WHAT COULD BRING LLR OBSERVATIONS IN DETERMINING THE POSITION OF THE CELESTIAL POLE

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ABSTRACT. It has been demonstrated that the analysis of Lunar Laser Ranging (LLR) observations could bring scientific results in various domains including astronomy, gedoynamics and gravitational physics. Here, we focus on the contribution of the LLR in determining the Earth Orientation Parameters (EOP), especially, the direction towards the Celestial Intermediate Pole (CIP) in the Geocentric Celestial reference System. The strategy we have followed, consists in : first, calculating the LLR residuals over a period of more than 37 years, using the IAU 2006-2000A model of precession-nutation (i.e MHB 2000 nutation of Mathews et al. 2002 and P03 precession of Capitaine et al. 2003) and the CIO based procedure. Second, determining the GCRS X and Y coordinates of the Celestial Intermediate Pole at regular interval (i.e in our case, every 70 days). Finally, comparing the results obtained with VLBI observations in order to evaluate the potential of LLR as compared to VLBI for estimating the X, Y quantities.

1. INTRODUCTION

The main purpose of this paper is to focus on the application of the Lunar Laser Ranging technique in the field of the Earth rotation, especially for the determination of the celestial pole coordinates.
We can divide our work into two principals parts :

- the first part consists in the calculation of the LLR residuals with respect to all the best available models,
- the second part consists in the determination of the celestial pole coordinates from LLR and analysis of the correction to the IAU precession-nutation model.

2. CALCULATION AND ANALYSIS

For the calculation of the residuals, we have used the LLR data from both stations of McDonald and CERGA over periods spanning 1969–2006 and 1984–2005, respectively. Figure 1 shows the residuals obtained for McDonald's station.

Then, we have calculated the corrections to the celestial pole coordinates with respect to the IAU 2006-2000A model of precession nutation (i.e MHB 2000 as the nutation model and P03 as the precession model) every 70 days. We have used the CIO procedure and the SOFA 2007 routines (see at `www.iau-sofa.rl.ac.uk`).
Figure 2 represents the DX, DY corrections to the celestial pole coordinates obtained with this computation.

In order to characterize the signal, we have first estimated the corrections to the long term nutation amplitudes (18.6-yr, 9.3-yr, secular term and constant term). Second, we have estimated the annual, semi-annual, secular and constant term. In this case, we have first removed the Free Core Nutation using a routine developed by S.Lambert (cf. IERS Conventions 2003 updated).
The results obtained in the first case are provided in Fig.3.
Figure 4 represents the results obtained in the second case.

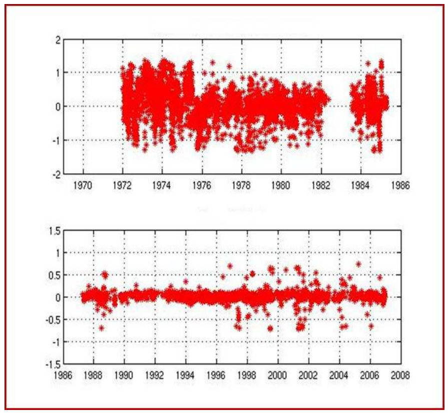

Figure 1: LLR residuals of McDonald's station from 1969 to 2006 (in meters)

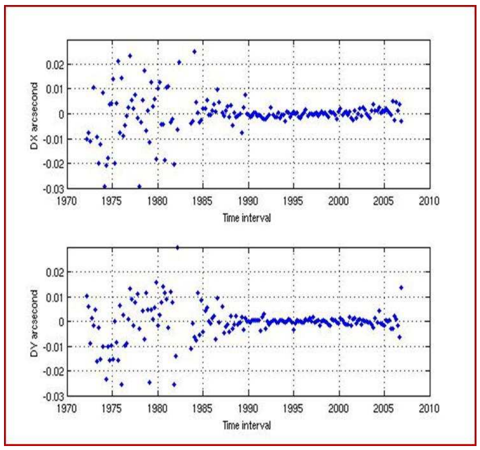

Figure 2: DX, DY corrections to the celestial pole coordinates (LLR data, IAU 2006-2000A precession nutation model)

