3.5.4 ICRS Centre

Introduction

The IAU has charged the IERS with the responsibility of monitoring the International Celestial Reference System (ICRS), maintaining its current realization, the International Celestial Reference Frame (ICRF), and maintaining and improving the links with other celestial reference frames. Starting in 2001, these activities have been run jointly by the ICRS Centre (US Naval Observatory and Observatoire de Paris) of the IERS and the International VLBI Service for Geodesy and Astrometry (IVS), in coordination with the IAU. The present report was jointly prepared by the U.S. Naval Observatory and Paris Observatory components of the ICRS Centre. The ICRS Centre web site (<http://hpiers.obspm.fr/icrs-pc>) provides information on the characterization and construction of the ICRF (radio source nomenclature, physical characteristics of radio sources, astrometric behaviour of a set of sources, radio source structure). This information is also available by anonymous ftp (<hpiers.obspm.fr/iers/icrs-pc>), and on request to the ICRS Centre (icrs.pc@obspm.fr).

Maintenance and extension of the ICRF

Some activities of the Paris Observatory IVS Analysis Center (OPAR, Gontier, Lambert & Barache 2007) are linked to the ICRS maintenance and improvement of quasar catalogues, and are also in relation to the IAU/IVS/IERS working group "Second realization of the ICRF". In parallel to the operational VLBI solutions (EOP and global terrestrial and celestial reference frames), we have computed time series of radio source coordinates for approximately 500 radio sources. Most of the available diurnal VLBI sessions involving at least three antennas from 1984 are processed. To provide time series of coordinates in ICRS, all sources are estimated as local parameters, except five sixth of the 247 stable sources (Feissel-Vernier et al. 2006) estimated as global parameters and used for the no-net-rotation condition with respect to ICRF-Ext.2 (Fey et al. 2004). To obtain time series for all observed sources six analyses are conducted. Figure 1 shows an example of time series for the source 1803+784. In a second step the series will be investigated to determine a set of stable sources that could be used to define the axes of the next ICRF. All of these products and related statistics are made available on the OPAR Analysis Center web site (<http://ivsopar.obspm.fr>, launched in October 2006) in both ASCII and VOTable format. They are updated quarterly.

Another research area is the estimation of the contribution from the instabilities in the celestial reference frame to nutation estimates, in the context of the on-going efforts to identify the various sources of the uncertainties in the estimates, and to minimize further contributions to these uncertainties (Lambert et al. 2007).

