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COMMISSION 8 ASTROMETRY

ASTROMÉTRIE

PRESIDENT	**Imants Platais**
VICE-PRESIDENT	**Irina I. Kumkova**
PAST PRESIDENT	**Wen-Jing Jin**
ORGANIZING COMMITTEE	**Edgardo Costa, Christine Ducourant, Dafydd W. Evans, Mario G. Lattanzi, Chunlin Lu, Ralf-Dieter Scholz, Mitsuru Sôma**

DIVISION I / COMMISSION 8 WORKING GROUPS

Division I / Commission 8 / WG	**Astrographic Catalogue and Carte du Ciel Plates (†)**
Division I / Commission 8 / WG	**Densification of the Optical Reference Frame**

PROCEEDINGS BUSINESS MEETING on 21 August 2006

1. Business Meeting (chair I. Platais)

The Business Meeting was opened by the president, Imants Platais. He presented the agenda which was unanimously approved. This session was attended by 40 participants. The meeting approved Dafydd Evans as secretary of minutes.

A minute of silence was observed in memory of the Commission members who had passed away since the Sydney GA: Nina Bronnikova, Jurgen Stock, Ronald Stone and Volodymyr Telnyuk-Adamchuk. Also, Zdenka Kadla who had made significant contributions to astrometry although formally she had not been a member of Commission 8.

1.1. *Commission activities 2003-2006*

Platais briefly described the main work done in this triennium. Most of the information dissemination was conducted via the Commission's WWW homepage at `<http://www.pha.jhu.edu/iau_comm8/comm8.html>`. As of this writing, the Commission's web page now has a new URL at `<http://www.ast.cam.ac.uk/iau_comm8/>`. A total of six electronic newsletters were circulated during the 2003-2006 period. Some Commission members have not reported their e-mail address or have an obsolete one that, unfortunately, resulted in a loss of communications. All members are strongly encouraged to check their personal data in the IAU membership directory and update them. This can also be done via the Commission's WWW homepage.

Following many revisions and modifications of the initial draft version, the Commission now has its own Terms of Reference. This is the main document defining the Objective, Scope, Organization, and Implementation that cover all aspects of the Commission's functions and organization in accordance with the IAU Statutes and Bye-Laws. The Terms of Reference were unanimously approved by the Commission members present at the Business meeting.

The largest task was the compilation of the Triennial Report. Platais thanked the national organizers for their excellent job in collecting the individual reports. The science highlights in this triennium were: (1) completion of large catalogues, such as NPM, USNO-B1.0 and UCAC; (2) re-analysis of the raw Hipparcos data; and (3) discovery of several low-mass "cool neighbours" near the Sun, detected by astrometric means in combination with other techniques.

A large success is the proposal by the Commission and acceptance by the IAU of the astrometric meeting entitled *A Giant Step: from Milli- to Micro-arcsecond Astrometry* (IAU Symposium No. 248) to be held in Shanghai, China PR, 15-19 October 2007. The Commission has also supported JD 16 (*Nomenclature, Precession and New Models in Fundamental Astronomy*), JD 13 (*Exploiting Large Surveys for Galactic Astronomy*) and IAU Symposium No. 240 (*Binary Stars as Critical Tools and Tests in Contemporary Astrophysics*) here at the Prague GA.

1.2. *New Commission members*

The following new Commission members were confirmed by the meeting:

a) IAU members requesting membership of Commission 8

John Bangert (USNO, USA), David Boboltz (USNO, USA), Anthony Brown (Leiden Observatory, the Netherlands), Alan Fey (USNO, USA), Toshio Fukushima (NAOJ, Japan), Valeri Makarov (JPL, USA), Francois Mignard (Observatoire de la Côte d'Azur, France), Myles Standish (JPL, USA), Yoshiyuki Yamada (Kyoto University, Japan), Taihei Yano (NAOJ, Japan).

