Mechanical loss characterisation of a large monocrystalline silicon test mass at cryogenic temperatures for the E-TEST

1. Context

Next-generation gravitational-wave observatories, such as the Einstein Telescope, aim to significantly improve the sensitivity of gravitational-wave detection across a wide frequency range. One of the major limitations in these detectors arises from thermal noise originating in the test masses and their suspensions.To reduce thermal noise, the Einstein Telescope plans to operate part of the detector at cryogenic temperatures using monocrystalline silicon mirrors as test masses. Silicon exhibits excellent mechanical and thermal properties at low temperatures, making it a promising candidate material for future detectors. However, the mechanical loss of large silicon test masses at cryogenic temperatures must be carefully characterised, as even small losses can limit the detector sensitivity.

Within the framework of the Einstein Telescope, E-TEST facility, experiments are conducted to study the behaviour of large silicon test masses under cryogenic conditions. Understanding mechanical dissipation, thermal behaviour, and environmental effects at temperatures down to 10–20 K is essential for validating technologies required for the Einstein Telescope.

2. Topic of the thesis

The objective of this thesis is to experimentally investigate the mechanical loss of the largest monocrystalline silicon test mass currently available in the laboratory when cooled to cryogenic temperatures (10–20 K).The student will participate in the preparation and operation of a cryogenic experimental setup designed to measure the mechanical quality factor (Q) of the silicon test mass. The work will include cooling the test mass, exciting its mechanical modes, and analysing the resulting ring-down measurements to quantify mechanical dissipation.

In addition to the experimental work, the student will contribute to the mechanical and thermal modelling of the system. This may involve FEA simulations and the design and optimisation of experimental components using CAD tools etc. Several complementary investigations may also be carried out. The student will gain experience in cryogenic experimental techniques, precision measurements in vacuum environments, finite element modelling, CAD-based mechanical design, and data acquisition and analysis. The project combines hands-on experimental work in the laboratory with numerical simulations and data interpretation, providing exposure to research activities related to next-generation gravitational-wave detector technology.

3. Contact

Person of contact: Hemendra Singh (hsgahlot@uliege.be)

Lab: Precision Mechatronics Laboratory, University of Liège

Supervisor: Christophe Collette