatory and San Juan (Argentina) to obtain precise positions of radio stars and to study the relationship between anomalous residuals of time and latitude and earthquakes (Hu et al. 1999).

Image restoration is a way to remove the influence of tracking error in the astrometric CCD images. The method is based on the characteristics of spatially invariant tracking

errors within a CCD frame. The direct deconvolution method was used in the process of image restoration. The results indicate improved precision of image centering, including the cases of close pairs of images. In particular, close binaries can be separated easily after image restoration (Tang et al. 2001).

**GERMANY.** Schmidler at Munich reports that the observations of fundamental stars, major planets and minor planets Ceres, Pallas, Juno and Vesta are continued with the Munich vertical circle.

**ROMANIA.** Stavinschi at Bucharest reports that astronomical and geodetic measurements were performed with Danjon astrolabe. The Prin-Merz double astrograph (38/600cm) was used in the following programs: CONFOR international cooperation aimed to connect the FK5 system to the radio reference system (188 areas with radio sources); observations of asteroids to study the motion of the fundamental plane (Bocas 2000, 2001).

A huge number of photographic plates obtained at the Observatory of Bucharest and Timisoara Astronomical Institute have been archived in the international Wide-Field Plate Database (WFPDB), which provides information on 383,400 plates from 78 catalogues of plates worldwide, obtained over several decades (Tsvetkov et al. 2000).

**RUSSIA.** Kumkova at St.-Petersburg reports that the M.S. Zverev meridian telescope (PMT) and the L.A. Sukharev meridian automatic horizontal telescope (MAGIS), both at Pulkovo were modernized by implementing CCD cameras which allow to observe stars down to 16 mag. The trial observations with the PMT around the polar zone indicated that the mean error of a single observation is 40 to 250 mas, depending on the star's magnitude (Gorshanov et al. 2001, Shkutov et al. 2000). The test observations in some areas of the sky such as around the open clusters M67, Praesepe and others were made with the MAGIS. The formal precision of positions of stars with 11-12 mag within one frame is 5 mas, whereas in zenithal zone the external night-to-night error for stars with 11-14 mag is ~40-150 mas depending on the magnitude.

**SPAIN.** Muiños at San Fernando reports that in collaboration with the Copenhagen University Observatory and the Institute of Astronomy of Cambridge a CCD camera has been installed on the Carlsberg meridian telescope (CMT), which is operated in drift-scanning mode since April 1999. The limiting magnitude is ~17. A survey of the northern sky in the range  $-3^\circ < \delta < +50^\circ$  was started. At present more than 80% of the survey has been completed.

Nuñez and Muiños at San Fernando report that a new CCD camera will replace the old Baker Nunn camera on the Schmidt telescope (500/500mm). It will provide a useful field-of-view of  $5^\circ \times 5^\circ$  and would allow to observe in both, the conventional stare and the TDI scanning, modes. The TDI mode would permit to observe 6,000 square degrees of sky per night down to the limiting magnitude of  $V = 20.5$ . The main targets of these observations will be NEOs, PHAs, asteroids, comets, and TNOs. Other possible applications are detection of extra-solar objects, novae, supernovae and optical counterparts of GRBs.

**UK.** Argyle at Cambridge reports that the absolute accuracy of global plate model will possibly approach the emulsion noise limit, if the plate models are sufficiently detailed along with the dense catalogues. Initial investigations using the UCAC catalogue were made at Edinburgh (Cannon et al. 2001).

Evans at Cambridge, reports that a technique has been developed to efficiently calibrate the atmospheric fluctuations found in the drift-scanning observations of the CMT (Evans 2001a). The astrometry is then placed on the ICRS using Tycho-2.

**UKRAINE.** Pinigin at Nikolaev reports that two telescopes: the axial meridian circle (AMC; 180/2480mm) and zone astrograph (160/2046mm) were equipped with similar CCD cameras (ISD017AP,  $1040 \times 1160$  pix) at the Nikolaev Astronomical Observatory during 1999-2001 (Protsyuk 2000).

Vertypolokh at Kiev reports that the meridian axial circle (MAC; 180/2300mm) was furnished with the CCD-micrometer (based on CCD ISD017AP,  $1040 \times 1160$  pix), allowing

to observe in stare and drift-scanning modes, and was put into operation at the Main Astronomical Observatory in 2001 (Telnuk-Adamchuk et al. 2002).

USA. Rafferty at Washington reports that in September/October 2001 the astrograph was relocated from CTIO, Chile to Flagstaff, AZ to continue the Northern Hemisphere observations. At the end of the reporting period, 82% of the sky had been observed.

YUGOSLAVIA. Pakvor at Belgrade reports that there are three Askania fundamental meridian instruments: transit circle, meridian circle, and vertical circle (190/2578mm). The meridian circle was destroyed by fire during the Yugoslavia conflict and the other two instruments have stopped observing because of the modernization efforts related to installation of the CCD detectors. The models for transformation of positions, obtained with the meridian instruments in a former fundamental system, to the FK5 and Hipparcos (ICRS) systems were developed. The influence of systematic differences between the FK5 and Hipparcos reference frame on the longitude determination was also studied (Cvetkovic & Perovic 1999).

#### 4. Extragalactic Reference Frame

BRAZIL. Andrei at Rio de Janeiro reports that the optical positions of 315 ICRF sources with precision better than  $\sim 45$  mas were determined by using improved positions from the GSC1.1 catalog and the Digitized Sky Survey images based on photographic plates of the UK Oschin Schmidt telescope. The positions of GSC1.1 objects have been locally corrected into the system of ACT, Hipparcos and Tycho Catalogues (da Silva Neto et al. 2000).

CHINA(PR). Jin at Shanghai reports on the program of precise determinations of optical positions of extragalactic radio sources (ERS) by using three telescopes equipped with CCD detectors: 1m telescope at Yunnan Astronomical Observatory, 60/90cm Schmidt telescope and a 60cm reflecting telescope at Beijing Observatory (Tang et al. 2000a, 2002).

A joint project between Shanghai Observatory and Nikolaev Observatory aiming at determination of precise optical positions for  $\sim 70$  ERS is being continued using these telescope and the fully automated meridian circle at Nikolaev. The preliminary results have been reported (Tang et al. 2000b and Pinigin et al. 2000, 2001.)

RUSSIA. Kumkova at St.-Petersburg reports that the work to establish a reference system of intermediate stars with magnitudes 13-17 in fields containing the ERS is carried out at the Engelgardt Kazan Astronomical Observatory of the Kazan State University. This reference system is represented by a compilation of 20,000 star positions in the system of ICRF obtained from the plates of Zeiss astrographs (40/200cm) at Zelenchuk and Zvenigorod stations.

