PhD thesis proposal: Frequency dependent squeezing for next generation gravitational-wave detector Einstein Telescope

Start of the PhD: 1st October 2026

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

Context:

Since the first detection of gravitational waves ten years ago, 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 gravitational-wave astronomy.
The next generation of gravitational waves detectors Einstein Telescope, will aim at reaching most of the observable Universe for compact binary coalescences. To reach this goal, Einstein Telescope will have to be ten times more sensitive than the design of current generation gravitational-wave 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 gravitational-wave 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. Einstein Telescope will start observing by the end of 2030's with upgrade phases during decades.

Objectives:

Quantum noise will be a major limiting noise of Einstein Telescope. Consequently, controlling and reducing it using frequency dependent squeezed states of light will be a major challenge for Einstein Telescope. Such states of light require the use of kilometric suspended optical cavities, called filter cavities. Moreover, the parameters of these cavities must be tunable to follow the changes in the gravitational-wave detector implementation. The objective of the PhD will be in particular to develop, characterise and control a variable finesse cavity to cope with the needed in-situ tuning and/or reduce the needed length of the cavities using a linear three-mirror cavity instead of a two-mirror cavity.
The results of the PhD thesis will have an impact on the design of the squeezing filter cavities for Einstein Telescope and the PhD student will be part of the Einstein Telescope Squeezed Light Working group.

Working environment:

The PhD candidate 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 the current gravitational-wave detector 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 Advanced Virgo, and may be a basis for Einstein Telescope, which facilitates sharing techno-

IJCLab - Laboratoire de Physique des 2 Infinis **Irène Joliot-Curie**
UMR 9012, CNRS, Université Paris-Saclay, Université Paris Cité
Bâtiment 100 - 15 rue Georges Clémenceau - 91405 Orsay cedex - France

logy between the systems, and allows the PhD student to be trained on a gravitational-wave detector-like environment.

Provisional timetable:

The first year of the PhD will be devoted to the experimental implementation of the linear three-mirror suspended cavity on the CALVA facility, along with simulation of the impact of such cavities on the quantum noise reduction with respect to two-mirror cavities, considering loss sources both on the CALVA set-up (to be compared at the end of the PhD with experimental measurements) and for Einstein Telescope.
The second year will then be dedicated to the control of the linear three-mirror cavity on the CALVA facility and its characterization.
Finally, during the third year, squeezed states of light will be injected into the linear three-mirror cavity to measure frequency dependent squeezing for the first time using linear suspended three-mirror cavities.

Application deadline: 15 January 2026 (M2 internship to be done before the PhD)

Contact: Angélique Lartaux (angelique.lartaux@ijclab.in2p3.fr)

IJCLab - Laboratoire de Physique des 2 Infinis **Irène Joliot-Curie**
UMR 9012, CNRS, Université Paris-Saclay, Université Paris Cité
Bâtiment 100 - 15 rue Georges Clémenceau - 91405 Orsay cedex - France