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Orthometric height determination using optical clocks

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General relativity theory predicts that there exists a gravity frequency shift (gravitational red shift) if an electromagnetic signal propagates from one point to another point, and the frequency shift depends on the geopotential difference between these two points. Inversely, by measuring the gravity frequency shift between arbitrary two points we may determine the geopotential and consequently the orthometric height difference between these two points. To improve our previous investigations (Shen and Peng 2012), the present study provides further foundation of the optical-fiber frequency transfer approach (OFTA; Shen and Peng 2012) and describes in details how to determine the orthometric height between two points using optical clocks via optical fiber. Optical clocks have achieved a stability of 10E-17 to 10E-18. In another aspect, remote optical fiber communication (e.g. Predehl et al. 2012) demonstrates a frequency comparison accuracy at the level of 10E-18 (or better), which is equivalent to a height variation of 1cm. The quick development of time-frequency science, including the high-precise optical clocks, provides potential of determining the orthometric height between arbitrary two points which are connected by optical fiber. This study suggests that determining the orthometric height difference between two points using optical clocks via optical fiber frequency transfer communication technique is prospective and potential. The realization of the OFTA may greatly contribute to the unification of the world height system (WHS). This work was supported partly by the NSFC (grant No. 41174011), National 973 Project China (grant No. 2013CB733305), NSFC (grant No. 41210006, 41128003, 41021061, 40974015).