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Test of gravitational redshift based on tri-frequency combination of frequency links between Atomic Clock Ensemble in Space and a ground station

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Atomic Clock Ensemble in Space (ACES) is an ESA mission designed mainly to test gravitational redshift with high-performance atomic clocks in space and on the ground. Here we develop tri-frequency combination (TFC) method based on the measurements of frequency shifts of three independent microwave links between ACES and a ground station. The potential scientific object requires an accuracy of at least 3×10^{-16} , thus we need to consider various effects including Doppler effect, second-order Doppler effect, atmospheric frequency shift, tidal effects, refraction caused by atmosphere, Shapiro effect, with accuracy level of tens of centimeters. The ACES payload will be launched in middle of 2021, and the formulation proposed in this study will enable us to test gravitational redshift at an accuracy level at least 2×10^{-6} level, one order more higher than the present accuracy level. This study is supported by NSFCs (grant Nos. 41721003, 41631072, 41874023, 41804012, 41429401, 41574007) and Natural Science Foundation of Hubei Province of China (grant No. 2019CFB611).