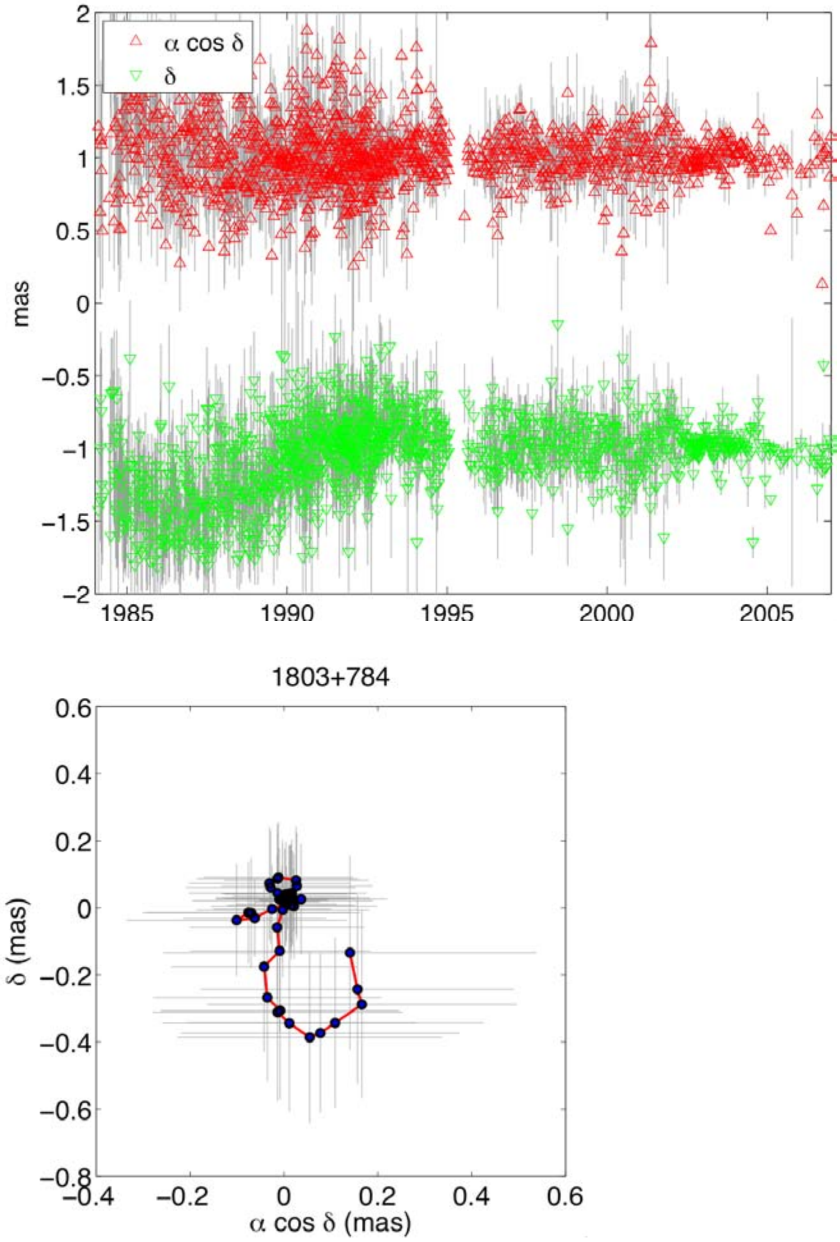

Fig. 1: Radio source 1803+784. Top: positions by sessions. Bottom: semi-annual positions.

Investigation of future realizations of the ICRS

Involvement by ICRS Centre personnel in the celestial reference frame VLBI program continued in 2006, increasing the number of observations of ICRF quasars in the southern celestial hemisphere and continuing an extensive observing program in the northern hemisphere. This observing program will eventually result in a new realization of the ICRS, tentatively called ICRF 2. Plans for the formulation of ICRF 2 were discussed at XXVI[th] General Assembly of the International Astronomical Union (IAU) held in Prague, Czech Republic in August 2006. In the Southern Hemisphere, the USNO and the Australia Telescope National Facility (ATNF) are collaborating in a continuing VLBI research program in Southern Hemisphere source imaging and astrometry using USNO, ATNF and ATNF-accessible facilities. These observations are aimed specifically toward improvement of the ICRF in the Southern Hemisphere, by a) increasing the reference source density with additional S/X-band bandwidth-synthesis astrometric VLBI observations, and b) VLBI imaging at 8.4 GHz of ICRF sources south of $\delta = -20°$. New milliarcsecond accurate astrometry of 34 Southern Hemisphere radios sources was obtained in 2006. In the Northern Hemisphere a major source of VLBI data continues to be the series of RDV experiments, which consist of observations of ICRF sources at radio frequencies of 2.3 GHz and 8.4 GHz using the Very Long Baseline Array (VLBA), together with up to 10 geodetic antennas. These VLBA RDV observations constitute a joint program between the U.S. Naval Observatory (USNO), Goddard Space Flight Center (GSFC) and the National Radio Astronomy Observatory (NRAO) for maintenance of the celestial and terrestrial reference frames. During calendar year 2006, six VLBA RDV experiments were observed and images from four RDV experiments were added to the USNO Radio Reference Frame Image Database (RRFID). In addition VLBA observations to extend the ICRF to K-band (24 GHz) and Q-band (43 GHz) continued in 2006. These observations are part of a joint program between the National Aeronautics and Space Administration, the USNO, the National Radio Astronomy Observatory (NRAO) and Bordeaux Observatory. Images at K-band from one experiment were added to the RRFID.

