ON OPTIMAL DETECTION AND ESTIMATION OF THE FCN PARAMETERS

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ABSTRACT. Statistical approach for detection and estimation of parameters of short-term quasi-periodic processes was used in order to investigate the Free Core Nutation (FCN) signal in the Celestial Pole Offset (CPO). The results show that this signal is very unstable and that it disappeared in year 2000. The amplitude of oscillation with period of about 435 days is larger for dX as compared with that for dY.

1. INTRODUCTION

Free Core Nutation (FCN) is a free motion of the Celestial Intermediate Pole (CIP) in space due to the interaction of the mantle and the fluid, ellipsoidal core of the Earth. FCN signal is the most significant oscillation in the Celestial Pole Offset (CPO) residuals with respect to the IAU 2000A nutation model. It was investigated by many authors (for references see Malkin, 2004, Kalarus et al., 2006) which have showed that this signal was non-stationary one. Supposing the space-referred retrograde period of the FCN is constant (about 430 days) the variations of amplitude and phase of oscillation were determined (see, for example, Brzezinski, 2005). Studies were performed to understand possible causes of the FCN, in particular the diurnal variability in the system of atmosphere-oceans. Nevertheless, there is no final conclusion on this matter and a search for possible sources of excitation of the FCN has to be continued. For this reason additional study of the FCN time-varying signal in the CPO through the use of new methods could be of some interest. In this study a new statistical approach for detection and estimation of parameters of quasi-periodic processes proposed by Panasenko and Chernogor (2007) was used for analyzing the CPO included in the IERS C04 (IAU 2000).

2. METHOD OF ANALYSIS

Method for detection and estimation of the parameters of quasi-periodic processes proposed by Panasenko and Chernogor (2007) was used in order to determine areas of the FCN signal i.e. time of appearance of the signal and duration of its existence. This method is based on the theory of optimal detection and optimal estimation of quasi-periodic processes (QPP) of the type

$$s(t) = A\cos(\omega + \varphi)[\theta(t-\tau) - \theta(t-\tau-t_p)],$$

where $\omega = 2\pi/T$; T is the period of QPP; t and t_p are time of appearance and duration of existence of QPP, respectively;

$$\theta(t) = \begin{cases} 0, t < 0 \\ 1, t \geq 0 \end{cases}$$

In case of additive noise $w(t)$ we have

$$x(t) = s(t) + w(t).$$

Optimal detection criterion is defined by equation

$$L = \frac{W_w[x(t)]}{W_s[x(t)]} > L_n,$$

where $W_w[x(t)]$ and $W_s[x(t)]$ are the likelihood functional in cases of absence of signal $s(t)$ and its presence respectively; L_n is adopted limit value of L.

3. DATA AND RESULTS OF ANALYSIS

The CPO time series dX and dY (IERS CO4 1984-2006) with the sampling interval of 1 day where used in the analysis. From previous studies of the FCN we know that there is significant power in the retrograde period range from 300 to 600 days. Therefore for the analysis of this period range and for decreasing an amount of computation the 30 days average values of dX and dY were used in what follows. The results of this computation are shown in Fig.1 and Fig.2.

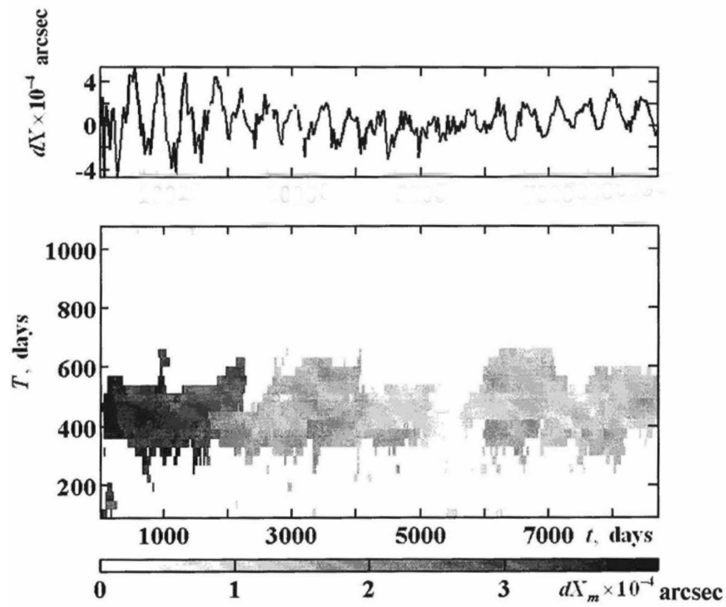

Figure 1: Optimal detection and estimation of amplitude (dX_m) of the FCN signal in the dX of the CPO.

