

Formulation of testing gravitational redshift based on frequency links between ACES on board international space station and 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. A crucial part of this experiment lies in its two-way MicroWave Link (MWL), which uses the uplink of carrier frequency 13.475 GHz (Ku band), and downlinks of carrier frequencies 14.70333 GHz (Ku band) and 2248 MHz (S band) to transfer time and frequency. The formulation based on time comparison has been studied over a decade years. However, there are advantages using frequency comparison rather than time comparison to test gravitational redshift. Hence, here we develop a formulation based on the measurements of frequency shifts of three independent MWLs 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 the near future, and using the formulation proposed in this study could test gravitational redshift at an accuracy level at least one-order higher than the present accuracy level. This study is supported by NSFCs (grant Nos. 41631072, 41721003, 41429401, 41574007, 41874023, 41804012).