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COMMISSION 8 ASTROMETRY *(ASTROMETRY)*

PRESIDENT	**Irina Kumkova**
VICE-PRESIDENT	**Dafydd Wyn Evans**
PAST PRESIDENT	**Imants Platais**
ORGANIZING COMMITTEE	**Alexandre Andrei, Alain Fresneau, Petre Popescu, Ralf-Dieter Scholz, Mitsuru Sôma, Norbert Zacharias, Zi Zhu.**

PROCEEDINGS BUSINESS SESSION, 10 August 2009

1. Business session (Chair I. Kumkova)

The business meeting was opened by the President, Irina Kumkova. She presented the agenda, which was approved. This session was attended by 42 participants. The meeting approved Dafydd Evans as secretary of minutes. A minute of silence was dedicated to the memory of the Commission members who had passed away since Prague GA, namely:

Gérard Billaud (Grass Observatory, France),
Peter Stephen Bunclark (Institute of Astronomy University of Cambridge, UK),
Dmitry Polozhentsev (Pulkovo Observatory, Russia).

1.1. *Commission Activities 2006–2009*

Kumkova reported about the main work done during the triennium. Most of the information dissemination was conducted via the Commission's WWW home page at `http://www.ast.cam.ac.uk/iau_comm8/`. A total of five electronic newsletters were circulated during the 2006–2009 period. Unfortunately, several Commission members have not reported their changed and new e-mail addresses which resulted in a loss of communication. All members are strongly encouraged to check and update their personal data in the IAU membership directory. The difficult task undertaken was the compilation of the Triennial Report. Kumkova thanked the national organizers of the job in collecting the individual reports. The science highlights in this triennium were:

(*a*) A new reduction of Hipparcos data van Leeuwen (2007), which resulted in a higher accuracy of parallaxes, improved by up to a factor 5 for the brightest stars.

(*b*) Much effort was dedicated to the preparation of the Gaia mission, now approved to be launched in 2011.

(*c*) JASMINE – a Japanese infrared astrometric satellite – Nano-JASMINE will be launched in 2010.

(*d*) IAU Symposium 248 "A Giant Step: From Milli- To Micro-Arcsecond Astrometry" was very successfully held in Shanghai, China PR, October 2007.

1.2. *New Commission Members*

The following new Commission members were confirmed by the meeting:

1.2.1. *IAU members requesting membership of Commission 8*

Sergei Klioner (Russia)
Timo Prusti (Netherlands)
Jan Souchay (France)

1.2.2. *New IAU members requesting membership of Commission 8*

Ummi Abbas (USA)	Nakagawa Akiharu (Japan)
Eswar Bacham (India)	Octavian Badescu (Romania)
Antoine Bouchard (South Africa)	Yavor Chapanov (Bulgaria)
Alfred Chen (Taiwan)	Melania Del Santo (Italy)
Lan Du (China PR)	Octavi Fors (Spain)
David Hobbs (Ireland)	Anatoliy Ivantsov (Ukraine)
Belinda Kalomeni (Turkey)	Sebastien Lepine (Canada)
Nadiia Maigurova (Ukraine)	Claudio Mallamaci (Argentina)
Yury Nefed'ev (Russian Federation)	Jinsong Ping (China PR)
Sabine Reffert (Germany)	Zhiqiang Shen (China PR)
Alessandro Sozzetti (Italy)	Fuping Sun (China PR)
Andrea Zacchei (Italy)	Wei Zhang (China PR)
Yong Zheng (China PR)	

The total membership in the Commission has now reached 259, representing 36 countries.

1.3. *Election Results and New Commission Officers*

Kumkova thanked cordially the outgoing members of the Organizing Committee: Imants Platais, Alain Fresneau, Ralf-Dieter Scholz, Mitsuru Sôma for their dedicated service. Elections were held for the positions of President, Vice-President and four vacant positions in the Organizing Committee. By IAU tradition the outgoing Vice-President, Dafydd Evans, becomes the new Commission President. Out of two nominations for Vice-President only one agreed to remain on the ballot list. Norbert Zacharias was elected as Vice-President unanimously by the Organizing Committee. Seven scientists were nominated to the new Organizing Committee. Four among these have been elected (taking into account geographical distribution): A. Brown (Netherlands), N. Gouda (Japan), J. Souchay (France), S. Unwin (USA). The new Organizing Committee was approved unanimously.

