THE INTERPRETATION OF HIGH FREQUENCY SIGNALS IN THE G-RING LASER GYROSCOPE

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ABSTRACT. As a promising geodetic instrument, the G-RLG(ring laser gyroscope) which is located at the Geodetic Observatory Wettzell (Germany) has been improved over the last several years. Its current sensitivity is around 10^{-9} which makes it possible to detect the variations of the IRP (Instantaneous Rotation Pole) directly and precisely. In this work our aim focuses on modelling and interpreting the diurnal and semi-diurnal signals which are mainly caused by variable rotations of the Earth and orientational variations of the platform.

1. INTRODUCTION

Similar to mechanical gyroscope systems, large RLGs sense its rotational variation with respect to the local inertial system. Their platforms co-move with the Earth with a variable location and orientation on the Earth's surface in the International Terrestrial Reference System (ITRS). By modeling these variations large RLG can provide an observation of the Earth's rotation independent and complementary to VLBI /LLR /SLR observations that refer to quasars, the Moon or satellites as reference objects.

In this work, 72 days of RLG data from "G" are analyzed. Its temporal resolution of 30 minutes allows us to investigate high frequency signals. Here only the diurnal and semi-diurnal signals are considered, and three main contributing sources will be discussed: Oppolzer terms, solid Earth and ocean tides.

2. REDUCED GEOPHYSICAL EFFECTS ON G-RING

The classic Sagnac equation which describes the Sagnac effect in RLG reads:

$$f = \frac{4A}{\bar{\lambda}P}\overrightarrow{n}\cdot\overrightarrow{\Omega}, \tag{1}$$

where, A, P, $\bar{\lambda}$, $\overrightarrow{n}$, $\overrightarrow{\Omega}$ are the enclosed area, perimeter (beam path length), optical wavelength of the RLG, normal vector to A and the instantaneous rotation vector, respectively.

Considering the RLG's orientation $\overrightarrow{n} = [\cos\phi\cos\lambda, \cos\phi\sin\lambda, \sin\phi]$ and the rotation vector of the IRP $\overrightarrow{\Omega} = \Omega[m_1,\, m_2, 1+m_3)]$, the Sagnac equation will turn into a function in terms of orientation and rotation parameters:

$$f = \kappa\{\cos\phi_0\cos\lambda_0 m_1 + \cos\phi_0\sin\lambda_0 m_2 + \sin\phi_0 m_3 + \cos\phi_0 d\phi + \sin\phi_0\}, \tag{2}$$

where $\kappa = \frac{4A\Omega}{\bar{\lambda}P}$, and (ϕ_0, λ_0) is the RLG's geographic latitude and longitude.

The Eq. (2) depicts explicitly how the variations of the Earth's rotation and RLG's orientation affect the performance of RLG. The preliminary result is shown in Fig.1.

The Oppolzer terms driven by the tidal potential are obtained by solving the Earth's rotation dynamical equations in terms of the IRP (Brzezinski, 1986; Mathews et al. 2002).

The variations of polar motion of IRP and LOD driven by ocean tides are derived from Table 8.2 and 8.3 of the IERS Conventions 2003 (McCarthy and Petit, 2004) by a transition from the CIP (Celestial Intermediate Pole; see (*ibid.*) for definition) to IRP in the following form derived by Brzezinski (1992)

$$m = p - i\frac{\dot{p}}{\Omega}, \tag{3}$$

where $i = \sqrt{-1}$ denotes the imaginary unit and $m = m_1 + im_2$, $p = x_p - iy_p$ are the terrestrial coordinates of the IRP and CIP expressed by complex variables.

The tilt of G-RLG platform dominates the semi-diurnal signals in G-RLG data and contributes partly to diurnal and long period signals as well. In this work, the tilt effects are calculated with the second order HW95 tidal potential (Hartmann and Wenzel, 1995) and Wahr's frequency-dependent Love numbers(Wahr, 1981).

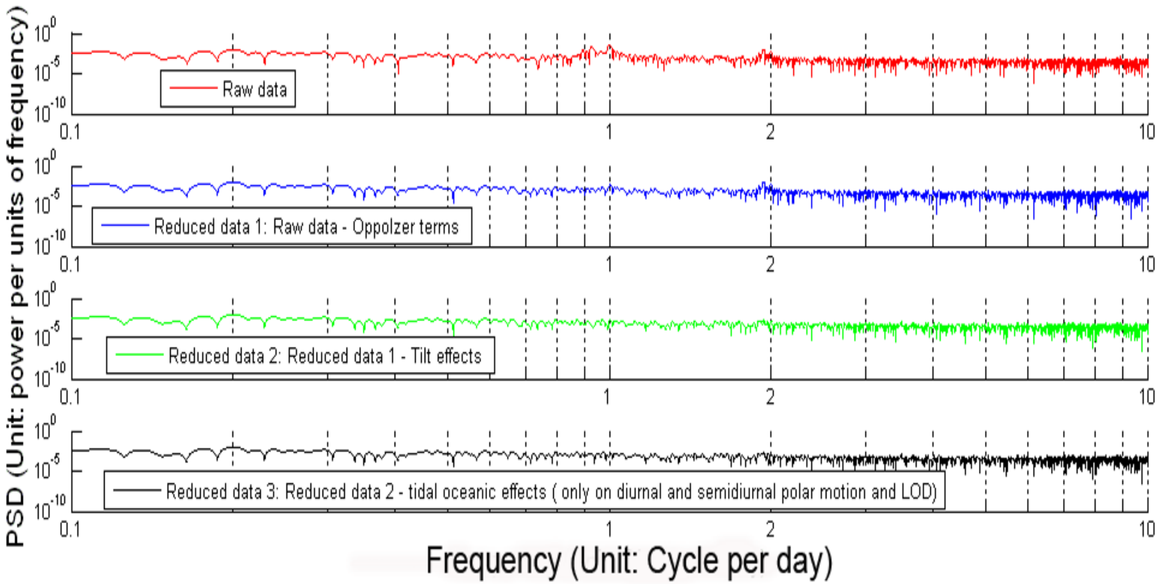

Figure 1: The PSD of high-pass filtered time series

3. CONCLUSIONS

The tidal oceanic effects on RLG are investigated. The retrograde diurnal effect is considered by taking the MBH 2000 into account. The prograde diurnal and semi-diurnal effects are calculated based on the IERS conventions and the kinematical Eq. (3). All these effects contribute only a few μHz to the Sagnac signal and are in the order of the present noise level.

Even though this study does not use the observation of tiltmeters to reduce the RLG's tilt, the tidal tilt signals in RLG are still well removed by our tilt model. When using tiltmeters for tidal correction, one might introduce small attraction model errors in the data. Thus, careful attraction modeling and tiltmeter calibration is required. However, when studying non-periodic signals, the use of measured tilt data is mandatory.

In order to detect signals in the μHz range, further reduction of the noise level by improving the instrument stability and modeling the environmental impact on the Ring Laser Gyroscope are recently in progress.

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4. REFERENCES

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