In the coming decades, there will be significant advances in the area of space-based optical astrometry. Proposed and scheduled missions such as the National Aeronautics and Space Administration's (NASA) *Space Interferometry Mission* (SIM-PlanetQuest) and the European Space Agency's (ESA) *Gaia* mission will achieve astrometric positional accuracies well beyond that presently obtained by any ground-based radio interferometric measurements. In 2006, ICRS Center personnel continued their participation in the NASA SIM mission, through direct involvement in one of the SIM key science projects: *Astrophysics of Reference Frame Tie Objects*. In addition, ICRS Center personnel have been working on concept development for a microsatellite based astrometric mission, called the Joint Milli-Arcsecond Pathfinder Survey (J-MAPS), to produce milliarcsecond level astrometry for all of the bright stars up to 12^{th} magnitude (limiting magnitude ~15–16). Together with several government and industrial partners, in 2006 ICRS Center personnel completed a preliminary concept study with the goal of better understanding mission related costs, schedule, and risks.

Monitor source structure to assess astrometric quality

VLBA RDV Imaging

As discussed above, observations of ICRF sources at radio frequencies of 2.3 GHz and 8.4 GHz using the Very Long Baseline Array (VLBA), together with up to 10 geodetic antennas, continued in 2006. These VLBA RDV observations constitute a joint program between the U.S. Naval Observatory (USNO), Goddard Space Flight Center (GSFC) and the National Radio Astronomy Observatory (NRAO) for maintenance of the celestial and terrestrial reference frames. During the calendar year 2006, six VLBA RDV experiments were observed and images from four RDV experiments were added to the USNO Radio Reference Frame Image Database (RRFID).

VLBA High Frequency Imaging

As also discussed above, VLBA observations to extend the ICRF to K-band (24 GHz) and Q-band (43 GHz) continued in 2006. These observations are part of a joint program between the National Aeronautics and Space Administration, the USNO, the National Radio Astronomy Observatory (NRAO) and Bordeaux Observatory. During the calendar year 2006, one VLBA high frequency experiment (BL122C) was calibrated, imaged and added to the Radio Reference Frame Image Database.

ICRF Maintenance in the Southern Hemisphere

The USNO and the Australia Telescope National Facility (ATNF) are collaborating in a continuing VLBI research program in Southern Hemisphere source imaging and astrometry using USNO, ATNF and ATNF-accessible facilities. These observations are aimed specifically toward improvement of the ICRF in the Southern Hemisphere by a) increasing the reference source density with additional S/X-band bandwidth-synthesis astrometric VLBI observations, and b) VLBI imaging at 8.4 GHz of ICRF sources south of declination –20 deg. New milli-arcsecond accurate astrometry of 34 Southern Hemisphere radios sources was obtained in 2006.

VLBI images for a total of 111 Southern Hemisphere ICRF sources at a frequency of 8.4 GHz using the Australian Long Baseline Array have been published. These data were used to quantify the magnitude of the expected effect of intrinsic source structure on astrometric bandwidth synthesis VLBI observations by calculating a “structure index” for all 111 southern hemisphere sources; the structure index yields an estimate of their astrometric quality. Approximately 35% of the sources were found to have a structure index indicative of compact or very compact structures. The remaining two-thirds of the sources are less compact and should probably be avoided in astrometric and geodetic VLBI experiments requiring the highest accuracy unless intrinsic source structure can be accounted for in the astrometric/geodetic analysis.

The Radio Reference Frame Image Database

The Radio Reference Frame Image Database (RRFID) is a web accessible database of radio frequency images of ICRF sources. The RRFID currently contains 4777 VLBA images of 587 sources at radio frequencies of 2.3 GHz and 8.4 GHz. Additionally, the RRFID contains 1339 images of 274 sources at frequencies of 24 GHz and 43 GHz. The RRFID can be accessed from the Analysis Center web page or directly at <http://rorf.usno.navy.mil/rrfid.shtml>.