The Commission officers for 2009–2012 are
Dafydd W. Evans (UK) President
Norbert Zacharias (USA) Vice-President

Organizing Committee:
A. Andrei (Brazil)
A. Brown (Netherlands)
N. Gouda (Japan)
I.Kumkova (Russia)
P. Popesku (Romania)
J. Souchay (France)
S. Unwin (USA)
Z. Zhu (China)

1.4. *Report of the WG on Densification of the Optical Reference Frame*

Zacharias (USNO) presented the final report of this WG, who suggested to terminate the WG and received no objections from the members. More work in this area will continue by a few dedicated colleagues but it was felt that no IAU organizing structure is needed to support this activity.

The web site of the WG was moved to `www.astro.yale.edu/astrom/dens_wg/` where all 3 newsletters of the past triennium can be found together with a general overview about optical astrometric surveys and their future.

The achievements of the WG up to 2008 have been summarized in Zacharias (2009). Highlights for this year are the almost completed Southern Proper Motion (SPM) 4th catalog and the release of the third US Naval Observatory CCD Astrograph Catalog (UCAC3) at the XXVII GA. The Yale San-Juan first-epoch catalog (YSJ1) forms the basis for both the early epoch SPM4 and the UCAC3 southern proper motions.

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New observing programs were briefly mentioned. Within the next few years large amounts of sky survey data are expected from projects like PanSTARRS (Hawaii), SkyMapper (Siding Springs), and URAT/U-mouse (USNO). Several astrometric space missions are in preparation as well: Jasmine (Japan), J-MAPS (USNO), and Gaia (ESA).

1.5. *General discussion and AOB*

Kumkova started the discussion by asking how do we make the Commission more active? Pourbaix thought that we didn't have to worry too much and that there was nothing to change. Look at the triennial report which lists many Commission 8 activities. Most of the rest of the discussion focussed on organizing more astrometric meetings.

van Altena thought that it was good to reinstate the science sessions at the General Assemblies, Souchay wondered if there is a big astrometry meeting planned? Kumkova said that we have had difficulty to get IAU support for these. We tried 3 or 4 times and the very good Shanghai meeting was the result. Small meetings are probably more likely. Also we need to wait for new results.

Klioner pointed out that next year there will be a Gaia meeting in Paris. It is important to stress the new face of astrometry. It is a tool for astronomy in general. We need to attract new people. Commission 8 should help with this.

Kumkova said that the China-France school was good for this and Capitaine pointed out that there will also be regular Journée meetings. Evans asked that any details about future meetings be sent to him to put on the Commission 8 website.

Popescu suggested that next year or so might be a good opportunity to have a small meeting on QSOs and the reference frame. He asked Souchay if he would be willing to organize this. Ma thought that this would be a good idea since the optical-radio link will still be important before Gaia catalogues get released.

Souchay pointed out that in Paris they have not had problems attracting young astronomers to do astrometry. Gaia will have a magnitude limit of 20, so transfering the reference frame to denser magnitudes using CCD observations will be important.

Kumkova finished by pointing out that we should not consider astrometry as separate from astrophysics. We will need to draw attention of young astronomers to the topic and perhaps organize groups on specific problems.

Two short presentations were given by van Altena on SPM4 and his new astrometry book.