b) New IAU members requesting membership of Commission 8

Carine Babusiaux (Paris-Meudon Obs., France), Yuri Barkin (Sternberg AI, Russia), Dalia Chakrabarty (University of Nottingham, UK), Maria-Rosa Cioni (University of Edinburgh, UK), Nicholas Cooper (University of London, UK), Vassyl Danylevsky (Kyiv AO, Ukraine), Dana Casetti-Dinescu (Yale University, USA), Marcelo Emilio (Universidade Estadual de Ponta Grossa, Brazil), Zhang Hong (Nanjing University, China PR), Liliya Kazantseva (Kyiv AO, Ukraine), Douglas Mink (Harvard Smithsonian, USA), Jucira Penna (Observatorio Nacional, Brazil), Alexander Rodin (Pushchino Radio AO, Russia), Masahiro Suganuma (NAOJ, Japan), Jonathan Tedds (Leicester University, UK).

c) Commission consultants

The current Commission consultants expressed their wish to discontinue membership. Thus, there are no consultants within Commission 8.

This brings the total membership in the Commission to 241, representing 31 countries.

1.3. *Election results and new Commission Officers*

Platais Platais thanked the outgoing members of the Organizing Committee: Edgardo Costa, Christine Ducourant, Wen-Jing Jin, Mario Lattanzi, and Chunlin Lu for their dedicated service. Elections have been held for the positions of president, vice-president and five vacant Organizing Committee posts. By IAU tradition, the outgoing Vice-President, Irina Kumkova, becomes the new commission president. Out of four nominations for vice-president, only one agreed to remain on the ballot list. Dafydd Wyn Evans was elected unanimously by the Organizing Committee to the position of vice-president for 2006-2009. Eleven commission members were nominated to the new Organizing Committee. The following five were elected (taking into account geographical distribution): Alexandre Andrei, Alain Fresneau, Petre Popescu, Norbert Zacharias, Zi Zhu.

The new Organizing Committee for 2006-2006 was approved by acclamation:
Irina I Kumkova (president, Russia), Dafydd Wyn Evans (vice-president UK). Members: Alexandre H. Andrei (Brazil), Alain Fresneau (France), Imants Platais (USA, ex officio), Petre P. Popescu (Romania), Ralf-Dieter Scholz (Germany), Mitsuru Soma (Japan), Norbert Zacharias (USA), and Zi Zhu (China PR).

2. Working Group reports

In 2003-2006 Commission had two working groups set up to accomplish specific tasks. Their reports and the decisions made about their future are provided below.

2.1. *WG on Densification of the Optical Reference Frame*

Urban (USNO) reported on this Working Group. The main objectives of the WG is the dissemination of information rather than the production of a deliverable. It was pointed out that originally this group was a subgroup under the ICRS Working Group of Division I and that at the Sydney GA it became a Working Group under Commission 8.

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Since the Sydney GA, many new catalogues have been measured and released. Also new technology and hardware are becoming available that will be useful for the WG's task, in particular CMOS detectors which have a large dynamic range.

Detailed information on various ground-based and astrometric satellite projects can be found on the WG's WWW homepage at <http://ad.usno.navy.mil/dens_wg/>. Urban asked if the Working Group should continue and requested that, if it did so, it should be under new leadership. Platais gave the group his endorsement and opened the floor for discussion. Among the audience Corbin, Evans, Hilton, Platais, van Altena, Zacharias made several suggestions mainly related to the Working Group's mission in the context of astrometric support to astronomers outside the Commission.

Platais then proposed Zacharias (USNO) as the next chairman of the Working Group and described his work and qualifications. Since there were no objections, Zacharias was approved to this post for 2006-2009.

2.2. *AC/CdC Working Group*

Zacharias (USNO) gave a report on behalf of Beatrice Bucciarelli, the chairwoman of this WG, on the AC/CdC Working Group. The goals of the WG were described and recent results given. Scanning has been carried out for the following CdC zones: Cordoba, San Fernando, Toulouse (photometry), Bordeaux (PM2000) and Sydney. Although no CdC scanning has been carried out at the 1 micron level, it has been done at the 2-3 micron level. More details are provided on the WG's website at <http://www.to.astro.it/AC_CdC/>.