Maintenance of the link to the Hipparcos catalog

During the reporting period (2006) progress has been achieved at USNO in several areas related to the maintenance of the Hipparcos link: UCAC project (work toward the final release), the extragalactic and galactic link to radio frame sources, URAT and J-MAPS. Results of all items presented here were also presented at the 2006 IAU General Assembly in Prague with publications upcoming next year.

Software development for the pixel re-reduction of the USNO CCD Astrograph Catalog project proceeded with emphasis on image profile models and double star fitting. The goal is to improve completeness, astrometric and photometric accuracy significantly over the UCAC2. Release of the UCAC3 is scheduled for 2008.

As part of the UCAC project, early epoch photographic plates are being measured on the StarScan machine at USNO to provide proper motions on the Hipparcos system. Measurement of all 2300 Hamburg Zone Astrograph and all 900 USNO Twin Astrograph (Black Birch, New Zealand program) plates were completed in 2006.

Reductions of the deep CCD images taken of extragalactic, compact radio sources during the UCAC project continued. Preliminary results were presented at the Lowell meeting (Zacharias & Zacharias, 2005) and the IAU General Assembly (Zacharias, Zacharias & Rafferty, 2006).

Monitoring a sample of 12 ICRF quasar optical counterparts continued at the 1.55m telescope at NOFS. This effort is part of the SIM preparatory science for the celestial reference frame key project (PI is K. Johnston).

VLA and PT observations of 46 radio stars obtained at multiple epochs will be summarized in an *Astronomical Journal* paper (Boboltz et al. 2007). The radio positions (ICRF) are consistent with the optical Hipparcos Catalogue Reference Frame (HCRF) on the 1-sigma level of internal errors.

The program for the USNO Robotic Astrometric Telescope (URAT) project has been developed further (Zacharias et al, 2006). The detector development for URAT has been successful. In June 2006 a wafer run produced the world largest, monolithic CCDs with 111 million pixels (95 mm by 95 mm). Phase 1 of the URAT project will have 4 of these detectors mounted at a new focal plane assembly at the USNO “redlens” astrograph. The goal is to produce an all-sky astrometric catalog more accurate than UCAC and 2 magnitudes deeper, including proper motions and parallaxes on the HCRF utilizing Tycho-2 as reference stars.

In a joint effort with USNO and Paris Observatory, Rio de Janeiro observatory took the lead and started work on an astrometric catalog of quasars utilizing the USNO B1, GSC2.3 and SDSS DR5 catalogs. Target positions are corrected with local reductions to the UCAC (Andrei et al. 2006).

Based on a stare-mode operations concept (Zacharias & Dorland, 2006) the Joint Milli-Arcsecond Pathfinder Survey (J-MAPS) space mission has been developed further. If successful, this micro-satellite will produce an all-sky catalog on the 1 mas level for many millions of stars at a 2011 mean epoch. Combining with Hipparcos data, proper motions of better than 0.1 mas/yr can be obtained.

Linking the ICRF to frames at various wavelengths

This link appears as a major issue in the present and next decade, with the drastic increase of quasars recorded at various wavelengths, thanks to huge surveys such as the Sloan Digital Sky Survey (SDSS) and the 2dF redshift survey (2QZ). In order to complete our knowledge of the ICRF sources, we have carried out a cross-identification between the ICRF and the last release of the Véron-Cetty and Véron catalogue (2003; hereafter VV2003). The results are gathered in Souchay et al. (2006).

We have shown that a significant part of the ICRF objects are not recorded in VV2003: 17% of the defining sources, 30% of the candidate ones and 11% of the other ones. Nevertheless, the remaining common identifications enable one to point out some general trends of the ICRF quasars with respect to the average properties of quasars (magnitude, redshift, and flux at 6 cm and 11 cm) established from the large set (48 290 objects) of the VV2003 catalogue. They are relatively much brighter, much closer (according to the redshift) and their flux at radio wavelengths comparatively more dispersed as in this last catalogue. In addition to the 403 quasars belonging both to the ICRF-Ext.2 and to the VV2003 catalogue, 63 BL LAC objects and 69 active galaxies (AGN) were cross-identified.