2. Science Sessions (chairs N.Zacharias & D.W.Evans)

The following presentations were given during the meeting. Summaries are given here. Many of the presentations can be found on the meeting website:
http://www.ast.cam.ac.uk/iau_comm8/iau27/

2.1. *400 Years of Astrometry: From Tycho Brahe to Hipparcos*
Erik Høg (Niels Bohr Institute, Copenhagen)

The four centuries of techniques and results were reviewed, from the pre-telescopic era until the use of photoelectric astrometry and space technology in the first astrometry satellite, Hipparcos, launched by ESA in 1989. Galileo Galilei's use of the newly invented telescope for astronomical observation resulted immediately in epochal discoveries about the physical nature of celestial bodies, but the advantage for astrometry came much later. The quadrant and sextant were pre-telescopic instruments for measurement of large angles between stars, improved by Tycho Brahe in the years 1570–1590. Fitted with telescopic sights after 1660, such instruments were quite successful, especially in the hands of John Flamsteed. The meridian circle was a new type of astrometric instrument, already invented and used by Ole Roemer in about 1705, but it took a hundred years before it could fully take over. The centuries-long evolution of techniques was reviewed, including the use of photoelectric astrometry and space technology in the first astrometry satellite, Hipparcos, launched by ESA in 1989. Hipparcos made accurate measurement of large angles a million times more efficiently than could be done in about 1950 from the ground, and it will soon be followed by Gaia which is expected to be another one million times more efficient for optical astrometry.

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2.2. *Series of JASMINE projects – Exploration of the Galactic Bulge*

Naoteru Gouda and JASMINE Working Group (National Astoronomical Observatory of Japan)

An introduction was given for the following series of JASMINE projects in Japan:

Nano-JASMINE project: Nano-JASMINE project is planned to demonstrate the first space astrometry in Japan and to perform experiments for verification of some techniques and operations for JASMINE. Nano-JASMINE uses a nano-satellite whose size and weight are about 50 cm^3 and 25 kg, respectively. The targeted accuracy of parallaxes is about 3 mas at z=7.5 mag. Moreover, proper motions with high accuracies (0.1 mas/year) can be achieved by combining the Nano-JASMINE catalogue with the Hipparcos catalogue. There is a high possibility that Nano-JASMINE will be launched by a Cyclone-4 rocket in July 2010.

Small-JASMINE project: Small-JASMINE is an astrometric mission that observes in an infrared band (Kw-band). The central wavelength is 2.0 micron. Small-JASMINE will determine positions and parallaxes accurate to 10 micro-arcseconds for stars in the Galactic bulge, brighter than Kw=11 mag, and proper motion errors of 10 micro-arcseconds/yr. It will observe small areas of the Galactic bulge with a single beam telescope with a diameter of the primary mirror of around 30cm. The target launch date is around 2015. The main science objective of small-JASMINE is to clarify the formation history of the Galactic bulge and also determine the moderate model of bulge structure formation.

JASMINE project: JASMINE is an extension of the small-JASMINE mission. It is designed to perform a survey towards the whole Galactic bulge region with a single-beam telescope with a primary mirror diameter of around 80cm, determining positions and parallaxes accurate to 10 micro-arc seconds for stars brighter than Kw=11 mag, and proper motion errors of 10 micro-arc seconds/yr. The target launch date is around 2010–2015

2.3. *A Very Small Satellite for Space Astrometry: Nano-JASMINE*

Yoichi Hatsutori, Naoteru Gouda, Yukiyasu Kobayashi, Taihei Yano, Yoshiyuki Yamada and the Nano-JASMINE team, National Astoronomical Observatory of Japan

