The rotation of the Earth is routinely monitored by a global network of radio telescopes using quasars as fixed markers in space. The operation of such a network requires expensive equipment and a lot of maintenance effort, while on the other hand no other technique yields Earth rotation parameters with such a precision: 10 microseconds in length of day (LOD) and 0.1 millisecond of arc (mas) in polar motion.

Ring lasers open up an alternative way for continuous monitoring of Earth rotation. Diagnosing the Sagnac effect ring laser measures rotations absolutely, without the need for observing external objects like stars or satellites. Attached to the Earth they allow the measurement of the Earth rotation rate and the orientation of the instantaneous rotation axis relative to an Earth fixed frame.

Benefits of ring laser measurements are:
- Complementary measurements to geodetic space techniques
- Completely different type of measurement
- High temporal resolution for monitoring subtle variations
- Continuous operation, no time availability
- No network required
- Direct access to pole motion
- Ring lasers are sensitive to motions of the rotation axis with respect to Earth
- They are not sensitive to motions of the rotation axis in space
- They measure the rotation of the Earth
- They can be used in underground labs
- They are not sensitive to motions of the rotation axis in space

Principle of Operation

Ring lasers use the Sagnac effect, which is the frequency splitting of two counterpropagating laser beams forming a closed light path in a ring resonator due to rotation (Sagnac 1913). The resonator cavity is filled with a He-Ne-Ne gas mixture, which is excited by an alternating electric field. The frequency difference between the co-rotating and the counter-rotating beam is described by the Sagnac formula for active resonators:

\[ \Delta f = \frac{G}{4} \cdot \Omega \]

where \( G \) is the gain of the resonator, \( f \) is the laser frequency, \( \lambda \) is the laser wavelength, and \( \Omega \) is the rotation vector of the Earth.

The task is to measure the frequency of the optical interference pattern, which is roughly 12 magnitudes below the optical frequency, with a relative precision of 10⁻¹⁰.

Because ring lasers measure the projection of the Earth rotation vector on the instrument axis, it is sensitive to both spin variations and orientation changes of the Earth's axis with respect to the instrument.

Orientation Monitoring

Because ring lasers measure the projection of the Earth rotation vector on the instrument axis, it is sensitive to both spin variations and orientation changes of the Earth's axis with respect to the instrument.

Amplitudes at Tidal Frequencies

The recent detection limit for periodic subdaily signals is 0.5 mas for polar motion and 0.2 ms for LOD. For the Wettzell ring laser, the performance of the Wettzell ring laser has been significantly improved in 2006. According to the IERS conventions 2003, the terms amplitudes of diurnal polar motion and polar motion are defined only by frequency, rather than by their physical meaning. The main diurnal polar motion, showing a superposition of the annual and Chandler wobble with the Brückner (1906) model terms series of thermal polar motion.

The 4 x 4 m ring laser “G” in the underground lab during maintenance work.

Modifications in 2006
- Improvement of the vacuum system
- Stabilization of the Sagnac frequency suffered from outgassing from impurities (H₂, H2O) from the stainless steel surface
- Replacement of the old 50 mm by 150 mm tubes
- Installation of a getter tank to catch gas impurities
- Replacement of the Rb frequency standard by a reference frequency coming from a hydrogen maser

The technical upgrades in 2006 resulted in a significant improvement in stability and resolution.

The performance of the Wettzell ring laser has been significantly improved in 2006. The recent detection limit for periodic subdaily signals is 0.5 mas for polar motion and 0.2 ms for LOD. The amplitudes of 7 diurnal polar motion terms (Q1, O1, M1, P1, K1, J1, OO1) have been reliably determined with formal errors less than 0.2 mas. The recent detection limit for periodic subdaily signals is 0.5 mas for polar motion and 0.2 ms for LOD.

Superimposition of the annual and Chandler wobble with the Brückner (1906) model terms series of thermal polar motion.

The technical upgrades in 2006 resulted in a significant improvement in stability and resolution.

The 4 x 4 m ring laser “G” in the underground lab during maintenance work.

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Summary
- The performance of the Wettzell ring laser has been significantly improved in 2006.
- The recent detection limit for periodic subdaily signals is 0.5 mas for polar motion and 0.2 ms for LOD.
- The amplitudes of 7 diurnal polar motion terms (Q1, O1, M1, P1, K1, J1, OO1) have been reliably determined with formal errors less than 0.2 mas.
- Regarding the technical feasibility there is still potential for an increase in resolution and stability.