The Pulkovo normal astrograph has been used to compile two catalogs of positions of intermediate brightness (13-16 mag) stars – PUL ERS and PUL GRS – around 73 extragalactic and 110 galactic radio sources. This effort is being continued by using the CCD observations. At present, the coordinates of stars have been determined in the fields around 32 ERS (Dement'eva 2001) and 42 GRS (Ryl'kov et al. 2001, Narizhnaya & Ryl'kov 2000), all in the system of reference catalogs PPM, CAMC and Tycho-2. The positions of 13 ERS (Dement'eva 2000a, 2000b) were calculated in the same reference system.

At the Institute of Applied Astronomy of RAS the research on extension and densification of reference systems is continued. This also includes a study of the link between the radio and optical coordinate systems in the context of IAU resolutions 2000 (Kumkova & Stepashkin 2001).

UK. Hambly at Edinburgh reports that from infrared observations with the UK Infrared Telescope, an infrared counterpart of the second brightest persistent Galactic X-ray source GX 5-1 (classified as a Z source) was identified by colleagues at Edinburgh, with the reference of Tycho-ACT standards stars and an accurate radio position (Jonker et al. 2000).

UKRAINE. Pinigin at Nikolaev reports that the AMC 1B catalog of secondary reference stars (12-14.5 mag) in the fields around 190 ERS between declinations  $-20^\circ$  and  $+90^\circ$ ,

obtained from observations with the AMC in 1996-1998, has been completed. The catalog contains about 15,000 stars with the internal accuracy about  $\pm 0''.08$  in both coordinates (Kovalchuk et al. 1999).

As a result of the joint program between five observatories in China, Russia, Turkey and Ukraine, an improvement of linking the optical and radio reference frames has been achieved. The preliminary values of orientation angles were obtained from observations of 60 ERS with the AZT-22 in Turkey and the 1-m telescope in China, which accounts for 37 ERS in the Northern hemisphere and 23 ERS in the Southern hemisphere (Pinigin 2001).

At the Institute of Astronomy of Kharkov National University about 500 CCD images of stars and more than 50 ERS were made to obtain accurate positions of the optical counterparts of ERS by using the USNO-A2.0, AMC, and ERL catalogs. The internal accuracy of star positions down to 18 mag is estimated to be better than  $0''.1$ . The preliminary values of orientation angles between the coordinate systems have been obtained. A catalog of star positions and proper motions down to 17 mag and within the  $1^\circ \times 1^\circ$  areas around the ICRF source will be completed in 2002 by incorporating the data from the Palomar POSS-I and POSS-II (Filonenko 2000, Pinigin et al. 2000, Fedorov et al. 2001).

Vertypolokh at Kiev reports that a preliminary version of the IR reference frame has been compiled on the basis of the CPIRSS catalogue (Kharin et al. 2000).

The photographic Intermediate Reference Star catalogue of 2126 reference stars (12-15 mag) was created for 116 ERS fields in the declination zone  $0^\circ$  to  $+90^\circ$ , using the observations obtained by the double refractor at the mean epoch 1991. Another project started in 2001 with the meridian axial circle is supposed to provide fainter reference stars (12-16 mag) in 209 ERS fields, declination zone  $0^\circ < \delta < +30^\circ$ .

USA. Zacharias at Washington reports that a catalog of precise (50 mas) positions of 89,422 stars ( $V=11-14$ ) in 398 fields around ICRF sources, called ERLcat, was published jointly by the US Naval and Hamburg Observatories. The USNO extra-galactic link program continues with 3 to 4 observing runs per year using the CTIO and KPNO telescopes, following the UCAC sky coverage and using the same bandpass at 579-642 nm, (Zacharias et al. 1999).

Sovers at JPL reports that in collaboration between Bordeaux Observatory, JPL, USNO and GSFC the maps of the S- and X-band structures of 160 sources were constructed and applied to correct the  $\sim 200,000$  VLBI observables in 10 experiments spanning 1.6 years in the late 1990s. It was concluded that intrinsic variable source structure is not presently the dominant error source in the astrometric VLBI, but it does affect the celestial reference frame at the level of  $\sim 10 \mu\text{as}$ .

YUGOSLAVIA. Pakvor at Belgrade reports that identifications of the common objects in the Hipparcos and 2MASS catalogs were carried out in cooperation with the Paris Observatory.

## 5. Special Projects

### 5.1. Positions and Proper Motions

ARGENTINA. López at San Juan reports that the Second Catalogue of Stars (CPASJ2) containing 5241 stars has been compiled using the observations with the Chinese photoelectric astrolabe from January 1992 to March 1997. The mean precision is  $\pm 3.2$  ms in right ascension and  $\pm 0''.057$  in declination (Manrique et al. 1999a). During the same period a catalogue of 69 radio stars (RSSJ95) was also obtained. The mean precision of this catalogue in RA and Dec, respectively, is  $\pm 2.2$  ms and  $\pm 0''.035$  (Manrique et al. 1999b).

The positions of more than 100,000 stars common between the SAO and Hipparcos catalogs were compared using the vector spherical harmonic analysis. Large Fourier high-order coefficients indicate significant distortions in the reference system represented by the SAO catalog (Arias et al. 2000).

**BRAZIL.** Andrei at Rio de Janeiro reports that positions from the USNO-A2.0 catalog have been compared with the ACT, with the improved GSC1.1 positions on the ACT reference frame, and with the ICRF source positions and observations made by the Valinhos CCD meridian circle. Systematic differences were found in the positions of USNO-A2.0 catalogue, different in its southern and northern part (Assafin et al. 2001).

A catalogue containing positions, proper motions,  $V$ -magnitudes and cross-identifications for 41,721 objects down to  $V = 15$  was compiled using observations with the Valinhos CCD meridian circle in 51 selected areas of the sky (Camargo et al. 2001). The positional precision of the catalog is better than 50 mas for  $V \leq 14$ .

The proper motions of 213 pre-main sequence stars in the southern star-forming regions (galactic longitude range  $290^\circ$ - $360^\circ$ ) were determined using the observations with the Valinhos CCD meridian circle in combination with the selected catalogues, AC2000 and USNO-A2.0, as well as the SERC-J Schmidt plates. The accuracy of proper motions is 5 to 10 mas/yr. Systematic motions of groups of stars have been discovered in these regions (Teixeira et al. 2000).

**CHINA(PR).** Jin at Shanghai reports on the observing program related to the maintenance and extension of Hipparcos catalogue. For this purpose, 3435 plates taken with the 40cm refractor at SHAO since 1901 are available. They cover 764 different sky regions and contain  $\sim 10,000$  Hipparcos stars. New positions and proper motions were obtained for 54 stars (including 16 Hipparcos stars) with respect to the ACT reference catalogue from measurements of 15 plates in two areas (Wang S. H. et al. 2000).

