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Determining the geopotential by clock transportation time comparison

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Abstract According to Einstein's general relativity theory (GRT), a high-precision clock (such as Hydrogen-maser clock or Cesium-fountain clock) runs quicker at a position with higher gravity potential (geopotential) than a clock at a position with lower potential. Hence, one may determine the geopotential differences and orthometric heights by comparing the time elapse using precise clocks, referred to as relativistic time comparison approach. However, until now, there are not sufficient experiments in comparing two clocks' running rates difference. Our clock transportation experiments were performed between two Time-Frequency labs, Luojia Mountain station and Jiugong Mountain station, separated by a geographic distance of about 130 km with 1242 meters in orthometric height. Here we present direct comparison results using a fixed hydrogen clock and a transportable hydrogen clock with their frequency stability around 5×10^{-15}. The experiments results indicated that the relativistic time comparison with uncertainty of about 1×10^{-14}@ 3 days and the precision of the geopotential difference between two stations are about 760 m^2/s^2, which is equivalent to 76 m. Results coincide with the general relativity theory prediction about the clock's running rate within the clocks' accuracy range. This study is supported by NSFCs (grant Nos. 41631072, 41721003, 41429401, 41574007, 41874023, 41804012) and Guangxi Key Laboratory of Spatial Information and Geomatics (grant No. 17-259-16-04).