The outline and the current status of the Nano-JASMINE project was presented. The objective of this project is a scientific, astrometric and technical demonstration for JASMINE and a first experience of space astrometry in Japan. Nano-JASMINE is a very small satellite for space astrometry. It is only 25 kg and aims to carry out astrometric measurements of nearby bright stars ($z<7.5$mag) with an accuracy of 3 milli-arcseconds. This satellite adopts the same observation technique used by the HIPPARCOS satellite. In this technique, two different fields of view are observed by a beam-combiner simultaneously. The Nano-JASMINE telescope is based on a standard Ritchey-Chretien type optical system and has a beam-combiner, a 5 cm effective aperture, a 167 cm focal length and a field of view of 0.5×0.5 degree. The major technical difference between Nano-JASMINE and HIPPARCOS is the CCD sensor. A full depletion CCD will be used in a time delay integration (TDI) mode in order to efficiently survey the whole sky in wavelengths, including the near infrared. By using TDI mode, Nano-JASMINE will achieve astrometric accuracy comparable to that achieved by HIPPARCOS but with a small satellite. From a scientific viewpoint, Nano-JASMINE will measure the same stars that were observed by HIPPARCOS with the same accuracy, then a significant improvement on the accuracy of proper motions can be made and correct the degradation of the HIPPARCOS catalogues. The current status of Nano-JASMINE is that it is in the process of production as an engineering model. Thermal tests and vibration tests have already been conducted with a Structure-Thermal Model (STM) last summer, and the design validation of the satellite was confirmed. Moreover, it is confirmed that the telescope can achieve the diffraction limit during the performance test. The plan is to launch Nano-JASMINE in 2010. National Astronomical Observatory of Japan, The University of Tokyo, Alcantara Cyclone Space and SDO Yuzhnoye have reached a consensus to launch Nano-JASMINE with the Cyclone-4 rocket in the Federal Republic of Brazil.

2.4. *The Second Realization of the International Celestial Reference Frame: ICRF-2*

Alan L. Fey, USNO

Construction of a second realization of the International Celestial Reference Frame, ICRF-2, has been underway for the last several years. The work was carried out by two working groups: the ICRF-2 Working Group of the International Earth Rotation and Reference System Service (IERS) in cooperation with the International VLBI Service for Geodesy and Astrometry

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(IVS) and the ICRF-2 Working Group of the International Astronomical Union. The task of the IERS/IVS Working Group was to generate ICRF-2 from Very Long Baseline Interferometry observations of extragalactic radio sources consistent with the current realization of the International Terrestrial Reference Frame and Earth Orientation Parameter data products with oversight from the IAU Working Group. A brief summary of the results were presented.

2.5. *Strengthening the ICRS optical link in the northern hemisphere*

P. Popescu, A. Nedelcu, O. Badescu & P. Paraschiv, Astronomical Institute of the Romanian Academy

In 2005 the Astronomical Institute of the Romanian Academy has started an observational program, using the Belogradchik Zeiss Telescope (Bulgaria), to investigate the link between the International Celestial Reference Frame (ICRF) and its representation at optical wavelengths. 59 astrometric positions of ICRF optical counterparts were obtained with average values of the optical-radio offsets of +6 mas and +7 mas in R.A. and Declination and standard deviation of 51 mas and 57 mas respectively. The radio-stars astrometry program is in progress and it will be extended to include sources from the VLBA Calibrator Survey – the largest high resolution radio survey available.

2.6. *UCAC, NOMAD, URAT - star catalogs for astrometry*

Norbert Zacharias, USNO

Properties of the final release of the USNO CCD Astrograph Catalog were presented. This all-sky astrometric catalog supersedes UCAC2. The USNO Robotic Astrometric Telescope is a new observing program which will begin in late 2009. Plans for updates of the Naval Observatory Merged Astrometric Dataset (NOMAD) were discussed and recommendations given about the "best" star catalog to be used for astrometric reference stars for the general astronomer.

2.7. *Determination of L Dwarf Distances and Objects in the L/T Transition*

Richard Smart, Jucira Lousada Penna, Alexandre H. Andrei, Ramachrisna Teixeira, Beatrice Bucciarelli, Victor A. d'vila, Julio Ignácio Bueno de Camargo, Dario N. da Silva Neto, Mario Lattanzi, Kátia M.L. da Cunha