Zhu at Shaanxi reports that systematic differences of the FK5 proper motion system as compared to that of Hipparcos, were analyzed using the PPM and ACRS catalogues. The global rotation of proper motions between the PPM and Hipparcos and between the ACRS and Hipparcos shows a large offset with respect to the correction of the precession constant. It could be an internal non-rigid feature in the FK5 system of proper motions or an effect of some mis-alignment between the PPM and FK5 systems. Using the proper motions of about 24,000 K-M giants, a largely differing velocity of Galactic rotation was found:  $V=249.6 \pm 7.0$  km/s from Hipparcos and  $178.3 \pm 6.6$  km/s from the ACRS proper motions (Zhu 1999, 2000a).

**FRANCE.** Cr ez e at Paris reports that a survey containing relative proper motions, magnitudes in two colors, and stellarity indicators for some 80,000 sources (down to 24.5 mag) and covering 1.4 square degrees at the intermediate galactic latitude is being carried out. The observational material has been obtained using the CFHT12K CCD mosaic camera on the 3.6m Canada-France-Hawaii telescope at two different epochs separated by one year. The investigation aims at putting constraints on the possible contribution of very old halo white dwarfs in the budget of baryonic dark matter. Five faint candidates of such white dwarfs with proper motions larger than 2 pixels per year were found associated with a nearly non-rotating velocity centroid. The possible applications of astrometric possibilities offered by the SNAP project are discussed.

Ducourant at Bordeaux reports that the Bordeaux M2000 catalogue will be completed by the end of 2002. The survey of the Bordeaux CdC zone ( $+11^\circ < \delta < +18^\circ$ ) with the meridian instrument was terminated in December 2000. The corresponding catalog (Rapaport et al. 2001) contains 2,300,000 stars with  $V < 16.3$ . A comparison to the Hipparcos and Tycho-2 positions led to an estimate of the external precision of 35 mas in RA and 37 mas in Dec. The current Bordeaux CCD meridian observations will be combined with the positions derived from 511 CdC plates with the mean epoch 1900 (measurements at Cambridge, UK have been completed in April 2002) to produce proper motions with the accuracy of 1-2 mas/yr.

**GERMANY.** The Sixth Catalogue of Fundamental Stars (FK6), Part III combining 3272 single-star candidates in the FK5 Extension and in the FK5 Supplementary Stars with the Hipparcos data yields the positional precision equal to 0.54 mas at the central epoch 1991.25 and a 0.59 mas/yr precision in proper motions (Wielen et al. 2000). From the resulting catalogues "GC+HIP" and "TYC2+HIP" the catalogue "ARJHIP" was compiled

giving the best positions and proper motions for 90,842 HIPPARCOS stars with solutions in one of the above mentioned catalogues (Wielen et al. 2001).

**RUSSIA.** Kunkova at Pulkovo reports on the catalogue PUL 2 containing absolute proper motions of 59,646 stars down to 16.5 mag determined with respect to external galaxies. It also contains equatorial coordinates in the system of ICRS and its proper motions have been used to study galactic kinematics (Bobylev 2000). The magnitude equation, color dependence and coma effects in the measured coordinates were thoroughly investigated for constructing the Catalogue PUL 3. The first results for 10000 stars have been obtained (Khrutskaya et al. 2001). The internal and external errors from comparison with Tycho-2 are 80 and 210 mas, respectively.

The revision of observational material in the International Program of Bright Stars has been completed. New proper motions were obtained for 6508 stars from comparison of positions in the sense 'GC - Hipparcos' and 'NewBS - Hipparcos' (Khrutskaya 2001).

**SPAIN.** Muñíos at San Fernando reports that the Hispano-Argentinian Meridian Catalogue (HAMC) has been published in April 2001. It is based on the CMASf observations during October 1997 - September 1999. The HAMC catalog contains positions and proper motions for more than 6,000 stars with declinations ranging from  $-90^\circ$  to  $+40^\circ$  and magnitudes  $12.5 < V < 15.4$ . More than 900 positions of Uranus, Neptune and Pluto, the satellites Callisto, Ganymede, Titan, Iapetus and Hyperion and 84 selected minor planets were obtained.

**UK.** Hambly at Edinburgh reports that the project of the SuperCOSMOS Sky Survey (SSS) aims to digitize the sky in *BRI* colors and in one color at two epochs via the Schmidt plates taken during the second half of 20th century. The external astrometric accuracy is typically around  $0''.3$  in position with respect to the Tycho-2 and internal precision is  $0''.03$  (Hambly et al. 2001a, 2001b).

Irwin at Cambridge reports that the astrometry for UKST and POSS I catalogues has been updated following the publication of Tycho-2. A comparison with the faint ICRS astrometric standards shows that the external errors in both catalogues are now at the level of  $0''.22$  and  $0''.30$ , respectively.

Evans at Cambridge reports that the CMC12 catalogue with positions of more than 6 million stars (limiting  $r'=17$  mag) with the external accuracy of 36 mas in the region  $-3^\circ < \delta < +3^\circ$  was released in the summer of 2002 (Evans 2001b, Evans et al. 2002). The remainder of the primary survey area of  $-3^\circ < \delta < 30^\circ$  will be released by the end of 2002. The results of extinction measurements in  $r'$ -bandpass, which are also carried out by the CMT are available on the CMT web site.

**UKRAINE.** Kislyuk at Kiev reports that the first version of the astrographic catalogue FONAC 1.0, which contains the positions (mean epoch 1988.19), proper motions and photometric data for 2,008,383 AC stars covering the sky within  $+90^\circ > \delta > -2^\circ$ , was constructed. The estimated precision in the FONAC catalogue is  $0''.2$ , 3 mas/yr and 0.18 mag in positions, proper motions and photometry, respectively (Kislyuk et al. 2000).

Kharchenko at Kiev reports that the All-Sky Compiled Catalogue of 2,501,977 stars (ASCC-2.5) with the limiting magnitude  $V=12-14$  has been created by combining the positional and photometric data from a variety of high precision catalogues of space and ground-based observations (Kharchenko 2001).

Vertypolokh at Kiev reports that the compiled catalogue of 16,721 near-polar star proper motions (north of  $\delta = +74^\circ$ ) was obtained with the purpose of maintenance of the Hipparcos proper motion system in the polar region. In total, 15 catalogues were used with observation epochs ranging between 1885 and 1991. The astrometric MAC CCD survey in the equatorial zone  $0^\circ < \delta < 5^\circ$  was initiated in 2001 with the aim to extend the Hipparcos/Tycho-2 reference frame.

