



## GREAT: Galileo gravitational Redshift test with Eccentric sATellites

Einstein's General Relativity (GR) predicts that time flows differently for two clocks that have a relative speed and are placed in different gravitational potentials. It is therefore possible to test GR by comparing two clock frequencies, so-called gravitational redshift test. As several alternative theories of gravitation predict violations of this effect – e.g. in attempts to unify GR and quantum theory – experimental constraints are of paramount importance. The best test to date was performed with the Gravity Probe A (GP-A) experiment in 1976 with an uncertainty of  $1.4 \times 10^{-4}$ .

The GREAT (Galileo gravitational Redshift test with Eccentric sATellites) experiment proposes to use the on-board atomic clocks of the eccentric Galileo satellites 201 and 202 to test the gravitational redshift. An elliptic orbit induces a periodic modulation of the gravitational redshift while the very good stability of Galileo clocks allows measuring this periodic modulation to a high level of accuracy. It has been shown that considering realistic noise and systematic effects it is possible to improve on the GP-A limit down to an uncertainty around  $(3-4) \times 10^{-5}$  after one year of integration of Galileo 201 data<sup>1</sup>.

However, a good control of systematic effects will be essential in order to calculate robust limits on the parameters of the GR violation. In this context, **the proposed dedicated Satellite Laser Ranging measurements will become very helpful to disentangle in a good extent systematic errors coming from the orbit and impacting the clock determination from other systematics.** This will require the best coverage of Galileo 201 orbit in space and in time.

### NOTE:

For the GREAT GR tests, two parallel research activities have been launched by the European Space Agency, led respectively by the following two institutions:

- ZARM Center of Applied Space Technology and Microgravity, at Bremen University in Germany;
- SYRTE laboratory - Systèmes de Référence Temps-Espace – of CNRS / Paris Observatory – PSL Research University /UPMC – Sorbonne Universités in France, both specialists in fundamental physics research.

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<sup>1</sup> Delva, P., A. Hees, S. Bertone, E. Richard, and P. Wolf. 'Test of the Gravitational Redshift with Stable Clocks in Eccentric Orbits: Application to Galileo Satellites 5 and 6'. *Classical and Quantum Gravity* 32, no. 23 (2015): 232003. doi:10.1088/0264-9381/32/23/232003.