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RESEARCH TRAINING GROUP
Models of Gravity

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A test of the gravitational redshift with Galileo satellites in an eccentric orbit

Abstract

The European GNSS satellites Galileo 5 and 6 launched in August 2014 have not reached their targeted circular orbit at approximately 22.000 km height. Instead, they have been injected into an eccentric orbit due to a launch mishap and after a series of correction maneuvers their orbits now possess an eccentricity of 0.16 corresponding to a periodic variation of altitude of about 8000 km. While this is of some disadvantage for navigation purposes it offers a unique possibility to perform a precise test of the gravitational redshift as predicted by Einstein's theory of General Relativity. Thus, with support from the European and German space agencies ESA and DLR we have conducted an analysis of the clock and orbit data from these two satellites. Both satellites are equipped with passive hydrogen maser clocks and Rubidium atomic frequency standards. The modulation that these clocks' frequencies undergo due to the gravitational redshift is approximately $1 \cdot 10^{-10}$ in relative frequency $\Delta \frac{\nu}{\nu}$. We show that with the clocks onboard of these satellites an improved test of this general relativistic effect over the most accurate such test so far, obtained by the Gravity Probe A experiment in 1976, can be achieved. We present an analysis of the data so far covering approximately 3 years and discuss the main systematic effects we have identified. From this we derive an error budget giving both statistical and systematic uncertainties comparable to the result of GPA.