

## New era of time-frequency geoscience

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According to general relativity theory (GRT), an atomic clock runs quicker at a position with higher gravity potential (geopotential), or equivalently the vibration frequency of the clock is larger at a higher geopotential position. Inversely we may compare time elapse or frequency shift between two atomic clocks at two stations to determine the corresponding geopotential difference via various techniques. Time and frequency science develops very quickly, and scientists generated optical atomic clocks with uncertainty of about  $1 \times 10^{-18}$  level, which enables 0.1 geopotential unit level (equivalent to one centimeter level) measurement, opening a new era of time-frequency geoscience. Here we discuss two kinds of approaches, time comparison approach and frequency comparison approach, for geopotential determination, and their potential applications in geoscience, including gravitational redshift test, geopotential determination, gravity field determination, orthometric height determination, world height system unification. This study is supported by NSFCs (grant Nos. 41721003, 41631072, 41874023, 41574007, 41804012).