THE USE OF LLR OBSERVATIONS (1969-2006) FOR THE DETERMINATION OF THE CELESTIAL COORDINATES OF THE POLE

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ABSTRACT. Analysis of Lunar Laser ranging observations allows to determine a number of parameters related to the dynamics of the Earth-Moon system. It also contributes to the determination of the Earth Orientation Parameters (EOP) such as precession-nutation, polar motion and UT1. Here, we focus on the determination of the precession-nutation corrections DX, DY to the conventional model for the coordinates of the CIP (Celestial Intermediate Pole) in the GCRS (Geocentric Celestial Reference System), which are used in this study, instead of the classical parameters determined in previous works.

1. INTRODUCTION

The Lunar Laser Ranging technique consists in determining the round-trip travel time of light pulses between a transmitter on the Earth and reflectors on the surface of the Moon. The actual observational data consists of 'normal points' built on the number of detected photons in the interval of the observations.

This technique has many applications in various domains including astronomy, lunar science, geodynamics, and gravitational physics. In the field of geodynamics, it defines intrinsically a dynamical system. It allows in particular the positioning of the dynamical mean ecliptic of J2000.0 with respect to the CIP (Celestial Intermediate Pole) and to the GCRS (Geocentric Celestial Reference System) using this transformation (for more details, see for example the IERS conventions or Capitaine et al. 2003) :

$$[CRS] = Q.R.W[TRS]$$

Q : is the matrix transformation for the motion of the CIP in the celestial system (X,Y),

$$Q = \begin{pmatrix} 1-aX^2 & -aXY & X \\ -aXY & 1-aY^2 & Y \\ -X & -Y & 1-a(X^2+Y^2) \end{pmatrix} .R_3(s)$$

R : is the matrix transformation for the Earth rotation,

$$R = R_3(-ERA)$$

W : is the matrix transformation for the polar motion in the ITRS (International Terrestrial Reference System),

$$W = R_3(-s')R_2(x_p)R_1(y_p).$$

2. CALCULATION AND RESULTS

In a first step, we have calculated the LLR residuals for (i) McDonald station during the period of 1969 to 2006 and (ii) CERGA station during the period of 1984 to 2005, using the P03 precession of Capitaine et al. (2003) as the model for precession and the MHB 2000 of Mathews et al. 2002 for the nutation. The residuals from MacDonald are represented on Fig 1. We note that the residuals have been improved from 1m in 1972 to 0.2 m in 2001. Then, in the bottom of this figure, we can note a degradation of the residuals since the end of 2001, due probably to instrumental errors.

In a second step, we made a new analysis with fitting the X, Y parameters (Celestial Pole coordinates). The preliminary results of the fitting and the formal errors are represented on Fig 2.

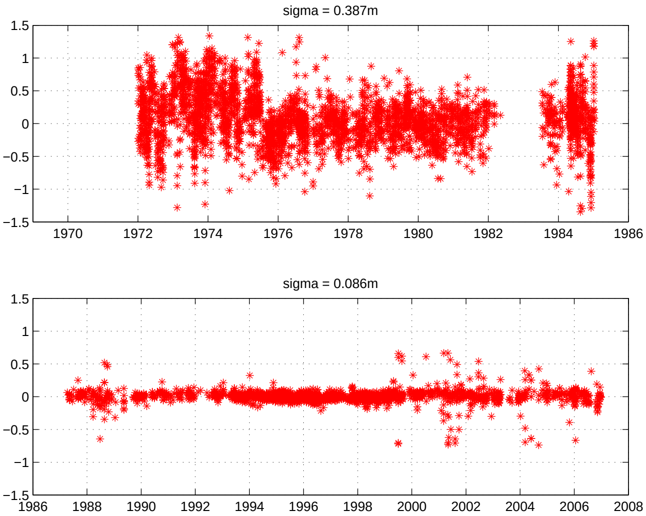

Figure 1: Residuals (in meters) from MacDonald LLR observations

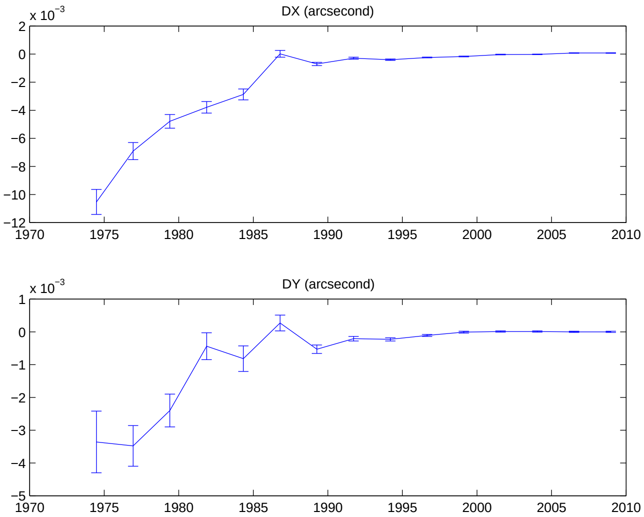

Figure 2: Corrections DX, DY to the conventional model at J2000.0

Each point represents the correction to DX, DY from the beginning of the observations until the date of the observation at that point. We note the improvement of the fitting since 1990 because the period of observation become longer and the observations more precise.

In this preliminary study, we have derived the celestial coordinates of the CIP (Celestial Intermediate Pole) at J2000.0 from LLR observations spanning the period 1969-2006. In a further study, we will use such determinations at appropriate intervals for deriving corrections to the precession-nutation model.

3. REFERENCES

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