**USA.** Urban at Washington reports that the Tycho-2 Catalogue (a joint project between Copenhagen University Observatory and the U.S. Naval Observatory), containing astrometry and two color photometry for 2.5 million stars was released (Høg et al. 2000).

The USNO CCD Astrograph Catalog (UCAC1) containing 27.4 million Southern hemisphere stars on the ICRS in the magnitude range  $16 > R > 8$  has been released (Zacharias et al. 2000). A second data release (UCAC2), which will supersede UCAC1, is under way. Its proper motions will utilize the data from the Tycho-2 proper motion work, a re-reduction of the SPM and NPM data (a joint project between the USNO and Yale University), and new measurements of the AGK2 plates with the refurbished StarScan measuring machine – a joint USNO/Hamburg Observatory project.

Klemola at Santa Cruz reports that the NPM2 (347 Milky Way fields north of  $\delta = -23^\circ$ ) is being continued. All 1,041 NPM2 plates were scanned with the PMM at USNO Flagstaff station by 1999. Images of stars with accurate catalog positions are extracted automatically from the PMM scans, as are the anonymous astrometric reference stars. Most faint stars were identified from the Input Catalog of Special Stars. The NPM2 Catalog will be finished in 2003 and is expected to attain the global systematic accuracy at the level of 10 mas in positions and 1 mas/yr in proper motions. The rms errors for an individual star are the same as in NPM1, i.e., 100 mas in position and 5 mas/yr in proper motion.

van Altena at New Haven, Platais at Washington, and López at San Juan report on the SPM – a joint program between the Yale Southern Observatory and the University of San Juan. As reported earlier, the second epochs were only partially finished in 1987-1997 due to the cut-off in the plate supply. van Altena, Girard (Yale) and López (Univ. San Juan, Argentina) with the assistance of Holvorcem (Brazil) completed the installation of CCD imagers on the Double Astrograph at El Leoncito. The new system will be used to complete the second epoch of the Southern Proper Motion Program. The main imager, a PixelVision 4K×4K CCD camera, is capable to cover about one square degree in the focal plane of astrograph's visual lens.

Platais at Washington and van Altena at New Haven report that the reductions of all 718 SPM first-epoch fields, measured by Monet at Flagstaff with the PMM, have been completed. This has resulted in the catalog of positions at a mean epoch 1970 of over 28 million UCAC objects (Platais et al. 2001a).

## 5.2. Minor Bodies in the Solar System

**BRAZIL.** Andrei at Rio de Janeiro reports that solar diameter observations were being continued with the CCD astrolabe at the Observatorio Nacional during 1999-2000. Periodic variations of solar diameter were observed with an amplitude of  $0''.02 - 0''.07$ , which apparently are related to the solar rotation and the characteristic lifetime of sunspots (Puliaev et al. 2000, Penna et al. 2002).

Photographic positions of major 8 Saturnian satellites in 1982-1988 and Helene (1985-1987) were obtained by using the 1.6m reflector at Itajuba. The standard deviation of O-C is  $0''.3$ , while the values of C were calculated using the TASS1.7 ephemeris (Veiga et al. 1999a, 2000a). CCD observations of major Uranian satellites (1995-1998) and the Saturnian satellite Phoebe (1995-1997) were also taken with the 1.6m reflector. The precision of these observations is  $0''.05$  (Veiga et al. 1999b, 2000b). Comparing observations with the DE403 and DE405 ephemeris, the observations with the CCD meridian circles at Bordeaux and Valinhos yield the largest differences of 100 and 60 mas for Pluto and Saturn, respectively. The DE405 ephemeris appears to better represent the observations (Rapaport et al. 2002).

The international campaign PHESAT95 was organized by the Institut de mécanique céleste et de calcul des éphémérides. A catalogue of 6006 positions of seven Saturnian satellites with precision  $0''.07$  and 43 mutual eclipses and occultations were obtained with the 1.6m and 0.6m telescopes using a CCD camera (Vienne et al. 2001, Thuillot et al. 2001).

**CHINA (PR).** Shen at Shaanxi reports that the analysis of four main astrometric calibration methods was made for CCD observations of Saturnian satellites using 3,000 observations of 8 Saturnian satellites in 1990-1997.

In the reductions of satellite observations, the TASS theory developed by Duriez and Vienne provides a significant improvement in the precision of ephemeris ( $0''.015$ ) as compared to the precision from another theory ( $0''.03$ – $0''.05$ ). Thus, 451 observations of Saturnian satellites obtained photographically in 1994–1996 with the 1.5m reflector at Shanghai and additional 199 CCD observations taken with the 1m telescope at Yunnan Observatory in 1996–2000 have produced positions with the rms scatter in O-C equal to  $0''.04$  (Shen et al. 2001, Qiao et al. 1999, Peng et al. 2002). From 122 CCD frames taken the 1.5 m telescope at Shanghai, positions of 5 major Uranian satellites at the oppositions of 1995–1997 were obtained with the precision  $0''.03$ – $0''.05$  (Shen et al. 2002).

ROMANIA. Stavinschi at Bucharest reports that the observation campaign PHEMU 2003 (mutual phenomena of the Galilean satellites of Jupiter) has been prepared (Dumitrescu 1999).

RUSSIA. Kumkova at St.-Petersburg reports that a number of observations of the solar system bodies have been obtained with the normal astrograph (photographic observations), the Pulkovo 26in refractor (photographic and CCD) and the ZA-320 reflector-type astrograph (CCD). The photographic plates with Saturnian and Uranian satellites taken with the wide-field double astrograph in Abastumani in 1984 have been reduced using the ACT reference catalog (Chanturiya et al. 2001). The CCD observations with the 26-inch Pulkovo refractor of the Saturnian and Jovian satellite occultation and eclipse events were also reduced. In 1994–2001 parallel photographic and CCD observations of Saturnian satellites have been obtained. Using these observations it was confirmed that there is an error of longitude in the orbital motion of Hyperion (SVII). Finally, a number of CCD observations were obtained for the Pluto-Charon system with the ZA-320 astrograph.

UKRAINE. Pinigin at Nikolaev observatory reports that more than 30 minor planets have been observed with the zone astrograph equipped with CCD since 2000 (Ivantsov et al. 2000). Preliminary processing of 6 minor planets in the system of USNO-A2.0 and UCAC1 catalogues indicate the precision equal to  $\sim 0''.1$  and the external accuracy of  $0''.3$ – $0''.4$ . The observations of two NEOs, 1999 KW4 and 1998 WT24, yield the precision and external accuracy of  $0''.36$  and  $0''.8$ , respectively.