We have also studied the sky coverage of the ICRF catalogue and the VV2003 catalogue. We have shown (Souchay et al., 2006) that some important areas exist on the celestial sphere, for which the closest ICRF quasar is at a distance greater than 10°. On the other hand the zones for which a quasar of the VV2003 catalogue is at a distance greater than 10° is limited mostly to the galactic plane.

Representation of the ICRS at the Optical Wavelength

The HCRF (Hipparcos Catalogue Reference Frame) (ESA, 1997) provides an extension of the ICRF for the optical domain, through the position, proper motion and parallaxes for 120,000 stars with 1 milli-arcsecond level astrometry. A complementary representation of the ICRS has been developed following its defining principles, namely kinematically non-rotating with respect to an ensemble of distant extragalactic objects, aligned to the mean equator and dynamical equinox of J2000.0, and realized by a list of adopted coordinates of extragalactic sources.

This representation, termed OCRF (Optical Celestial Reference Frame), is directly tied to the optical counterpart of the ICRF sources whenever feasible. Starting from an updated, presumably complete, list of QSOs (Souchay et al., 2007), initial optical positions are taken from the catalogues USNO B1.0 (Monet et al., 2002), GSC23 (HST and OATo, Zacharias et al., 2007), and from the Data Release 5 of the SDSS (2006). In the next step, the initial positions are placed onto the UCAC2 reference frame, following an alignment to the ICRF, as represented by the optical counterpart of ICRF sources as well as of the most precise sources from the VLBA calibrator list and from the VLA calibrator list. Finally the OCRF axes are surveyed through spherical harmonics, considering right ascension, declination and magnitude terms. The final resulting frame is globally tied to the ICRF at the milli-arcsecond level, and individual positions have typical accuracies better than 100mas. A first instalment of the OCRF, containing 46,000 objects, was presented in the JD16 at the Prague XXVIII IAU GA (Andrei et al., 2006). The next release will be available soon and will contain 110,000 objects.

Maintenance of the link to the solar system dynamical reference frame using Lunar Laser Ranging analyses

Lunar laser observations (LLR normal points) consist in measurements of the round-trip travel time of the light between a terrestrial station and a lunar reflector. There are more than 17000 LLR normal points provided between 1969 and 2006 by three stations: McDonald 1969–2006 (Fort Davis, Texas), Observatoire de la Côte d'Azur 1984–2005 (Grasse, France), Haleakala 1987–1990 (Maui, Hawaii). Several analyses on the LLR data have been performed by the lunar analysis center POLAC (Paris Observatory Lunar Analyses Center) located at SYRTE laboratory (Observatoire de Paris, France). Some of them concern in particular the orientation of the solar system dynamical reference frame with respect to other reference frames.

The solar system dynamical reference frame is realized by the dynamical mean ecliptic and equinox (epoch J2000.0) related to the orbit of the Moon through the ephemerides of the semi-analytical lunar solution ELP (Chapront-Touzé M. and Chapront J., 1997). The analysis of the LLR observations enables to define the orientation of dynamical mean ecliptic and equinox of J2000 with respect to ICRS. In the same time, the LLR analysis enables to determine other parameters and to update the ELP theory (Chapront J. et al., 2002, 2003).

The position of the dynamical mean ecliptic with respect to the ICRS is defined by two angles: $\varepsilon^{(ICRS)}$, the inclination of the dynamical mean ecliptic to the equator of ICRS, and $\varphi^{(ICRS)}$, the angle between the origin $o^{(ICRS)}$ of right ascensions on the equator of ICRS and the ascending node $\gamma_I^{(ICRS)}$ of the dynamical mean ecliptic on the equator of ICRS.

