

Geopotential-difference determination using a satellite optical-frequency-transfer network

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Abstract

Optical-clock frequency comparisons provide a direct means of determining geopotential differences based on general relativity. This study presents a satellite optical-frequency-transfer network for determining geopotential difference between distant ground stations by simulated data. Several low-orbit satellites and two space stations are used to construct a controlled 14-day simulation involving two ground stations Wuhan and Boulder. Two-way optical-frequency links among ground stations, space stations and satellites are modelled. The two ground stations have no simultaneous common-view epochs with either space node during the simulated period. After independent calibration of constant relative clock offsets and systematic frequency shifts, observations through one spacecraft recover the geopotential difference with a formal uncertainty equivalent to 3.0 cm in height. Introducing the second space node increases the effective sampled ground-link observation time by 81%. The dual-spacecraft network with the inter-satellite link reduces the formal uncertainty to 2.5 cm. The inter-satellite link further reduces the formal uncertainty by 12.8% when it acts as the bridge between otherwise separate space-clock subnetworks. These results demonstrate that an intercontinental geopotential difference can be recovered by satellite optical-frequency-transfer network, which may contribute to unification of global or regional height system. This study was supported by the National Science and Technology Major Project (Grant No. 2025ZD0300700), the National Natural Science Foundation of China (Grant Nos. U25D9002 and 42388102).

Oral report: Wenbin Shen, Professor, Wuhan University.