Highly Environmentally-Stable Facilities

W. A. Terrano, J. H. Gundlach, E. G. Adelberger, C. A. Hagedorn
wterrano@princeton.edu

1. Abstract

Environmental noise is the limiting factor in several experiments at the precision frontier, such as tests of gravity and gravitational waves, and searches for ultra-low-mass dark matter. Certain types of noise – notably low-frequency vibrations, thermal fluctuations and changes in local gravity – require large-scale facilities to suppress. To that end we propose a national facility or network of facilities designed and built (perhaps underground) to suppress low-frequency noise sources, providing access to highly-stable lab space for a variety of smaller-scale experiments – selected by proposal from different institutions – that they individually could not afford to develop, and allow the individual groups to focus on improving the measurements themselves.

- *Low Vibrations*: Vibrational noise can be suppressed by using multi-level vibrational isolation, but the isolation is only effective at suppressing noise at frequencies above the resonant frequency of the isolation stack, so for lower frequencies it rapidly becomes large and complicated and is eventually completely ineffective.
- *Thermal Stability*: Thermal effects are among the most challenging systematics for mechanical experiments, and can manifest themselves in complicated ways. An underground facility that is very stable thermally would ameliorate them.
- *Gravity Gradients*: Changes in the local gravitational field are very difficult to monitor and stabilize experimentally. Again a moderately deep underground facility chosen for low-gravity-gradient noise would immediately improve the experiments sensitive enough to be limited by fluctuations in local-gravity [1, 2].

References

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[2] T A Wagner, S Schlamminger, J H Gundlach, and E G Adelberger. Torsion-balance tests of the weak equivalence principle. *Classical and Quantum Gravity*, 29(18):184002, aug 2012.