The reductions of the 1961–1998 photographic observations of major planets and Saturnian satellites are well advanced. The resulting precision on the system of ICRS is better than  $0''.22$ .

The catalog of positions for Jovian Galilean satellites obtained from 1314 photographic plates taken in 1961–1997 has been posted on the web-page of IAU Commission 4. The average precision of positions is  $0''.13$ .

The observations of geostationary satellites have started in early 2001 with the CCD-equipped telescope on parallactic mounting. A new approach was developed to allow for observing in both stare and drift-scanning modes. The accuracy of a single CCD observation is  $0''.2$  for objects of 12th mag. (Kovalchuk 2001).

At the Institute of Astronomy of Kharkov National University observations of selected minor planets and reductions of the solar system bodies are being continued. In total, 74 CCD positions have been obtained for the comet C/2001 LINEAR A2 with the standard error of a single observation  $0''.50$ . A study of the magnitude equation in positions has been completed for the SRIA Zeiss short-focus astrograph. This study aims at the extension and supplementing the catalogue of comet brightness bursts. The work on the light curve catalog of comets is continued. A new catalog of up-to-date astrometric parameters for nearby stars is under preparation at the SRIA (Filonenko et al. 2000).

Vertypolokh at Kiev reports that a data base has been created comprising the results of about 24,000 observations of total and grazing occultations of stars, planets, Jovian satellites, and Saturnian Rings by the Moon made at 77 observing sites in the former Soviet Union during 1963–2001 (Kazantseva et al. 2002).

Photoelectric observations have been obtained during the 1999 August 11 solar eclipse, allowing to estimate the solar diameter (Danylevsky 1999).

USA. Pascu at Washington reports that optical and IR observations of the satellites of Jupiter, Saturn, Uranus and Neptune, obtained with the 61in Astrometric Reflector at Flagstaff, were reduced and forwarded to JPL for ephemeris development. New mean motions for four inner satellites of Neptune were determined by using the HST astrometric observations. In addition, the observations of close approaches of pairs of the Galilean satellites of Jupiter were observed with the speckle camera on the USNO 26-inch refractor.

### 5.3. Trigonometric Parallaxes and Nearby, Low-Mass, and High Proper Motion Stars

UK. Hambly at Edinburgh reports that the SuperCOSMOS scans of four V-bandpass UK Schmidt plates centred on Kapteyn's Selected Area 94 have been studied in terms of their astrometric potential. With data spanning a baseline of 6 yrs, the proper motions accurate to  $\pm 23$  mas/yr have been derived and 189 stars have been identified having proper motions  $\mu > 0''.1/\text{yr}$ . Based on the distribution in the  $[H_V, (V-I)]$  reduced proper motion diagram and the spectroscopic observations of 30 stars with  $\mu > 0''.2$ , the stars in the complete sample were classified as candidate white dwarfs, main-sequence dwarfs, and halo subdwarfs. The estimates of luminosity function for disc and halo populations were derived from this dataset (Cooke & Reid, 2000).

A measurement of the trigonometric parallax ( $192 \pm 37$  mas) for a nearby very low mass star, DENIS 1048-39, was obtained using the SSS data (Deacon and Hambly 2001).

USA. Benedict at Austin reports that the HST Astrometry Team continued parallax work using the Hubble Space Telescope. Relative astrometry with Fine Guidance Sensor 3, a white-light interferometer on Hubble Space Telescope, has resulted in high-precision parallaxes for astrophysically interesting objects, upper limits on possible planetary mass companions of two M dwarf stars, and precision masses for low-mass stars in aid of the Mass-Luminosity Relationship. Parallax targets observed by FGS 3 in fringe-tracking mode were: the dwarf novae SS Aur, SS Cyg, and U Gem; the cataclysmic variables TV Col and RW Tri; the X-ray binary Feige 24; and the distance scale calibrators RR Lyr and  $\delta$  Cep. All parallaxes were characterized by  $\sigma_\pi < 0.5$  mas. Planetary mass upper limits ( $M_p < 3M_{Jup}$  for  $P < 2$  yr) were established for Barnard's Star and Proxima Centauri. Masses precise to better than 3% were determined through a combination of fringe-tracking and fringe-scanning for the components of the M dwarf binary stars Wolf 1062 and Gl 791.2.

### 5.4. Open & Globular Clusters and the Galaxy

*Open Clusters* BRAZIL. Andrei at Rio de Janeiro reports that relative proper motions and cluster membership probabilities of 30 stars in the young open cluster NGC 1662 were determined with the accuracy 2-7 mas/yr. To derive proper motions, observations with the Valinhos CCD meridian circle were combined with the positions from AC2000 or USNO-A2.0 (Dias et al. 2000). Mean proper motions of 112 open clusters, located within 1 kpc from the Sun, were determined by using the Tycho-2 catalog. The membership of 4006 Tycho-2 stars was established in 28 open clusters, which have no prior determination of astrometric parameters including the mean proper motion (Dias et al. 2001). The absolute mean proper motions of 94 open clusters located at the distances larger than 1 kpc were also determined. Among them, 55 clusters have a first-time determination of the mean proper motion (Dias et al. 2002).

CHINA(PR). Chen at Shanghai, reports on the open cluster program based on photographic data obtained from a series of plates with the 40cm refractor at Shanghai spanning 80 years. Proper motions and membership probabilities were determined for stars in the regions with NGC 1750, 1758, and 2548. Furthermore, the BV photometry of 789 stars in the NGC 1750 and NGC 1758 regions was also obtained from the photometric plates taken in 1992-1993 with the 1.56m telescope of Shanghai. According to the parameters such as an age, distance, and mass and the appearance of sequences in the HR diagram combined with

the shape of luminosity function and kinematic characteristics, two independent systems of stars exist in this region of the sky (Tian 2001, Wu 2002).

GERMANY. Geffert at Bonn reports that a program of photometric and astrometric studies of open clusters was started. First and second epoch plates from the double refractor of Bonn and the Carte du Ciel telescope of Sydney were combined with recent CCD observations in order to obtain relative proper motions. They were used to determine cluster membership and Initial Mass Function (IMF) in several open clusters: NGC 581 (Sanner et al. 1999), NGC 1960 and NGC 2194 (Sanner et al. 2000), and NGC 4103, NGC 5281 and NGC 4755 (Sanner et al. 2001). In addition, the Tycho-2 Catalogue was used to obtain cluster membership and evaluate the IMF of some other open clusters (Sanner and Geffert 2001).

UK. Hambly at Edinburgh reports that the very low-mass stars and brown dwarfs (BD) were studied in the young open cluster IC 2391. The accurate positions of 50 probable and 82 possible low luminosity members in this cluster were obtained by using the SSS data. The 9 candidate BDs in the Pleiades area were selected on the basis of having extremely red photographic colors and proper motions consistent with the cluster membership (Navascués et al. 2001, Hambly et al. 1999).