The evaluation of these two angles is involved in the transformation of the rectangular coordinates of the LLR stations from the terrestrial reference frame to the celestial reference frame taking into account the polar motion, the Earth rotation and the orientation of the celestial pole. The precession-nutation matrix is computed with the IERS conventions using the daily corrections of the nutation in longitude and obliquity provided by IERS (Earth Orientation Center series C04). The global root mean square of the post-fit residuals between observed and computed values of the distance station-reflector over the interval [1995–2006] is 4.2 cm for McDonald observations and 3.8 cm for OCA observations. The last determination is:

$$\varepsilon^{(ICRS)} = 23°26'21.411'' \quad \text{(formal uncertainty: 0.001 mas)}$$

$$\varphi^{(ICRS)} = o^{(ICRS)}\gamma_I^{(ICRS)} = -0.055 \text{ mas} \quad \text{(formal uncertainty: 0.001 mas)}$$

These results have been realized with the weighted fits of the lunar solution ELP to the LLR observations provided between 1972 and 2006 by the LLR stations: 9634 observations from Grasse, 7143 observations from Fort-Davis and 482 observations from Maui.

Maintenance of the link to solar system dynamical reference frame using pulsar timing

In the case of pulsar timing, the solar system dynamical reference frame is realized by the dynamical mean equator and equinox at J2000 related to the planetary ephemerides used in the reduction process of the timing data. Using different planetary ephemerides implies that the deduced positions of the pulsars are expressed in different mean equators and equinoxes. Furthermore, the accuracy in the determination of pulsar positions can reach a few mas in a frame consistent with the IERS 2003 conventions implemented in the new software of reduction of the pulsar timing data, Tempo2 (Hobbs et al. 2006). Comparing positions thus gives very accurate information about the relations between the planetary ephemerides reference frames. In the other hand, if the same pulsars are also observed with VLBI, comparisons between positions deduced from pulsar timing obtained in the dynamical reference frame of the planetary ephemerides and VLBI differenced positions to ICRF sources give the direct link between the planetary ephemerides dynamical reference frame and the ICRF.

In modern planetary ephemerides, an indirect link to ICRF is obtained by using differenced positions of planets versus ICRF sources obtained during VLBI tracking of space missions. The differenced positions are given with few mas accuracy but are highly dependent on space missions. Another independent link between planetary ephemerides reference frames and ICRF is thus necessary to ensure the maintenance of the tie.

Impact of using different planetary ephemerides in pulsar timing

In a first step, we tested to use two different planetary ephemerides, the JPL DE405 (Standish 1998) and INPOP06 (Fienga et al. 2008) in the reduction process of pulsar timing. We did not want to compare these ephemerides but to estimate the impact of using one of them or the other.

We have analysed pulsar timing data for 4 different pulsars, PSR 1937+21, PSR 1909–3744, PSR 1713+07 and PSR 0437–4715. As one can see on Figure 2, no peculiar signature is induced in post-residuals by the use of DE405 or INPOP06. No significant differences are noticeable in the values of physical parameters except for the deduced new positions of the pulsars. We then have modeled these differences in terms of a rotation matrix relating the positions deduced with DE405 to those obtained in using INPOP06 such as:

$$\begin{bmatrix} PSR\ 1937+21 \\ PSR\ 1909-37 \\ PSR\ 1713+07 \\ PSR\ 0437-47 \end{bmatrix}_{DE405} = R_x R_y R_z \begin{bmatrix} PSR\ 1937+21 \\ PSR\ 1909-37 \\ PSR\ 1713+07 \\ PSR\ 0437-47 \end{bmatrix}_{INPOP06}$$

Then, the angles obtained are:

$\theta = 0.02 \pm 0.7$ mas
$\varphi = -2.0 \pm 0.9$ mas
$\psi = -2.0 \pm 0.7$ mas