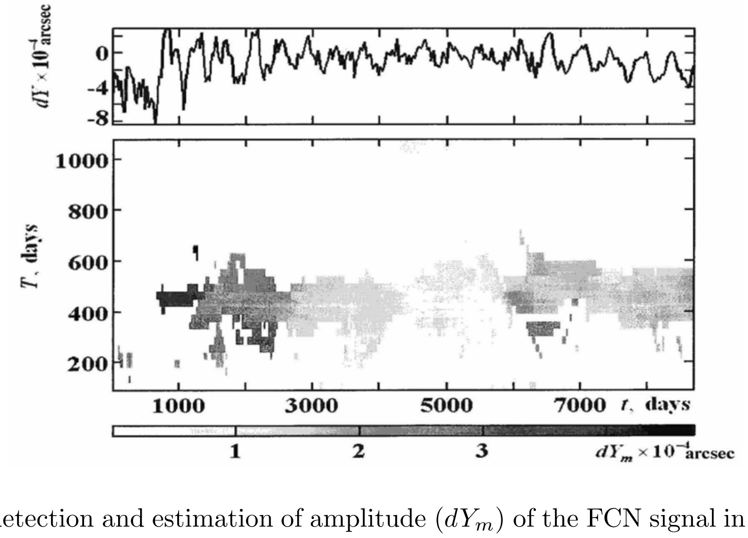

Figure 2: Optimal detection and estimation of amplitude (dY_m) of the FCN signal in the dY of the CPO.

These results were compared with those obtained by the adaptive Fourier transform and the Morlet wavelet analysis of the CPO. Because of the results of these computations for dX and dY are similar ones we show here (Fig. 3) the result for dX only.

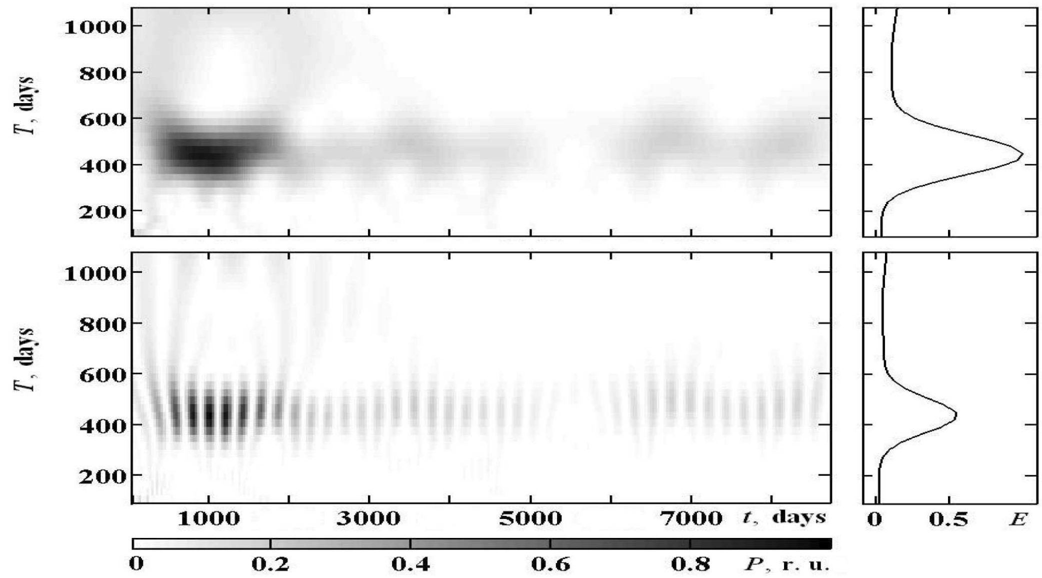

Figure 3: Adaptive Fourier transform (upper picture) and the Morlet wavelet (bottom picture) of the dX, where E is energy spectrum of process.

These figures show that there is a significant variation of amplitude of the FCN signal. One of striking results is the absence of signal in the year 2000. This fact could be used for search of possible source of the FCN excitation.

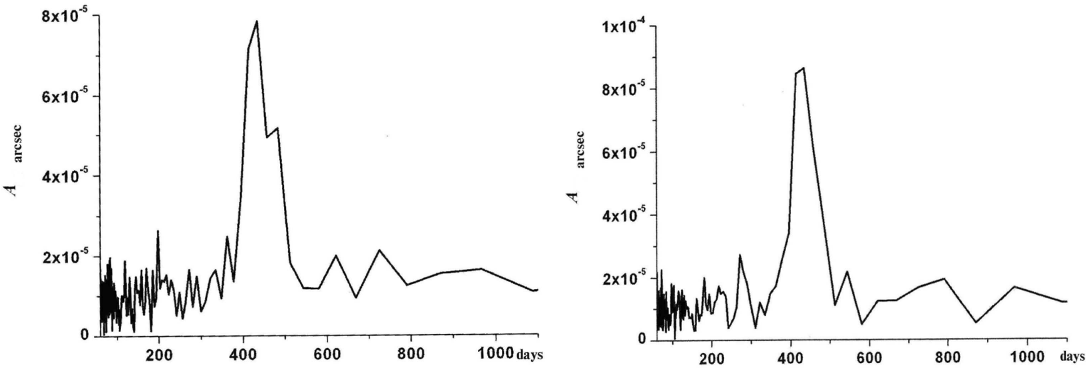

Figure 4: Amplitude spectrum of dX (left) and dY (right).

We have also computed the amplitude spectra of dX and dY (Fig 4). One can see that the average value of period of the FCN is of about 435 days which differs from what is used in the FCN model by Colarus et al. (2006). The FCN looks like as slightly elliptical motion because of the amplitudes for dX and dY are not equal.

4. CONCLUSION

The FCN which looks like as a quasi-periodic process is slightly elliptical motion with variable amplitude and period of about 435 days. There is a strong damping of this process in some interval of time resulting in a disappearance of the FCN signal in close proximity to the year 2000.

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5. REFERENCES

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