Informal Workshop
"Galileo Galilei" (GG) and GGG lab prototype: state of the art and new possibilities"
10-12 February 2010 (Pisa/San Piero a Grado)

Summary notes

The key issue of the Workshop was to assess the use in GG of a SIM like laser gauge at picometer level developed at JPL and the benefits it would bring in testing the Equivalence Principle (EP). It was found that the laser gauge can be implemented in GG. Moreover, a viable solution has been identified for a full scale validation test in the sGGG ("suspended GGG") prototype under completion.

The issue of thermal noise was revisited and a major new insight came from Mike Shao (JPL), who made the following point. Since in GG the signal is read at the rotation/modulation frequency of 1Hz, and the displacement thermal noise of the proof masses is inversely proportional to the square of the frequency at which displacement is modulated, thermal noise in GG is a factor 1 million smaller than in similar EP experiments where rotation frequencies are inevitably (by design) much smaller (~10^{-3}Hz in other satellite experiments as well as in rotating torsion balances). This explains why thermal noise of the LIGO and VIRGO mirrors –at 100Hz and above– has values orders of magnitude below the picometer. In GG, by up-converting the frequency of an EP violation signal in the field of the Earth from its (low) orbital frequency of ~1.7×10^{-4} Hz to the (high) rotation/modulation frequency of 1Hz –the highest ever in EP experiments– proof mass thermal noise is reduced by orders of magnitude, as the ratio of these frequencies squared. Instead, cooling the experiment to superfluid He temperature would only reduce thermal noise by a factor 10.

A very low thermal noise allows the target signal to be detected in a much shorter integration time, results in a very high duty cycle and allows high precision differential measurements by the laser gauge to be fully exploited. We therefore plan to carry out a careful re-analysis of all systematic perturbations in GG so as to possibly aim at testing the EP one order of magnitude better than in the current error budget, i.e. to 10^{-18}. The end-to-end GG simulator built at TAS-I in 2009 during GG Phase A-2 study is the crucial tool that allows this analysis to be performed in a reliable way and in a short time, at the very beginning of GG Phase B Study should ASI approve it.

The Workshop focused on the GGG lab results. The outcome of a recent 25 days continuous run of the prototype was received very positively, as well as the experimental demonstration that a passive cardanic suspension designed and built in the lab is now capable to attenuate low frequency terrain tilts (not present in space) by a factor 10^4. In combination with active attenuation, for which an ISA-GGG tiltmeter is available (provided by V. Iafolla, IFSI-INAF) as well as a very sensitive double pendulum tiltmeter (designed by D. Bramanti, built and operational in the GGG lab) it will be possible to significantly reduce platform noise. Motor and bearings noise (not present in space) might then become relevant, hence an improved bearings set-up has been mounted in the new sGGG rotor (partially assembled). The plan is for the suspended rotor to achieve the goal set for INFN of a ground EP test in the field of the Sun to 10^{-9} reaching a displacement sensitivity close to that required by GG in space. The experimental method devised to measure the effect of residual electric charge patches in the GGG running apparatus was also presented, demonstrating –in a direct and unquestionable manner– that electric patches are not, and will not be, a matter of concern.

GG is designed as a "flying payload" such that the payload can be tested thoroughly in the lab while the satellite is limited to minimal, key functions (such as hosting the instrument, compensating for residual drag, sending data back home). The former provides confidence in the space experiment to succeed; the latter brings down the mission cost.

The interest of JPL in GG has been confirmed and reinforced by Mike Shao and Slava Turyshev. They will explore all viable routes within NASA in order to obtain financial support –from the ROSES Call to the Explorer and Stand Alone Mission of Opportunity Calls recently announced. In this positive context, interest in GG was also expressed from within Europe by Hansjoerg Dittus (DLR, Bremen) based on expertise in fundamental physics experiments in the lab (with the ZARM drop tower) and related developments for free flyers.