L and T dwarfs are ultracool objects, cooler than M dwarfs, which are fundamental to the understanding of the star/planet transition. They have spectra dominated by molecular absorption due to water, methane and pressure-induced molecular hydrogen. Since the first defining L dwarfs, GD165B was known in 1997, there have been nearly 500 discovered. These come primarily from the Sloan Digital Sky Survey and from 2MASS. Model atmosphere analyses indicate temperatures of 2500 to 750 K. To understand the intrinsic properties of ultra cool dwarfs and ultimately massive Jupiter-like exoplanets, it is essential to determine their absolute luminosities. The only direct method to achieve this is with astrometric parallaxes, yet to date less than 40 have measured parallaxes. In this project a systematic determination is undertaken of L and T dwarf parallaxes. While the sequence of subdwarf luminosities is already reasonably defined by the objects with known parallaxes, this program allows a substantial improvement on that calibration and allow for direct confrontation with the structure models for sub-stellar objects. The observations are being made at the WFI ESO2.2m, La Silla. The program started in April 2007 and has secured time at least to the end of 2009. It contains 140 objects, all of which already with four or more observations. Typically the observations are made every other month, and so far there are at least four observations for each object, up to ten observations. This has enabled a first determination of parallaxes to some objects and a comprehensive study of the 2MASS referred proper motion field. The astrometric repeatability is at 10mas. At this level there is a significant reduction on the length and number of observations usually required for this type of program.

2.8. *The LQRF - An Optical Representation of the ICRS*

A.H. Andrei, J. Souchay, N. Zacharias, R.L. Smart, R. Vieira Martins, D.N. da Silva Neto, J.I.B. Camargo, M. Assafin, C. Barache, S. Bouquillon, J.L. Penna

The large number and all sky repartition of quasars from different surveys combined with their presence in large, deep astrometric catalogues, enables us to build an optical materialization of the ICRS following its defining principles - namely, kinematically non-rotating with respect

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to the ensemble of distant extragalactic objects, aligned to the mean equator and dynamical equinox of J2000, and realized by a list of adopted coordinates of extragalatic sources. The LQRF (Large Quasar Reference Frame) was built with the care of avoiding misrepresentation of its constituent quasars, of homogenizing the astrometry from the different catalogues and lists from which the constituent quasars are gathered, and of attaining the milli-arcsecond global alignment to the ICRF, as well as typical individual source position accuracies even to better than 100 milli-arcsecond. Starting from the updated and presumably complete LQAC (Large Quasar Astrometric Catalog) list of QSOs, initial optical positions for those quasars are found in the USNO B1.0 and GSC2.3 catalogues and from the SDSS Data Release 5. The initial positions are next placed onto the UCAC2-based reference frames, followed by an alignment to the ICRF, as well as of the most precise sources from the VLBA calibrator list and from the VLA calibrator list - in the three cases under the proviso that reliable optical counterparts also exist. Finally, the LQRF axis are surveyed through spherical harmonics, considering right ascension, declination and magnitude terms. The LQRF contains 100,165 quasars, well represented on an all-sky basis, from -83.5 to +88.5 degrees of declination, and with 10 arcmin as the average distance between adjacent elements. The global alignment to the ICRF is of 1.5 mas, and the individual position accuracies are represented by a Poisson distribution peaking at 139 mas on right ascension and at 130 mas on declination. As a by product, significant equatorial corrections appear for all the used catalogues (except the SDSS DR5), an empirical magnitude correction can be discussed for the GSC2.3 intermediate and faint regimens, both the 2MASS and the preliminary northernmost UCAC2 positions show consistent astrometric accuracy, and the harmonic terms come out small always. The LQRF contains J2000 referred equatorial coordinates and is completed by redshift and photometry information from the LQAC. It is aimed to be an astrometric frame, but it is also the basis for the Gaia mission initial quasars list and can be used as a testbench for quasar space distribution and luminosity function studies. The LQRF will be updated when there is a release of new quasar identifications and newer versions of the used astrometric frames. In the later case, it can itself be used to examine the interrelations between those frames.

