M2 Internship Subject (2023-2024) at Institut Pluridisciplinaire Hubert Curien (IPHC)
Department of Subatomic Research (DRS)

OGMA Team :
Contributions to Gravitational Wave Astronomy

The OGMA Team (**O***bservations with* **G***ravitational waves &* **Mu***ltimessenger* **A***stronomy*) is involved in Gravitational Wave (GW) Astronomy, with technical contributions to the Virgo interferometer plus the analysis of the LIGO and Virgo data. The team is also involved in High Energy Neutrino (HEN) Astronomy, with technical and physics contributions to the ANTARES and KM3NeT neutrino telescopes. In addition, OGMA contributes to MultiMessenger studies, i.e. combining data from GW, HEN and ElectroMagnetic (EM) instruments.

The GW astronomy is a new field started a few years ago with the first observation of GW in 2015. It has been followed two years later by the first observation of GW plus electromagnetic signals. Since then, this field is rapidly evolving, thanks to the improvement of the detectors and new data taking, with more than 140 events observed so far (Oct. 2023). In May 2023, the LIGO detectors have started a new observation run, named "O4". They will be joined by the Virgo detector in March 2024. These observation are leading to real time public alerts to enable MultiMessenger astronomy. OGMA is involved in the search for GW events from the merger of compact objects (black holes BH or neutron stars NS), for realtime analyses and for the production of signal catalogues, through the development of the analysis pipeline MBTA. This pipeline is providing candidate events to a common LIGO/Virgo infrastructure which publicly broadcast the most significant candidates.

With the ongoing O4 observing run, this internship is a good opportunity to discover Data Analysis in GW experiments by, for instance, studying the LIGO and Virgo detectors cross calibration using astrophysical events. Indeed, the proper calibration of the GW detectors is critical to ensure correct sky localization of the source and proper recovery of the possible electromagnetic counterpart.

The OGMA team is also developing a new calibration technique, the Newtonian Calibrator (NCal), based on the production of varying gravitational field thanks to a massive rotor. The proper calibration of the GW detectors is key to enable precision science like the measurement of the Hubble constant with GW detectors. Several NCals have been installed on the Virgo site, and regular calibration shifts are scheduled during O4 in addition to the continuous operation of this system. With the Virgo detector starting to collect data, the contribution to the NCal study is a further possible topic for a Master internship.

These works could be extended during a PhD Thesis.

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