

## **Final Discussion**

(Wednesday September 18, 11:50-12:25)

*Meeting notes by Catherine Hohenkerk and Susan Nelmes (30 September 2013)*

### **Topic of Session 3: IAU Working Group on Pulsar Time Scale and Atomic Time**

*Chair: Gérard Petit (GP), George Hobbs (GH)*

*Other contributors Francois Mignard (FM), Nicole Capitaine (NC), Chris Jacobs (CJ), Yaroslav Yatskiv (YY)*

GH, who is the Chair of the IAU WG on Pulsar Timing, started the discussion by summarising the current status. He told the audience that the IAU WG was set up at the last IAU to bring together people working on pulsar and atomic time scales. Atomic time scales have always been more precise, but pulsar time scales (which started in the 1990's) are improving all the time and now they are in the same "ball park" (1 order of magnitude out according to GP talk). Improvements are currently being made using the Parks 60 m dish, the compact array, and in the future with dishes in China and the Square Kilometre Array (SKA), all of which will all have an impact. The WG mission is to learn, talk, share data, i.e. in particular understand the basis and standards of the data, etc. Discussions have started on e-mail, mainly between GH, GP and Dick Manchester. Anybody who is interested is welcome to join in.

GP commented that long continuous sets of observations, including going back into the past was essential.

GH said that over the past 5 years there were good data sets. However, in the past the Pulsar community was not good at archiving their data. Some old data did exist. Parks had archived data back to the 1990's and efforts were being made to extract data from Arecibo and Greenbank, however some of it was not in a formal archive.

FM commented that pulsar timing is currently a matter of research and is showing quality, and asked if it could be turned into a service and what sort of effort would be needed to do this.

GH said that all the work on pulsars was on gravitational wave (GW) detection, for which there was much funding and hence funding for telescopes. Time scales were an easy side project, but it was only this WG that had a real interested in it.

GP commented that the GW community *should* be interested in Time Standards!

YY asked how accurate was the data?

GH: Pulsars were massive and complicated. Young pulsars are often 'funny' with glitches/wobbles. Milliseconds pulsars are much more stable, but there are some irregularities. Parks telescope has picked up some rotational irregularities over 10-year timescales. More pulsars are needed. The longer the time spans requires more pulsars in order to find and discount irregularities. Errors in TAI dominate over periods <30 years, solar system ephemerides errors over periods > 30 years. It is unclear where rotational irregularity errors fit in.

CJ asked what were these 'glitches'?

GH said that the glitches were like star quakes. Dramatic increase in spin rate and within a short time the rate would then decay back to almost, but not quite, the original rate.

CJ pointed out it was always easier to get funding if there was an IAU resolution.

NC asked if a new time scale could be produced through a combination of BIPM with pulsars.

GP said that TT(BIPM) was produced by post-processing every year and it would be possible to add in extra information from pulsar analysis to give stability.

**Topic of Session 2: Procedure for the realisation of the next ICRF. International effort for observations and combinations. ICRF3 versus GAIA celestial frame.**

*Chair: Francois Mignard (FM), Chris Jacobs (CJ)*

*Other contributors: Nicole Capitaine (NC), Yaroslav Yatskiv (YY), Axel Nothnagel (AN), AA (Alexandre Andrei), AB (Alessandra Bertarini), JK (Jean Kovalesky)*

CJ, Chair of the IAU WG on ICRF3, started the discussion by talking about the ways to contribute. It was not necessary to have large VLBI networks single dish-telescopes were good. Lots of groups can contribute to research.

FM said that there were systematic problems in both the optical and radio but consistent in the aspect of using the IERS conventions. GAIA perhaps could help with systematic errors in VLBI. Currently we have two independent reference frames. How can these be combined? There are not many overlapping sources.

CJ confirmed the need for optical counterparts to the radio sources for identification.

YY asked how many of the radio source would be visible with GAIA?

FM confirmed that there would be 500,000 optical quasars observed by GAIA. FM also confirmed that there would be software that would allow the 'bad' quasars/observations to be removed.

NC asked CJ what would be discussed by the "Next ICRF" WG?

CJ said that there was 2 phases, lasting until 2018. The current focus was the southern hemisphere observations, SX, SKA, and all the data combinations and comparisons, which would last until 2015.

AN said that solutions generated carry full covariance information. Combining catalogues into one reference frame is difficult due to the different covariances in the different systems. This is a big challenge for the WG.

CJ confirmed that the correlations are different between catalogues.

JK asked if separate catalogues were produced or just the combinations?

CJ said there were difficulties comparing catalogues from different frequencies, for example exactly where are the jets? Higher frequencies need more coverage. Also AN (who heads up International Very Long Baseline Interferometry Service (**IVS**)) is pushing for better comparisons between different frequency catalogues.

GH said it was hard to get time on large telescopes, so were smaller ones OK?

AB commented that more antennae would be good.

GH wondered if high frequency observations would be cut due to funding issues.

AB said they were hoping to get time on Parks before the funding was cut.

Audience asked how many sites so far?

CJ said that there was a small number at the moment but they were trying to increase the number. The Spanish or Portuguese may be able to purchase new antennae.

Audience: We recognise precision of the GAIA catalogue, but how do we connect with optical telescope observations? How do we use microarcsecond accuracy on the ground?

FM said that the GAIA (stellar) frame was very accurate—the best one yet. It would last a while, but it would degrade very slowly over time.

CJ said that the GAIA catalogue (frame) would be very useful, for example for adaptive optics.

AA Remember that star catalogues have zonal errors, but there will be no zonal errors in the GAIA catalogue. This is a big advantage. ICRF is only based on high frequencies, which is not accessible to lots of antennas.

CJ said that some parts were accessible, but it is a big issue.

AN said that change over of broad band will help the situation. Every telescope currently observing will be used for further work and may be improved to the KA band if suitable.

CJ suggested that the cost of research may come down due to cheaper data storage.

NC Closed the discussion at 12:25