Owing to scheduling issues and prior to this meeting, the Working Group had already become part of the Preservation and Digitization of Photographic Plates (PDPP) Task Force under Commission 5. Its chairwoman Elizabeth Griffin described this Task Force and the history behind it. She also explained why the AC/CdC Working Group would fit very well within the PDPP Task Force. Platais added that Bucciarelli had carried out a poll of AC/CdC Working Group members and they agreed to the move. Griffin also added that ordinary scanners are not good enough for digitizing photographic plates. Harvard have just completed building a new scanner as have Brussels. The way forward is to build and clone new machines, since it is difficult to keep the old machines running. Platais said that many of the existing premier measuring machines were currently out of action and not supported both technically nor financially.

Since no proposals were put forward for new working groups, in 2006-2009 under Commission 8 there will only be the WG on Densification of the Optical Reference Frame. With this, the Business Session was adjourned.

3. **Frontiers of Astrometry** (chairs J. Kovalevsky & R. Gaume)

In the preceding half a year Platais made all necessary preparations for a very successful science session entitled "Frontiers of Astrometry". The talks were mostly by invitation and covered the main areas of cutting-edge astrometric science and its applications. The abstracts provided here show the scope of the talks but cannot give the details. Therefore, many speakers have agreed to put their presentations on line. The reader is invited to visit the Commission's new website listed above and enjoy these presentations.

3.1. *Abstracts sorted alphabetically by the first author's name*

3.1.1. *A DATABASE OF QSOs AND SURROUNDING STARS FROM THE SDSS, by A. H. Andrei (MCT,UFRJ), J. I. Bueno de Camargo (UFRJ), M. Assafin (UFRJ), D. N. da Silva Neto (UFRJ) & R. Vieira Martins (MCT)*

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Sloan Digital Sky Survey (SDSS) Data Release 4 is used to select 62,021 QSOs and the stellar content from a 10-arcmin area surrounding each QSO. Available positional, photometric (and redshift) information for each QSOs and neighbouring stars is stored in the database, along with the error and quality indicators. When compressed the database occupies 4.4 GB only. Simple routines allow us to interrogate the database for the content in a specified area or query individual QSOs and stars. We will demonstrate the database and its use. Further, we will discuss the photometric peculiarities of stellar population around the QSOs. The conclusions we derive may have a significant value for the *Gaia* mission. Our database also enables an investigation of the QSO counterparts and their properties in the USNO B1.0 catalog and, thus, provides insights on the effectiveness of the USNO B1.0 as a research tool for the entire sky. Finally, an estimate of the SDSS astrometric position accuracy is also presented.

3.1.2. *HUBBLE FGS PARALLAXES OF GALACTIC CEPHEIDS AND P-L RELATIONS, by G. F. Benedict (U. of Texas), B. E. McArthur, T. G. Barnes, M. Feast, T. E. Harrison, R. J. Patterson, J. Menzies, and W. Freedman*

We present new absolute trigonometric parallaxes and relative proper motions for 9 Galactic Cepheids: l Car, ζ Gem, β Dor, W Sgr, X Sgr, Y Sgr, FF Aql, T Vul, and RT Aur. We obtained these results with astrometric data from Fine Guidance Sensor 1r (FGS), a white-light interferometer on *Hubble Space Telescope*. We estimate spectral type and luminosity class of the stars comprising each astrometric reference frame from various sources. The derived spectrophotometric parallaxes of reference stars are introduced into our models as observations with an error. We model a volume of space, and our end result is an absolute parallax for each Cepheid. The spectrophotometry also aids in estimating interstellar absorption, required for target absolute magnitudes. Adding our previous absolute magnitude determination for delta Cep, we construct a Period-Luminosity Relation for ten galactic Cepheids. We establish zero-points of the V, I, K, and Wesenheit W(VI) Period-Luminosity relationships with random errors of only 0.03 mag.