USA. Jones at Santa Cruz reports that a program was started to measure proper motions of stars in the vicinity of 18 open star clusters in order to determine much improved cluster membership. First epoch plates had been taken with the Lick 0.9m refractor between 1960 and 1973. Second epoch plates are being taken with the 0.9m, and CCD images are being obtained with the Lick Nickel 1m and Shane 3m telescopes. Second epoch imaging should be completed by the end of 2002.

Platais at Washington reports that a program of deep astrometry in selected open clusters is being continued by using the KPNO and CTIO 4m telescope archival photographic plates in combination with the current-epoch CCD Mosaic Imager data. A three-year monitoring campaign of the NOAO CCD Mosaic Imager at Kitt Peak yielded two important results which have implications for the future of ground-based astrometry. First, precision astrometry (better than  $\sim 20$  mas precision per observation) is possible with the CCD mosaic devices. Second, the individual CCD chips may move relative to each other. This aspect of CCD mosaic devices should be closely monitored in all astrometric applications (Platais et al. 2002). As a result of this study, a new astrometric standard of 1863 stars is now available in the field of NGC 188.

A young open cluster NGC 2451A is confirmed by using new proper motions, radial velocities and CCD *BV* photometry. The photometric distance of this cluster is in excellent agreement with the distance modulus from Hipparcos parallaxes (Platais et al. 2001b).

*Globular Clusters* CHINA(PR). Chen at Shanghai reports that a collaborative globular cluster program similar to its counterpart on open clusters was started. The photographic plates taken with the 40cm refractor at Shanghai over 80 years is the source of first epoch data. Recent CCD observations serve as a second epoch and were carried out in collaboration with the Sternwarte der Universität Bonn, Germany and Uttar Pradesh State Observatory, Naini Tal, India. Proper motions and membership probabilities were determined for stars in the regions of globular clusters NGC 4147, 5272, 6205, and NGC 6254. Based upon the Hipparcos Catalogue, the new proper motions were used to calculate the space motion and orbits for these globular clusters. A photometrically peculiar star located at the extension of RGB is confirmed to be a member of NGC 4147. It is shown that this cluster can reach an apogalactic distance of 22.5 kpc. The space motion and metallicity of NGC 6254 indicate that it is a halo object with an orbit reaching the maximum *z*-distance not exceeding 3 kpc (Chen et al. 2000, 2001; Wu et al. 2000; Wang et al. 2000).

GERMANY. Geffert at Bonn reports that relative proper motions and *BV* photometry were obtained for 4450 stars in NGC 6838 down to  $V=18.5$  using wide-field CCD observations. Membership probabilities yield 320 probable cluster members. The color-

magnitude diagram shows a well defined red giant clump and indicates the presence of 13 blue stragglers (Geffert & Maintz 2000).

*Galaxy ARGENTINA.* van Altena at New Haven and Platais at Washington report on the application of SPM absolute proper motions to refine the Galactic kinematic model. The absolute proper motions of more than 30,000 randomly chosen stars in the range  $9 < B_J \leq 19$  are best fitted by the Galactic kinematic model with a solar peculiar motion of +5 km/s in the V-component, a high LSR speed of 270 km/s and a disk velocity ellipsoid pointing towards the Galactic center. The absolute proper motions in the U-component indicate a solar peculiar motion of  $+11.0 \pm 1.5$  km/s with no need for a local expansion or contraction term. The fainter absolute proper motions show that the thick disk must exhibit a rather steep velocity gradient of about  $-36 \text{ km s}^{-1} \text{ kpc}^{-1}$  with respect to the LSR (Méndez et al. 2000).

*CHINA(PR).* Zhu at Shaanxi reports that local kinematics of the Milky Way was studied using the proper motions of young O-B5 stars, classical Cepheids and late-type K-M giants from the Hipparcos catalogue based upon the three-dimensional Ogorodnikov-Milne model. The two components of solar motion along the direction towards the Galactic center and its pole are +10 km/s and +8 km/s, respectively, for all types of stars, while the component pointing in the direction of Galactic rotation varies from +13 to +21 km/s. The galactic rotation derived from O-B5 stars is  $+269 \pm 12$  km/s, while it is  $+240.5 \pm 10.2$  km/s for classical Cepheids. A distinct warping motion of  $-3.49 \pm 1.05 \text{ km s}^{-1} \text{ kpc}^{-1}$  was obtained for O-B5 stars (Zhu 2000b, 2000c).

*GERMANY.* Brosche reports at Bonn that Galactic motions of 8,349 Hipparcos K0-5 giants (luminosity class III) were studied using Hipparcos proper motions. It appears that systematic velocities of these stars contain a non-classical shear motion  $C = -7 \text{ km s}^{-1} \text{ kpc}^{-1}$ . The dispersion of random velocities perpendicular to the Galactic plane (W-component) show an increase from  $\pm 18$  km/s at  $z = 0$  pc up to  $\pm 25$  km/s at  $z \approx 30$  pc (Brosche et al., 2001).

*UK.* Argyle at Cambridge reports that in liaison with colleagues at Strasbourg and Macquarie University, Sydney improved proper motions for stars in the Sydney zone ( $-52^\circ > \delta > -64^\circ$ ) have been obtained and these data are being used to investigate the deflection of Galactic stellar orbits by the Southern Coalsack (Fresneau et al. 2002).

The SSS deep proper-motion survey reveals a substantial, directly observed population of old white dwarfs, too faint to be seen in previous surveys. This newly discovered population accounts for at least 2% of the halo dark matter. It represents a direct detection of galactic halo dark matter (Oppenheimer et al. 2001), although this hypothesis has been contested by some other studies in favor of the high-velocity tail of the thick disk.

*Double and Variable Stars; Miscellaneous ARGENTINA.* López at San Juan reports on speckle interferometric observations of 160 double stars obtained by using the 2.15m telescope at El Leoncito in 1995-1996. The separation residuals show the rms scatter of 13.2 mas and a  $2.9^\circ$  scatter in the positional angle deviations, relative to ephemeris of a very well-determined orbits (Horch et al. 2001).

The identification of variable stars in the Southern constellations of Grus and Indus is completed and improved positions of these variable stars from USNO-A2.0 have been reported (López & Lépez 2000).

*CHINA(PR).* Chen at Shanghai reports that absolute proper motions were determined for 7 Galactic field RR Lyrae variable stars: RY Psc, XX And, RR Cet, XX Hya, TV Leo, U Com, and SW Aqr. The internal precision of these proper motions is significantly better than that of the NPM1 and there is a good agreement with the Hipparcos Catalogue (Wang et al. 1999).

