MEASURING EARTH ROTATION COMBINING RINGLASER AND VLBI

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INTRODUCTION

Precise knowledge of Earth orientation parameters (EOP) is indispensable for any kind of positioning and navigation on Earth and in space. Errors as large as one milliarcsecond cause positioning errors on the Earth surface of three centimetres and kilometres at distances like those to Mars when navigating spacecrafts.

The orientation of the Earth in space is usually described by five EOP which describe the deviation from a uniform rotation in 24 hours and the variations of the rotation axis with respect to Earth (polar motion) and space (nutation). It is necessary to regularly observe these variations, which are caused by different excitations and occur at different time scales from sub-diurnal to years.

STATUS QUO - VLBI

Very Long Baseline Interferometry (VLBI) is the only technique that can estimate the full set of five EOP. Normally, these parameters are measured with daily resolution and models are used to describe the diurnal and sub-diurnal variations, mostly caused by ocean tides and luni-solar torques. Many studies, however, detected deficiencies in these models [1] which need further improvement.

In geodetic VLBI, globally distributed radio telescopes observe the radiation from quasars billions of light years away. It can be assumed that they are fixed points on the sky and that the radiation arrives in plane wavefronts, thus being observed by one telescope earlier than by the other one. This difference in arrival time is the primary observable in geodetic VLBI.

Figure 1: Station Wettzell (Germany) with the new twin radio telescope

Since the telescopes observe at data rates like Gbits/sec, the huge amount of data has to be saved on hard disks which are then shipped to one common location where the signals are correlated. Usually these VLBI observations last 24 hours and are carried out twice or three times a week.

These observations can then be used for the determination of a variety of different parameters, such as the realisation of terrestrial and celectial reference frames and for the estimation of EOP.

IMPROVEMENTS USING RINGLASER

Ringlasers represent an elegant and alternative measurement technique. They can measure Earth rotation in an absolute sense, independently of an external reference frame like quasars used by VLBI. However, the demands on such instruments are extremely high and cannot be met by existing com-

mercial devices [2].

Up to now, there is only one ringlaser with sufficient precision, located in Wettzell, Germany. The ringlaser is sensitive enough to measure changes in Earth rotation. Actually, ringlasers measure rotations via the Sagnac effect, which means that two identical light beams travel around a closed ring on exactly the same path in opposite directions. If the ringlaser rotates, the path length is changing causing a phase shift. This phase shift is then translated into a frequency difference, the so-called Sagnac frequency [2].

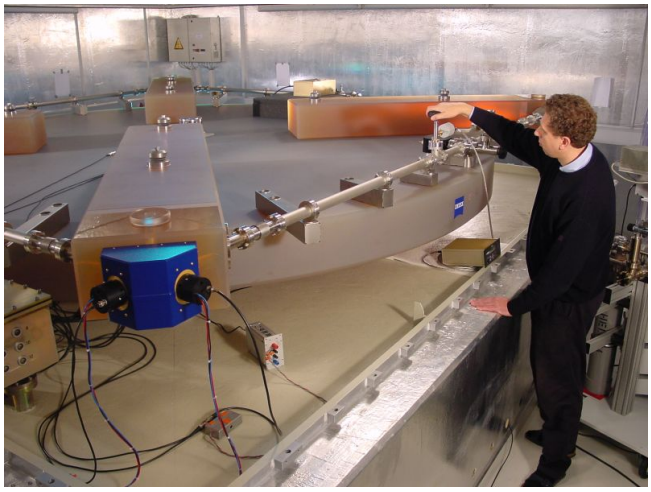

Figure 2: Ringlaser at Wettzell (Germany)

If the ringlaser is connected to the Earth, changes in the Earth rotation can be measured. The main advantage of ringlasers compared to VLBI is, that they measure Earth rotation directly in real-time with a high sampling rate. Therefore, they are sensitive to the sub-diurnal frequency changes. To get the complete information about orientation of the Earth, at least three different ringlasers at different positions on the Earth are needed.

COMBINATION

At the moment there is only one ringlaser for measuring Earth rotation. This means that it is not possible to estimate the whole orientation of the Earth, however, it is possible to combine ringlaser data and VLBI observations to improve the solution, mostly for the sub-diurnal variations. At the moment the accuracy of EOP from ringlaser data is one order of magnitude worse than the results from VLBI, but it is assumed that the accuracy gets better with further investigations as proposed in this project.

To perform a combination, great care must be taken that the same models are applied and all additional measurement influences are corrected correctly.

CONCLUSION

We plan to combine observations from VLBI and ringlaser to improve the quality of the estimated Earth orientation parameters. We have access to improved ringlaser data from Wettzell, so that we are optimistic to enhance the present approach of Earth rotation determination.

The main advantage of using ringlaser data is the they are very sensitive to sub-diurnal changes and they provide an independent measurement opportunity.

REFERENCES

[1] Combining VLBI and ring laser observations for determination of high frequency Earth rotation variation, Journal of Geodynamics, Vol. 62, pp. 69-73.

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