Master 2 internship - Artificial black holes in exciton-polariton fluids of light.

Overview

Institution: Sorbonne University - Ecole Normale Supérieure - CNRS - Laboratoire Kastler Brossel
Team: Quantum Fluids of Light team - Alberto Bramati, Quentin Glorieux, Hanna Le Jeannic
Supervision: Maxime Jacquet. **Location:** Jussieu campus. Paris, France
Duration: 3-6 months
Websites: www.quantumoptics.fr.

Quantum fluids of light

Photons are great carriers of information but they usually don't interact with one another. Atoms interact but are hard to manipulate and do not benefit from the toolbox of quantum optics for detecting quantum fluctuations and entanglement. Our approach to **marry these two systems for quantum simulation** is to use exciton-polaritons in semi-conductor microcavity.

Our team is using this platform to simulate astrophyics effects near artificial black holes with light.

Internship Description

Analogue gravity enables the study of fields on curved spacetimes in the laboratory [1]: it is possible to create conditions in which waves in media propagate as though they were in the vicinity of a black hole [2] or on an expanding universe [3], for example. In the Quantum Optics Group at Laboratoire Kastler Brossel, using exciton-polaritons in semiconductor microcavities and make them behave as "fluids of light" allows for simulating these effects in the lab.

At present, we are interested in engineering the flow (velocity) distribution of a fluid of light to create the analogue of an artificial black hole — an effective spacetime characterised by an intangible surface called the apparent horizon (the point of no-return that bounds the interior of the black hole). We have recently demonstrated full control of the spacetime and are now investigating the correlations stemming from the Hawking effect in this experiment.
The internship could consist in experimental and/or theoretical work.

Key Responsibilities

As a member of the quantum fluids of light team you will be in charge of various objectives (depending on your preferences).

- On the theoretical side, the student would use numerical methods [4] to simulate the hydrodynamics of the rotating fluid and calculate the Hawking correlations.
- On the experimental side, the student would use our new experimental platform to collect data (fluid density and phase, emission spectrum, noise correlations) and in analysing this data by comparing it with theoretical predictions.

Impact of the project

This project operates at the intersection of quantum physics and analog gravity. It allows us to create laboratory conditions where waves in media mimic behaviors near black holes or in expanding universes. This research involves a broad range of knowledge and experimental techniques that you will have the opportunity to learn during the Internship.

How to Apply - Contact Us

We are offering **an internship opportunity (followed by PhD if required)**
For inquiries or more information about this internship or to apply for this internship, please contact us directly at maxime.jacquet@lkb.upmc.fr.

Quantum fluids of light group at LKB

We are a group of friendly and welcoming scientists and we aim to create **an inclusive and supportive research environment.** We strongly believe in the value of diversity and inclusion in the field of quantum physics and we encourage **women and/or individuals from underrepresented minority groups** to apply for this internship.

References

[1] W. G. Unruh, “Experimental black-hole evaporation?,” *Physical Review Letters*, vol. 46, no. 21, p. 1351, 1981.

[2] M. Jacquet, T. Boulier, F. Claude, A. Maître, E. Cancellieri, C. Adrados, A. Amo, S. Pigeon, Q. Glorieux, A. Bramati, *et al.*, “Polariton fluids for analogue gravity physics,” *Philosophical Transactions of the Royal Society A*, vol. 378, no. 2177, p. 20190225, 2020.

[3] S. Eckel, A. Kumar, T. Jacobson, I. B. Spielman, and G. K. Campbell, “A rapidly expanding bose-einstein condensate: an expanding universe in the lab,” *Physical Review X*, vol. 8, no. 2, p. 021021, 2018.

[4] M. J. Jacquet, L. Giacomelli, Q. Valnais, M. Joly, F. Claude, E. Giacobino, Q. Glorieux, I. Carusotto, and A. Bramati, “Quantum vacuum excitation of a quasinormal mode in an analog model of black hole spacetime,” *Physical Review Letters*, vol. 130, no. 11, p. 111501, 2023.