Clock networks and their sensibility to time-variable gravity signals

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High-performance clock networks are considered as a novel tool in geodesy. Today the latest generation of optical clocks approaches a fractional frequency uncertainty of $1.0 \times 10^{-18}$, which corresponds to about 1.0 cm in height or 0.1 m$^2$/s$^2$ in geopotential. The connected clocks are thus promising to enable “relativistic geodesy” in practice: Gravity potential (or height) differences can be inferred through the ultra-precise comparison of clocks’ frequencies.

In this study, we will investigate the possibility of high-performance clock networks for detecting time-variable gravity signals. In the past two decades, the satellite gravity mission GRACE, now continued by its follow-on mission, has significantly improved our knowledge on the Earth's gravity field, especially on its changes over time. However, the results are limited in terms of spatial resolution (about a few hundreds of kilometers) and temporal resolution (standard is one month). Terrestrial clock networks can be used to observe point-wise gravity potential values at locations of interest. By continuously tracking of changes w.r.t. a reference clock, time-series of gravity potential values are obtained, which reveal the gravity variations at these locations. To elaborate this idea, we will address the following research questions:

- Are clock measurements with the accuracy of $10^{-18}$ sensitive enough to time-variable gravity signals? Or what is the requirement on the clock’s performance for detecting time-variable gravity signals?
- Which kinds of time-variable signals can be “seen” by clocks, the long-term trends (yearly), seasonal variations or short-term changes (weekly/daily)?
- In which regions might clock networks be sensitive to time-variable gravity signals, in Amazon, Greenland or also in Europe?
- An “absolute” reference clock is required for a network that should be least affected by gravity variations. Where should it be placed?

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