2.9. *Astrometry of ICRF Sources: The Influence of Radio Extended Structures on Offsets between the Optical and VLBI Positions*

J.I.B. Camargo, M. Assafin, A.H. Andrei, R. Vieira-Martins & D.N. Da Silva Neto

The International Celestial Reference Frame – ICRF – is the currently adopted IAU celestial reference frame. Its coordinate axes are materialized by the positions of 212 extragalactic radio sources unevenly distributed over the entire sky. Such positions are determined by VLBI techniques and have a median uncertainty better than 0.5 milliarcsecond. In addition to these so called defining sources, other 505 extragalactic radio sources are also listed in the ICRF. Their VLBI positions are consistent with the ICRF and serve to densify the frame. All of them, no matter whether defining or not, are in practice used to directly access the ICRF and may present spatially extended structures as seen from their high resolution S/X-band images. In this work, optical positions are obtained of 14 compact and extended ICRF sources with the ESO/MPG 2.2m telescope and compared to their VLBI counterparts. The intrinsic radio structure of the extragalactic sources is one of the limiting factors in defining the ICRF. It may also lead to the noncoincidence between the VLBI and optical positions. This question of noncoincidence, already addressed and verified by da Silva Neto (2002), is revisited here. In particular, two sources are identified for which this noncoincidence may have been motivated by the presence of the extended radio structure. As given by the Bordeaux VLBI Image Database, the structure indices of these sources in the X band are 3 and 4, indicating that they are probably not very good reference frame objects. From their high resolution images, as given by the USNO Radio Reference Frame Image Database, one may infer a possible correlation between the VLBI/optical offset and the plane of the sky orientation of the extended radio structures. One implication is that the relationship between the radio and optical frames should take into consideration structure effects in the future.

2.10. *The Joint Milli-Arcsecond Pathfinder Survey (J-MAPS) Mission: Introduction and Science Goals*

Ralph Gaume, USNO

J-MAPS is a small, US-funded, space-based, all-sky visible wavelength astrometric and photometric survey mission for 0th through 14th V-band magnitude stars with a 2012 launch. The

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primary objective of the J-MAPS mission is the generation of an astrometric star catalog with better than 1 milliarcsecond positional accuracy and photometry to the 1% accuracy level, or better at 1st to 12th mag. A 1-mas all-sky survey will have a significant impact on our current understanding of galactic and stellar astrophysics. J-MAPS will improve our understanding of the origins of nearby young stars, provide insight into the dynamics of star formation regions and associations, investigate the dynamics and membership of nearby open clusters, and discover the smallest brown dwarfs at distances up to 5 pc after a 2-year mission, and Jupiter-like planets out to 3 pc after 4 years. J-MAPS will provide critical milliarcsecond-level parallaxes of tens of millions of stars in the difficult 8-14th magnitude range, which when combined with stellar spectroscopy and relative radii determined from exoplanet transit surveys, allows a determination of stellar radii and exoplanet densities. In addition, the 20-year baseline between the groundbreaking Hipparcos mission and the J-MAPS mission allows a combination of the J-MAPS and Hipparcos catalogs to produce common proper motions on the order of 50–100 microarcseconds per year.

2.11. *The Wavelet Search for Stellar Clusters in NOMAD*

Veniamin Vitayzev, Alex Tsvwtkov and Irina Kumkova

The wavelet technique was presented for searching the heterogeneities of stellar density in the data of the NOMAD (Naval Observatory Merged Astrometric Dataset) catalogue which contains more than a billion stars. Many globular and open clusters have been detected in various photometric bands up to V=18. A lot of artifacts in NOMAD data were found in addition. This technique can be used for future catalogues including the products of the Gaia mission.

2.12. *Posters*

Significant radio-optical reference frame offsets from CTIO data
Zacharias, M. I. et al., USNO
Astrometric surveys 2000 to 2020
Erik Høg, Niels Bohr Institute, Copenhagen

Irina Kumkova
President of the Commission

References

van Leeuwen, F. 2007, *Hipparcos, the new reduction of the raw data* (Dordrecht: Springer)
da Silva Neto *et al.* 2002, *AJ* 124, 612
Zacharias, N. 2009, in *Trans. IAU XXVIIA*, Ed. K. A. van der Hucht, Cambridge Univ. Press, p. 34

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