Finally, we have calculated the VLBI celestial pole offsets with respect to the IAU 2006-2000A model of precession-nutation using the IVS combined solution (ivse08q1.eops). This solutions is given with respect to the IAU 2000A model of precession nutation. In order to be consistent with our work, i.e to refer the celestial pole offsets to the IAU2006-2000A model, we have used Eq.1 (from Capitaine & Wallace 2006, Eq.(41) after correcting a typographical error), which expresses the difference between the IAU2006 and IAU2000 model. The results are represented on Fig.5.

$$X_{IAU2006} - X_{IAU2000} = 155t - 2564t^2 + 2t^3 + 54t^4$$
$$Y_{IAU2006} - Y_{IAU2000} = -514t - 24t^2 + 58t^3 - 1t^4 - 1t^5 \quad (1)$$

It is clear from Fig.5 that the corrections to the celestial pole coordinates obtained from VLBI are determined with a better precision than with the LLR observations. This is due to the imperfect distribution of the LLR observations.

3. CONCLUSION

From LLR observations, it is possible to determine the corrections to the celestial pole coordinates with a precision of the order of 100μas, which is ten times greater than with VLBI. An appropriate combination of these two is expected probably contribute to the improvement of this determination.

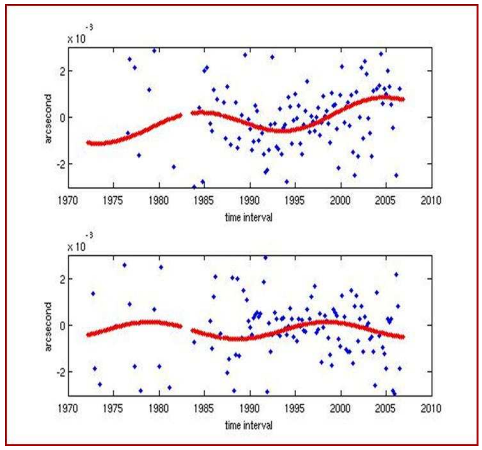

Figure 3: dots in blue: correction DX, DY to the celestial pole coordinates - lines in red: the fitted terms (18.6, 9.3, secular and constant term)

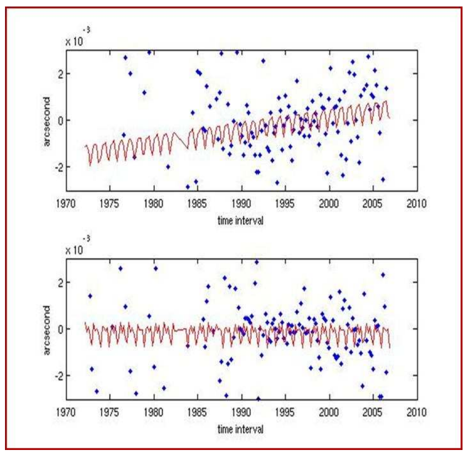

Figure 4: dots in blue: correction DX, DY to the celestial pole coordinates - lines in red: the fitted terms (annual, semi-annual, secular and constant term)

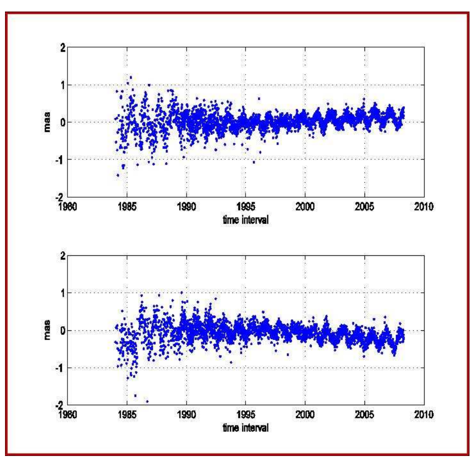

Figure 5: VLBI pole offsets with respect to the IAU 2006-2000A model of precession nutation

4. REFERENCES

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website : hpiers.obspm.fr/eop-pc/models/fcn/index.html.