Design and application of high-resolution rotation sensors for vibration isolation in gravitational wave detectors

1. Context

High-end scientific infrastructures, such as gravitational-wave detectors and particle colliders, must be isolated from seismic motion to operate effectively. Currently, inertial sensors are used to actively isolate sensitive components from ground vibrations. As these instruments continually push toward higher sensitivity and performance, the isolation level and frequency bandwidth must be continuously improved. One promising approach is the use of high-resolution rotation sensors at very low frequencies, where conventional inertial sensors are limited. Such scientific instruments impose exceptionally stringent requirements on their components. In particular, gyroscopes must achieve outstanding resolution, with the ability to detect extremely small rotations down to the nanoradian level (10^{-9} rad).

2. Topic of the thesis

The thesis topic is twofold. The first part focuses on the development and testing of a large-scale, high-resolution optical rotation sensor operating in a vacuum environment. The student will spend time in the laboratory contributing to the construction of the sensor and to the experimental setup required to characterize its performance, including sensitivity, self-noise, and dynamic range. The second part of the thesis focuses on the development of appropriate control strategies that exploit these sensors to actively isolate a platform from ground motion. The student will design and implement controllers in the MATLAB/Simulink environment and evaluate their performance using a model of an existing isolation platform. If the results are conclusive, the control strategies will be validated experimentally.

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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