M2 internship: Study of linear three-mirror cavity for frequency dependent squeezing in gravitational wave detectors

Place: IJCLab, Astroparticles, Astrophysics and Cosmology pôle, Gravitational Waves group

Context:

Since the first detection of gravitational waves (GW) in 2015, hundreds of compact binary coalescences have been observed. Even better, the observation of two merging neutron stars in 2017 and the associated electromagnetic observation heralded a new area of GW astronomy.

The next generation of GW detectors Einstein Telescope (ET), will aim at reaching most of the observable Universe for compact bynary coalescences. To reach this goal, ET will have to be ten times more sensitive than the design of current generation GW detectors and even better for frequencies below a few tens of Hz. The low-frequency part is crucial, as this is where most of the signal-to-noise ratio is picked up for many targeted GW sources, especially as we probe deeper in the Universe due to increased redshift of the signals. Moreover, extending the sensitivity towards the low frequencies enables early warning and localisation of merging neutron stars. ET will start observing by the end of 2030's with upgrade phases during decades.

Objectives:

Quantum noise will be a major limiting noise of ET. Consequently, controlling and reducing it using frequency dependent squeezed states of light will be a major challenge for ET. Such states of light need the use of kilometric suspended optical cavities, called filter cavities. Moreover, the parameters of these cavities must be tunable to follow the change in the GW detector implementation. Linear three-mirror cavities have been proposed as variable finesse cavities for the obtention of frequency dependent squeezing, but have never been experimentally studied. The objectives of the internship will be twofold :

- Define and test a locking strategy of the linear three-mirror cavity on an existing 1-m scale table top experiment to pave the way towards a suspended 50-m prototype
- Design the 50-m prototype parameters (mirror radius of curvature, reflectivity, etc.)

Working environment:

The M2 student work will be based at IJCLab in Orsay with both simulation and experimental aspects. IJCLab hosts the CALVA platform which is designed to study the control of a suspended cavity for Advanced Virgo with a 50m-long Fabry-Perot cavity and that is under modification to host a linear suspended three-mirror cavity. Moreover, the CALVA platform is now hosting the development of an in-vacuum squeezing source. By design, the tools used on the CALVA platform are the same as for Virgo, and may be a basis for ET, which facilitates sharing technology between the systems, and allow the M2 student to be trained on a GW detector-like environment. A PhD subject is proposed following this internship.

Application deadline: 15 January 2026

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