*GERMANY.* Schwan at Heidelberg reports that work is in progress to combine the Hipparcos catalogue with various ground-based catalogues at the ARI. The aim is, first, to derive improved proper motions and, second, to provide information on possible undetected

astrometric binaries. Such stars may show up in the differences between the ground-based and the Hipparcos proper motions. The derived combination catalogs yield various solutions for each star depending on whether the star is assumed to be a single star or an (undetected) astrometric binary based upon the Principle of statistical astrometry (Wielen et al. 1999).

Work is continued on the ARIGFH data base at ARI. The aim is to collect all relevant astrometric data on stellar positions and proper motions in a comprehensive data bank. About 10 millions of observations published in about 1,400 individual catalogues are presently identified with a large master catalog. The systematic relations between various important catalogues of the 20th century and the HIPPARCOS Catalogue were derived (Schwan 2001, 2002).

RUSSIA. Kumkova at St.-Petersburg reports on photographic observations of 61 Cyg, ADS 7251, 14710 made with the normal astrograph. In total, 116 visual binary stars, having separations  $1''.2 \leq \rho \leq 2''.5$  and within the magnitude range  $8.0 < m < 12.0$ , were observed with the Pulkovo 26-inch refractor using the ST-6 CCD camera. The stars with invisible components and some visual binaries with  $\rho > 2''.5$  were observed on photographic plates. The orbits of 9 visual binaries and the masses of their components were calculated using Apparent Motion Parameters Method. For the first time, an elliptical orbit has been calculated for the third component in the triple system ADS 48 (Kijaeva et al. 2001).

Using a homogeneous set of astrometric observations with the 26in refractor spanning 1972-1999, a period (5.6 yr) and a mass ( $0.2 M_{\odot}$ ) of the invisible component in the system of  $\delta$  Gem have been estimated. All plates of 61 Cyg obtained with the normal astrograph (observations spanning  $\sim 100$  yr) and the 26in refractor (50 yrs of observations) were measured with the automated measuring machine "Fantasia". New values of  $\rho$  and  $\theta$  have been calculated for plates of the 26in refractor (Kijaeva et al. 2001).

UK. Argyle at Cambridge reports that a joint investigation with colleagues at Strasbourg and Catania has examined the potential to detect flare stars from triple images found in the 130-year-old Bordeaux, Paris, and Uccle astrographic plates. The APM measurements of 200 variable stars with significant flares and the follow-up photoelectric *UBV* observations indicate that about 10% of them are possible pre-main sequence stars (Fresneau et al. 2001).

A binary pulsar, PSR J1740-3052 with a massive companion was discovered during the Parkes multi-beam survey. It is young with the age of 350,000 yr and is in a 231-day, highly eccentric orbit with a companion whose mass exceeds  $11 M_{\odot}$ , all estimated from timing observations at Jodrell Bank and Parkes (Stairs et al 2001).

USA. Hartkopf at Washington reports that the USNO Double Star CD 2001.0 was publicly distributed in 2001. The observations of visual binaries continue using speckle camera on the USNO 26in refractor. This speckle camera has also been used at the KPNO and CTIO 4m telescopes in an all-sky duplicity survey of 3,600 G dwarfs. It has also been used at the McDonald Observatory 84in, in a survey of over 1,000 other stars, primarily Hipparcos problem stars and Hipparcos and Tycho double stars requiring confirmation.

The absolute motion of Nova Velorum 1999=V382 Vel has been obtained in the system of ICRS, using a number of existing SPM plates. The pre-outburst *BV* photometry is also available from the same plates (Platais et al. 2000).

YUGOSLAVIA. Pakvor at Belgrade reports that positions and proper motions of double stars obtained at the Belgrade observatory were compared with corresponding data from the Hipparcos Catalogue (Cvetkovic et al. 1999).

As part of the Springer Astronomy and Astrophysics Library, the book "Astrometry of Fundamental Catalogues" (H. G. Walter and O. J. Sovers) was published in late 2000. It covers concepts and construction of Earth- and space-based optical and radio reference frames.

## 6. Space Astrometry

GERMANY. Schwan at Heidelberg reports that DIVA was selected as the next scientific mission within the German space program "Small Missions" by DLR's independent scientific selection committee. In its overall performance DIVA can be regarded as an intermediate step between Hipparcos and GAIA. DIVA will measure parallaxes, positions, proper motions, magnitudes and colors of some 35 to 40 million objects. The Preliminary Design Review was successfully completed in April 2002. The implementation phase (so-called phase C/D) may be initiated as early as in the beginning of 2003. Preliminary, the launch is scheduled for 2006.

USA. Gaume at Washington reports on The Full-sky Astrometric Mapping Explorer (FAME) which is a space astrometric mission to measure the positions, parallaxes and proper motions of 40 million stars between 5th and 15th magnitude to an accuracy of 50  $\mu$ s at 9th magnitude. A collaboration between the U.S. Naval Observatory, the Naval Research Laboratory (NRL), Lockheed Martin Advanced Technology Center, and Harvard Smithsonian Center for Astrophysics, the FAME mission began this reporting period with the submission of a Phase A concept study report (CSR) to NASA. The FAME CSR contained detailed cost, schedule, and technical detail to assist NASA in determining whether to select the FAME mission for flight development. In October 1999 FAME was selected as one of two missions to begin development within the NASA Medium-Class Explorer (MIDEX) program. Due to funding restrictions, only critical FAME components were developed from Oct 1999 through Aug. 2000, but full scale Phase B development of the FAME mission began with a Phase B kickoff meeting Sept 6-7, 2000 at the NRL. FAME Phase B development culminated in the program Preliminary Design Review Oct 30-31 2001. Due primarily to technical problems with obtaining detectors, and with associated cost overruns, in January 2002 NASA announced that it was not confirming the FAME mission for Phase C development, and withdrew future funding support. Between January and June 2002, an alternate supplier of detectors was identified. Fabrication of preliminary detectors by the alternate supplier has been extremely successful, and testing continues. In addition, significant progress has been made in the definition of optics and structural requirements to meet mission astrometric accuracy goals. At the end of the reporting period consideration was being given to re-proposing the FAME mission to NASA.

SWEDEN. Lindegren at Lund Observatory reports that, in October 2000, the European Space Agency's astrometry mission GAIA was selected as the 6th Cornerstone Mission (CS6) within the Agency's science programme. The full report of the 1997-2000 Concept and Technology Study is given in ESA-SCI(2000)4, and summarized by Perryman et al. (2001). In May 2002, GAIA's status within the ESA science programme was reconfirmed, with launch targeted for mid-2010.

