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High-Performance Clock Networks and Their Application in Geodesy

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The advancement of quantum technology brings new opportunities in precision measurements, which yields novel sensors for accelerometry, gradiometry, chronometry and so on. For chronometry, high-performance clock networks, i.e., optical clocks connected by dedicated frequency transfer techniques, are capable to observe the gravitational redshift effect. This can be applied to infer the point-wise gravity potential (or physical height) difference between long-distance sites. This concept is termed as relativistic geodesy with clocks, or chronometric geodesy. It opens a new door to obtain geodetic measurements.
In this study, we address the potential of high-performance clock networks for a few typical geodetic applications. Since clock networks with a fractional frequency uncertainty of 1.0 x 10-18 can determine the physical height differences between distant points with the target accuracy level of 1.0 cm, we study their potential for the realization of a homogeneous and accurate global physical height reference frame. We will show simulation results to demonstrate that clocks are powerful to unify the practically-used local height systems. Clocks are also considered to be operated at locations of interest, e.g., in Greenland and Amazon, where they can continuously track changes w.r.t. reference clock stations. The resulting time-series of gravity potential values can probably reveal the time-variable gravity signals at these locations. Moreover, clocks are assumed onboard a pair of co-orbiting satellites to collect relative gravity potential values with a global coverage. In this scenario, we will run closed-loop simulations to evaluate the potential of clocks for detecting time-variable gravity signals from space.

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