Ultra-precise laser-frequency stabilisation for gravitational-wave detectors

Location of the proposed internship

CALVA platform

IJCLab – “Astroparticles, Astrophysics and Cosmology” pole – Gravitational Waves group

Description

Context: Ground-based gravitational-wave (GW) detectors use kilometre-long Michelson interferometers to detect relative GW strain signals at the level of 10^{-23}. The CALVA platform at IJCLab is designed to develop and characterise optical-cavity stabilisation techniques for Virgo, notably thanks to a 50m-long suspended optical cavity (called “filter cavity”). The study of such long, suspended cavities is of importance to improve the sensitivity of ground-based GW detectors, which rely on these cavities to generate frequency-dependent squeezing of light.

Due to the extreme sensitivity reached by modern ground-based GW detectors, exquisite control of laser frequencies is paramount to control the length of the filter cavity. We also aim at evaluating the impact of frequency stabilisation on the quality of squeezed light.

Scientific activity: The proposed internship aims at implementing frequency stabilisation on a 1064 nm laser. Indeed, it is now possible at IJCLab to access an ultra-stable optical signal at 1542 nm, from the Refimeve fibred network. The stabilisation of our 1064 nm laser on this ultra-stable signal will be carried out by means of an optical frequency comb, which allows for spectral-purity transfer between the two different wavelengths. The expected frequency stability for the laser is on the order of a few Hz after 1 s of integration, which is 3 orders of magnitude better than the free-running laser—about 1 kHz.

The 1064 nm laser is used for the control of the filter-cavity length, and is also used to generate the squeezed light. If the stabilisation is implemented before the end of the internship, the next step would be to use the laser for the control of the filter-cavity length, with or without stabilisation. The stabilised laser could also be used to generate squeezed light, and the quality of the generated squeezing could be characterised.

Prior knowledge (not essential but helpful): Optics, optical cavities, electronics, feedback loops, programming, quantum mechanics.

Contacts

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