Design and construction of a high-amplitude ground shaker for the generation of a gravity signal on the E-Test prototype

1. Context

Gravitational wave detectors are high-precision, ultra-low-noise instruments based on large-scale Michelson interferometers. Their sensitivity is limited at low frequencies by disturbances such as *Newtonian Noise*—fluctuations in the local gravitational field caused by time-varying mass density in the environment (e.g., ground motion, seismic activity). Unlike other noise sources, Newtonian Noise cannot be shielded and must instead be estimated and subtracted using auxiliary sensors and modelling techniques.

However, current subtraction methods rely heavily on numerical simulations and analytical models, which lack direct experimental validation under controlled conditions. This project addresses that limitation by artificially generating a measurable gravity perturbation through controlled ground motion. The proposed approach is to design a high-amplitude ground shaker capable of inducing sufficient density variations in the soil to produce a detectable gravitational signal.

2. Topic of the thesis

The goal of this master thesis is to design, develop, and experimentally validate a high-amplitude ground shaker tailored to the requirements of the E-Test prototype. The shaker must be capable of generating controlled, repeatable ground vibrations strong enough to produce measurable Newtonian Noise.

The student will:

- Review existing ground shaker technologies and assess their suitability with respect to the experimental constraints.
- Identify and describe the key components of a typical shaker system (actuation mechanism, power electronics, control system, mechanical structure, coupling to the ground).
- Design a custom ground shaker adapted to the experimental needs.
- Select and procure the necessary components (actuators, sensors, electronics, structural elements).
- Assemble, integrate, and test the system in a laboratory environment.
- Evaluate the shaker's performance and its ability to generate measurable gravitational perturbations.

The candidate should be:

- Highly motivated and intellectually curious, with a strong interest in experimental physics and engineering systems.

- Autonomous and proactive, capable of managing a hands-on project from design to implementation.

3. Working environment

The thesis will be carried out within the **PML (Precision Measurement Laboratory)** at ULiège, in close collaboration with a dynamic research team composed of PhD students and researchers. The student will benefit from a stimulating, research-oriented environment with access to advanced experimental facilities and expertise in precision instrumentation and gravitational physics.

This project offers a unique opportunity to contribute to cutting-edge research at the intersection of engineering and fundamental physics, with a strong emphasis on experimental development and real-world validation.

4. Contact

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