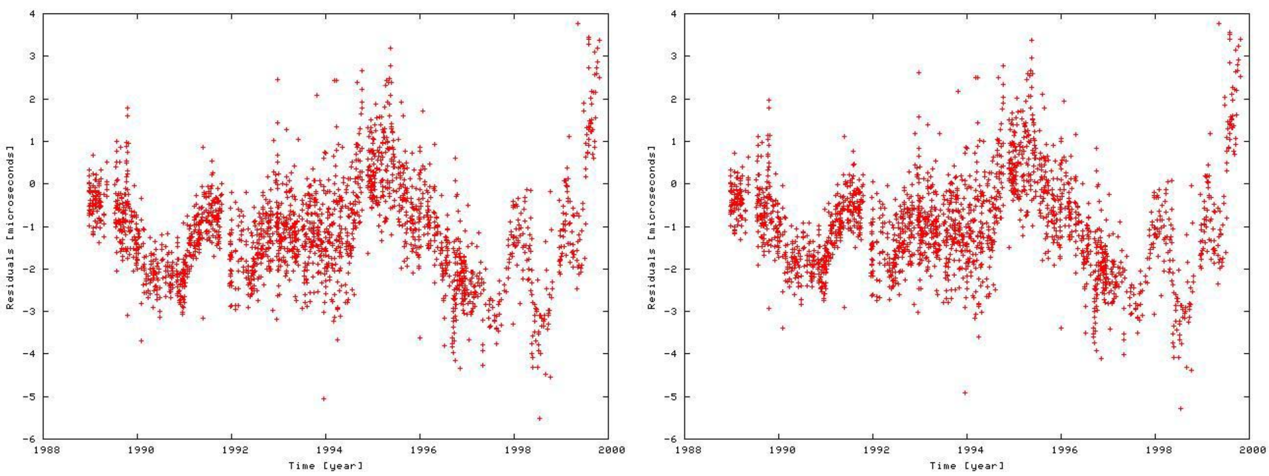

Fig. 2: PSR 1937+21: Differences between received radio signal by the Nancay observatory and the computed signal estimated using the software Tempo2 and two different planetary ephemerides: DE405 and INPOP06.

These values give the link between the reference frame defined by DE405 and the one of INPOP06. These angles are quite similar to those published by some authors (Standish 1998, Chapront et al. 1999, Simon, 2006) for comparisons established for different dynamical reference frames, DE405, ELP2000 and INPOP06, and between ICRF and these dynamical reference frames.

The first conclusion is that pulsar timing data are sensitive to planetary ephemerides only for the deduced positions of pulsars. No other parameters are significantly changed by a change in planetary ephemerides. Thus, the pulsar positions obtained by such process are directly expressed in the reference frame of the planetary ephemerides. Comparisons of pulsar positions deduced from the use of DE405 or INPOP06 in the reduction process give the rotation matrix between their reference frames.

First attempts of comparisons between VLA/VLBI positions and pulsar timing

Since the first discovery of pulsars, few programs related to VLBI or VLA observations of these objects were settled. In 1996, Bartel et al. gave results obtained by comparing positions of PSR 1937+21 with radio timing and the first positions observed using VLBI. Due to the faint signal emitted by the pulsars at VLBI wavelengths, a small number of objects of that kind have been observed since 1996. In fact, only two other objects are found in the literature: PSR 1912+57 observed by Nunes and Bartel (1998), and PSR 2021+51 observed by Campbell et al. (1996). Furthermore, this last object was not observed with radio timing by the Nançay observatory.

On the other hand, a program of pulsar observations was executed with VLA by Brisken et al. and Chatterjee et al. to estimate parallaxes (Brisken et al. 2000, Chatterjee et al. 2001, Brisken 2001). Almost 63 millisecond pulsars have been observed and their positions estimated to the accuracy of the VLA. A first attempt was then to use a sample of milliseconds pulsars observed in radio timing and in VLA. One can then estimate a matrix of rotation between the radio timing positions obtained in the dynamical frame of the planetary ephemerides used in the fit and the VLA positions obtained by differential observations to ICRF sources. This method provides the link between the dynamical reference frame of the planetary ephemerides and the ICRF at the level of accuracy of the VLA observations of pulsars. We then have found 2 pulsars PSR 1713+07 and PSR 1937+21 which were observed with VLA by (Chartterjee et al. 2001) and in radio by (Cognard et al. 2007) at Nançay observatory.