3.1.3. *WHERE IS GAIA NOW? by A. Brown (Leiden Observatory)*

Gaia is the European Space Agency mission which will provide a stereoscopic census of our Galaxy through the measurements of high precision astrometry, radial velocities and multi-colour photometry. *Gaia* is scheduled for launch in late 2011 and over the course of its five year mission will measure parallaxes and proper motions for every object in the sky brighter than visual magnitude 20 - amounting to about 1 billion stars, galaxies, QSOs, and solar system objects. It will achieve an astrometric accuracy of 12-25 micro-arcsec at 15th magnitude and 100-300 micro-arcsec at 20th magnitude. Multi-colour photometry will be obtained for all objects by means of low-resolution spectrophotometry between 330 and 1000 nm. In addition, radial velocities with a precision of 1-10 km/s will be measured for all objects down to 17th magnitude, thus providing full six-dimensional phase space information for the brighter sources. *Gaia* thus represents an improvement of several orders of magnitude over *Hipparcos* in terms of numbers of objects, accuracy and limiting magnitude. *Gaia* is fully funded by ESA and the prime contractor, EADS-Astrium, will build both the spacecraft and the scientific payload. The data processing is a task for the scientific community. I will present a brief overview of the current status of the *Gaia* mission with an emphasis on describing the latest EADS-Astrium design of the spacecraft and payload.

3.1.4. *SYNERGY BETWEEN RADIOASTRONOMY AND ASTROMETRY, by E. Fomalont (NRAO)*

High resolution radio interferometry has revolutionized astrometry over the last 30 years. Since the strongest radio sources have compact components smaller than 0.1 mas and are at cosmological distances, they form an excellent set of fixed fiducial points in the sky needed to define a quasi-inertial reference frame. In the 1990's the astronomical community defined the International Celestial Reference System (ICRS), based on a catalog of distant radio sources, and the frame orientation is accurate to 0.02 mas. Other frames (optical, solar-system ephemerides) are now tied to the ICRS. The relative position radio sources within a a few degree region of sky can be determined to an accuracy of 0.01 mas with about five hours of integration time using a large array, such as the VLBA, EVN and VERA. This type of observation have determined the basic astrometric parameters of objects with accuracy much greater than from other astronomical techniques, and rival that of future space interferometry missions. Some examples of putting in work the radio interferometry are: tests of General Relativity; detectable parallax for (radio)stars and pulsars anywhere in the galaxy; dynamics of the galactic center black hole; proper motions of radio-sources in nearby galaxies and accurate distance estimates; orbital motion of binary systems (GPB target); rotation of disks around black holes. Radio interferometry at higher frequencies with ALMA will open new horizons in the galactic and extragalactic research.

3.1.5. *INFRARED ASTROMETRIC SATELLITE JASMINE, by N. Gouda (NAOJ), Y. Kobayashi (NAOJ), Y. Yamada (Kyoto U.), T. Yano (NAOJ), T. Tsujimoto (NAOJ), M. Suganuma (NAOJ), Y. Niwa (Kyoto U.), M. Yamauchi (U. of Tokyo), Y. Kawakatsu (JAXA), H. Matsuhara (JAXA), A. Noda (JAXA), A. Tsuiki (JAXA), M. Utashima (JAXA), A. Ogawa (JAXA), N. Sako (U. of Tokyo) and JASMINE working group.*