As previously reported, GAIA aims at an astrometric and photometric survey of all point objects down to 20th visual magnitude, plus radial velocities to 16-17th magnitude. Targetted astrometric accuracies are 10  $\mu$ s for the positions, parallaxes and annual proper motions at  $V=15$  and a few hundred  $\mu$ s at  $V=20$ . The on-board detection defines an observing program which is expected to comprise some 1 billion stars, half a million quasars, and  $10^5 - 10^6$  solar-system objects.

The re-optimized GAIA includes two astrometric telescopes with apertures of  $1.4 \times 0.5 \text{ m}^2$ , separated by a basic angle of  $106^\circ$ , and a combined focal plane of  $0.6 \text{ deg}^2$  with 180 CCDs operating in drift-scanning mode at  $60''/\text{s}$ . A separate spectrometric telescope has an aperture of  $0.5 \times 0.5 \text{ m}^2$ , a  $6.4 \text{ deg}^2$  field for the multi-bandpass photometry and a  $3.2 \text{ deg}^2$  field for radial velocities using an  $R \sim 10^4$  spectrograph in the 849-874 nm wavelength region. The satellite will operate from an orbit around the Sun-Earth L2 point at 1.01 AU from the Sun. The scanning law will be similar to that of Hipparcos, but with a solar-spin angle of  $50^\circ$ . The mission length will be at least 5 years, with a mean transmission rate of 1 Mbit/s of raw science data.

While the ESA will be responsible for building, launching and operating GAIA, including its payload, the scientific community will have to undertake all science preparations including the full data analysis task. Organisation of these activities is already in progress. Several scientific working groups, coordinated and supervised by the ESA-appointed GAIA Science Team (GST), have been established to study specific aspects of the mission.

## 7. Working Group on AC and CdC Plates

Fresneau, Chairman of the WG, at Strasbourg reports that the goals and objectives of the WG are to investigate the benefits of using the deep plates of the Astrographic Programme to extend the Astrographic Catalogue. Trials performed with the 100-yr-old plates of Paris, Bordeaux and Uccle observatories (Fresneau et al., 2001) suggest that the astrometric accuracy of a single position is about 0.2 arcsecond and the photometric precision is 0.3 mag at  $B=13$ .

By using the APM measuring machine in Cambridge, UK, the plates of Bordeaux observatory are now digitized ( $+11^\circ < \delta < +18^\circ$  zone) and will be combined with new positions obtained with the CCD meridian circle.

The APM has also scanned a set of 245 plates from Sydney Observatory in the 4th Galactic quadrant and the digitized data are now available at Macquarie University in Australia. An average stellar density is on the order of 5,000 stars per square degree. Another set of deep Sydney zone plates will be measured soon, since they provide as early epoch as 1893 with the exposure time ranging from 30 to 80 min. These deep and old plates are used in the Galactic studies towards the Southern Coalsack,  $\eta$  Car, and the Southern Centaurus.

## 8. Symposia, Colloquia, Conferences

Studies of the Solar system body properties using CCDs, held in Nikolaev, Ukraine, 20-24 June 1999.

Journées 1999 systèmes de référence spatio-temporels, & IX Lohrmann- Colloquium Motion of celestial bodies, astrometry and astronomical reference frames, held in Dresden, Germany, 13-15 September 1999.

International conference CAMMAC 99 (Comets, Asteroids, Meteors, Meteorites, Astroids, Craters), held in Vinnytsia, Ukraine, September 26 - October 1, 1999.

IAU Colloquium 180 "Towards Models and Constants for Sub-Microarcsecond Astronomy" held at the U.S. Naval Observatory, 27-30 March 2000.

JENAM 2000, European Astronomy at the Turn of the Millennium, held in Moscow, Russia, 29 May 2000.

UKRASTRO-2000 Astronomy in Ukraine and beyond, held in Kyiv, Ukraine, 5-8 June 2000.

Journées 2000 systèmes de référence spatio-temporels, "A fundamental epoch for origins of reference systems and astronomical models", held in Paris, France, 18-20 September 2000.

Journées 2001 systèmes de référence spatio-temporels, "Influence of geophysics, time and space reference on Earth rotation studies", held in Brussels, Belgium, 24-26 September 2001.

JENAM 2001, held in München, Germany, 11-15 September, 2001.

ASTRO-KAZAN 2001 Astronomy and Geodesy in New Millennium, held in Kazan, Russia, 25 - 29 September 2001.

Ceres 2001 Workshop "Astrometry and Physics of Minor Planets from Observational Networks" held in Paris, France, 9-12 October 2001.

MAO-180 Extension and Connection of Reference Frames Using CCD Ground-based Technique, held in Nikolaev, Ukraine, 10-13 October 2001.

## 9. Related Links

Division 1: <http://danof.obspm.fr/iaudiv1/>

Commission 8: <http://center.www.shao.ac.cn/IAU-COM8>

WG "Future Developments in Ground-Based Astrometry": <http://www.astro.ro/wg.html>

WG on Astrometric Catalogue & Carte du Ciel Plates:  
<http://astro.u-strasbg.fr/~fresneau/workgroup.html>

### *Selected Catalogues and Large Data Sets*

ASCC-2.5 [ftp://ftp.mao.kiev.ua/pub/astro/cc\\_nkhar/](ftp://ftp.mao.kiev.ua/pub/astro/cc_nkhar/)  
 ARIHIP <http://www.ari.uni-heidelberg.de/arihip/>  
 CMC12 <http://www.ast.cam.ac.uk/~dwe/SRF/cmc12/>  
 FONAC 1.0 <ftp://ftp.mao.kiev.ua/pub/astro/fonac/>  
 GSC II <http://www-gsss.stsci.edu/gsc/GSChome.htm>  
 Hipparcos <http://astro.estec.esa.nl/SA-general/Projects/Hipparcos/hipparcos.html>  
 SPM2.0 <http://www.astro.yale.edu/astrom/>  
 SSS <http://www-wfau.roe.ac.uk/sss/>  
 Tycho-2 <http://www.astro.ku.dk/~erik/Tycho-2/>  
 UCAC <http://ad.usno.navy.mil/ucac/>  
 USNO-A2.0 <http://www.nofs.navy.mil/data/fchpix/>

### *Astrometric Space Missions*

DIVA <http://www.ari.uni-heidelberg.de/diva/>  
 FAME <http://www.usno.navy.mil/FAME/>  
 GAIA <http://astro.estec.esa.nl/GAIA/>  
 SIM [http://planetquest.jpl.nasa.gov/SIM/sim\\_index.html](http://planetquest.jpl.nasa.gov/SIM/sim_index.html)

Wenjing Jin

*President of the Commission*

Imants Platais

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