By combining with the same weight the VLA and VLBI positions of the three pulsars (PSR 1937+21, PSR 1713+07, PSR 1912+57), we have estimated a rotation matrix between the dynamical frame of INPOP used in timing reduction and the ICRF at the VLA accuracy. We have obtained the following values for the 3 angles:

$\theta = -114 \pm 85$ mas
$\varphi = -85 \pm 135$ mas
$\psi = -121 \pm 80$ mas

These values are quite larger than the expected accuracy of the timing data (few mas) but are consistent with the accuracy of the VLA relative astrometry to ICRF sources. A test with a denser sample of pulsars has to be made, but it seems that the VLA observations are not accurate enough to maintain a link between the dynamical frame of the planetary ephemerides and the ICRF at a mas level.

Conclusions and perspectives

There is now an urgent need to densify the number of millisecond pulsars observed with VLBI versus ICRF sources at the mas level demonstrated by this study. This task will be taken in charge at the Besançon Observatory in collaboration with the Paris Observatory (SYRTE) and the Nançay Observatory. A procedure for preparing such observations will have to be settled on as well as a reduction process. Criteria to optimize the selection of millisecond pulsars, which have to be observed in VLBI are on the way, and a first list of candidates will be submitted to the IVS. We hope then to densify the number of points linking the dynamical frame of the planetary ephemerides and the ICRF at a mas level.

Maintenance and developments of the website of the ICRS Center

The ICRS Center website <http://hpiers.obspm.fr/icrs-pc> has been recently updated. The following products are added:

- ICRF extension 2 catalogue of sources positions (717) and associated graphs
- Physical characteristics of ICRF extension 1 radio sources
- Time series of radio source coordinates into VOTable File.

VOTable File is a standard of IVOA (International Virtual Observatory Alliance). Time series provided with this format could be read and analysed directly by all the VO (Virtual Observatory) compatible freeware tools like:

- Aladin (freeware provided by CDS of Strabourg to manipulate star or quasar catalogues and data imaging associated with these topics: see <http://aladin.u-strasbg.fr/aladin.gml>),
- Topcat (freeware provided by Taylor et al. to manipulate VOTable, to make plots and cross matching for astronomy: see <http://www.star.bris.ac.uk/~mbt/topcat>),
- Stilts (public API provided by Mark Taylor and all used to make scripts for Topcat: see <http://www.starlink.ac.uk/stilts>)
- VOPlot (freeware provided by the Virtual Observatory – India tools to make astronomy plots: see <http://vo.iucaa.ernet.in/~voi/voplot.htm>).

Using these tools we have constructed a database of quasars in standard VOTable File format containing unique and homogeneous astrometry and physical data (optic and radio). For that project we have cross-matched 8 of the largest QSO catalogues (provided by the CDS and also directly from the web site of the Survey itself).

We have developed some tools around the VO freeware Topcat and Stilts to create our own file format for QSO's with all the necessary data and references. Moreover we kept the original data (in particular information concerning the catalogue of origin) and convert it into VOTable. We have also created scripts to provide automatic cross-match and to explain the ways to easily cross match the main large QSO catalogues. This work using the VO tools was validated by comparison with results obtained by independent FORTRAN programs.

Seven selected catalogues (ICRF-Ext.2, VLBA, VLA-015, JVAS, SDSS, 2QZ, FIRST) have already been processed resulting in the following data: 99 977 QSO coordinates, 96 2005 redshifts, 95 788 U, 74 869 G, 2394 B magnitudes, 3 235 flux at GHz, 910 flux at 5Ghz and 3 876 flux at 8.4Ghz.

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