We present the Japanese plan for the infrared (z-band: 0.9 mkm) *JASMINE* space astrometry project. *JASMINE* (*Japan Astrometry Satellite Mission for INfrared Exploration*) will measure the parallaxes and apparent motions of stars around the center of the Milky Way with unprecedented 10 micro-arcsec precision for parallaxes and positions and 10 micro-arcsec/yr for proper motions down to z = 14 mag. *JASMINE* will observe about ten million stars belonging to the bulge of our Galaxy, that are hidden by the interstellar dust extinction at optical wavelengths. The anticipated deep and precise mapping of the Milky Way bulge is expected to yield many new exciting scientific results in various fields of astronomy. Presently, *JASMINE* is in the development phase, with a target launch date around 2015. We have adopted a 3-mirror modified Korsch optical system for *JASMINE* with a primary mirror of 1 m. In the focal plane there are dozens of new type CCDs in the z-band to get a wide FOV. The highly-accurate measurements of astrometric parameters require an exceptional stability of the instrument's line-of-sight, including the stability of opto-mechanical parts of the payload. Currently, the overall system (bus) design is ongoing in cooperation the Japan Aerospace Exploration Agency (JAXA).

3.1.6. *DEEP ASTROMETRIC STANDARDS, by I. Platais (JHU), S.G. Djorgovski (Caltech), C. Ducourant (Obs. Bordeaux), A. Fey (USNO), S. Frey (FOMI), Z. Ivezic (UWa), K. Mighell (NOAO), A. Rest (NOAO), R. F. G. Wyse (JHU), N. Zacharias (USNO)*

The advent of next generation imaging telescopes such as LSST and Pan-STARRS - instruments with wide fields and huge Giga-pixel cameras - will soon create a critical need for deep and precise reference frames for astrometric calibrations. The Deep Astrometric Standards (DAS) program aims to establish such a frame by providing astrometry at the 5-10 mas accuracy level in four 10 sq. deg Galactic fields, to a depth of $V = 25$. We use 3-4 m class optical telescopes to set up these standards. The principal source of our reference frame is UCAC2 and VLBI positions of radio-loud QSOs having optical counterparts with $V < 25$. The novelty of the DAS project is a new way of linking our observations to the ICRF. We pre-select the candidate radio-optical link sources from existing radio surveys, then conduct the VLA observations to measure the spectra and spatial compactness and, finally, observe the best 10-15 sources with the VLBI. So far, two out of the four DAS fields are in the advanced stages of construction.

3.1.7. *A QUEST FOR THE NEAREST STARS, by R.-D. Scholz (AIP)*

The stellar census in the Solar neighbourhood is still remarkably incomplete. Even within a very locally set horizon of 10 pc more than 30% of the stars, mainly red and white dwarfs, are missing. In addition, we may be surrounded by large numbers of brown dwarfs from which only few (less than 10%) have been detected so far. In this talk I will give a brief review on various recent activities to foster our knowledge on the nearest stellar and sub-stellar neighbors and will summarise our own efforts: (1) to identify stellar neighbours among known proper motion stars; (2) to extend high proper motion surveys to fainter magnitudes in order to find extremely cool neighbours of different classes (brown dwarfs, cool subdwarfs and cool white dwarfs). The search for faint high proper motion objects based on archival data from SuperCOSMOS Sky Surveys led to the discovery of the nearest known brown dwarf, ϵ Indi B, later resolved as a close pair of T dwarfs and of some of the coolest known subdwarfs, members of the Galactic halo population crossing the Solar neighbourhood at high velocities.

3.1.8. *SIM PLANETQUEST – A SCIENCE AND MISSION UPDATE, by M. Shao (JPL)*

The *Space Interferometry Mission PlanetQuest* (*SIM PlanetQuest*) will be the first space-based long baseline Michelson interferometer designed for precision astrometry. With an

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accuracy of a few microarcseconds, *SIM* will contribute strongly to many fields including stellar and galactic astrophysics, planetary systems around nearby stars, and the study of quasar nuclei. *SIM* will search for planets with masses as small as a few Earth masses around the nearest stars, using measurements to 1 micro-arcsec precision. It will detect planets around young stars, providing insights into the how planetary systems are born and how they evolve with time. *SIM* will measure positions to 4 micro-arcsec on targets as faint as 19 mag, allowing accurate distances to many types of stars, and will measure stellar masses to 1%, the accuracy needed to challenge physical models. *SIM* will probe the galactic mass distribution, and through studies of tidal tails, the formation and evolution of the galactic halo, using measurements of proper motions. It will use precision astrometry to probe accretion disks and relativistic jets in the variable nuclei of active galaxies. *SIM PlanetQuest* is currently in project Phase B, with a preliminary Design Review in 2007.

