Contribution ID: **48** Type: **not specified**

A torsion pendulum test of LISA Pathfinder free-fall mode: measuring fN force variations in presence of constant nN forces

The LISA Pathfinder geodesic explorer mission for gravitational wave astronomy has demonstrated a residual acceleration between two free falling test masses at femto-m/s^2Hz^1/2 level in the frequency range 0.7 - 20 mHz. The relative acceleration between these two objects is perturbed by the presence of a large and constant relative acceleration that must be actively compensated in order to hold the test particles centred inside an orbiting apparatus. The actuation force applied to compensate this effect introduces a dominant source of force noise in the mission noise budget at frequency near and below the mHz. The 'free-fall mode'actuation control scheme has been designed to suppress this noise source and avoid actuation instabilities: actuation is limited to brief periodic impulses, with test masses in free fall in between two "kicks". This actuation-free motion is then analysed for the remaining sources of acceleration ultra noise.
We will discuss and present data for the on-ground torsion pendulum testing campaign of this technique, and the associated data analysis algorithms, at a level nearing the sub-femto-g/sqrt(Hz) performance required for LISA Pathfinder.

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