3.1.9. *ABRUPT CHANGES IN THE EARTH'S ROTATION SPEED, by M. Soma (NAOJ) and K. Tanikawa (NAOJ)*

From our analyses of total and annular solar eclipses recorded in Asia and Europe we show that the Earth's rotation speed changed abruptly in about AD 500 and AD 900. Specifically the parameter value DeltaT = TT-UT for the Earth's excess rotation changed by more than 3000 s within 160 years around the year 500, whereas it changed by more than 600 s within 40 years around the year 900.

3.1.10. *NEAR-INFRARED PARALLAX PROGRAM AT USNO, by F. Vrba (USNO)*

Beginning in 2000 at the USNO Flagstaff Station we began a program of measuring parallaxes and proper motions at near-infrared wavelengths of brown dwarfs, which are generally too cool and faint to be included in the USNO CCD parallax program. The program began with an initial selection of 40 objects evenly divided between L-type and T-type dwarfs. Preliminary results of the first two years of observations were previously reported by Vrba *et al.* in 2004, with the best parallaxes in the range of 1.5 mas. Since that time, the astrometric accuracies have been greatly improved and the program has been expanded to nearly 80 objects. I will review current astrometric accuracies and the program object list and discuss prospects for the future of the program.

3.1.11. *IAU 2000 RESOLUTIONS FOR THE GENERAL USER, by P. Wallace (SSTD/HMNAO)*

Even before 2000, the *Hipparcos* catalogue had provided a two-orders-of-magnitude increase in the accuracy of the optical frame, and the introduction of the ICRS had, once and for all, broken the link between star catalogues and the orientations of the equator and ecliptic. The IAU 2000 B1 resolutions added various refinements, including a more accurate precession-nutation model and two general-relativity-based reference systems for barycentric and geocentric problems. But to many users the most troubling change was the replacement of the equinox as the zero point for right ascensions and the elimination of sidereal time. The justification for the changed precession-nutation model was clear: a 2-3 orders of magnitude improvement in accuracy. Less obvious was that at these levels of accuracy the traditional equinox based methods had become unwieldy. A symptom of this was the complexity of the GST formula, now requiring both TT and UT and including dozens of correction terms. The "new paradigm" introduced in 2000 cleanly separates Earth rotation from the orientation of the Earth's axis, so that Earth rotation angle, the successor to GST, is simply a two-coefficient linear transformation of UT1. In fact none of this will affect the general user very much; the main consequence is that ordinary astronomers are now shielded from complicated and subtle details and some intimidating nomenclature. The real challenge is getting used to the improvements, and educating new generations of students.

3.1.12. *GROUND-BASED SURVEYS: UCAC AND BEYOND, by N. Zacharias (USNO)*

The all-sky and selected area-based astrometric surveys are reviewed. Recently the Carlsberg/Cambridge and Bordeaux scanning transit circle programs were completed, providing astrometric data for a large fraction of the sky down to about 17th magnitude. The USNO CCD Astrograph Catalog (UCAC) observing program was completed in 2004. Details about the

UCAC3 reductions and products will be presented, including the efforts to measure old photographic plates. The goal of the USNO robotic astrometric telescope (URAT; aperture 0.85 m, FOV 4.5 sq. deg) is to provide positions, proper motions and parallaxes at the 5 mas level in the 14-18 a limiting magnitude of 20. Going even deeper, the Pan-STARRS program will provide a multi-color survey down to 23rd magnitude with a great astrometric potential. Accurate reference stars for calibrating the new generation instruments, including the Large Synoptic Survey Telescope (LSST), will be provided in selected areas by the Deep Astrometric Standards (DAS) program.

Imants Platais
president of the Commission

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