M2 Internship Subject (2024-2025) at Institut Pluridisciplinaire Hubert Curien (IPHC)
Department of Subatomic Research (DRS)

OGMA Team / Virgo

Cross-calibration of Gravitational Wave detectors using Astrophysical events

The OGMA Team (**O***bservations with* **G***ravitational waves &* **Mu***ltimessenger* **A***stronomy*) is involved in High Energy Neutrino Astronomy (KM3NeT neutrino telescopes) and Gravitational Wave (GW) Astronomy, with technical contributions to the Virgo interferometer plus the analysis of the LIGO, Virgo and KAGRA data, for what concerns GW astronomy. The team is also involved in the low latency operations, leading to public alerts and enabling MultiMessenger astronomy.

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 (GRB, optical, radio). Since then, this field is rapidly evolving, thanks to the improvement of the detectors and new data taking, with more than 240 events observed so far (Oct. 2024). Currently, the LIGO and Virgo detector are jointly operated for the observation run, named "O4". They are detecting GW events at a typical rate of few events per week.

The OGMA Virgo group is involved in the search for GW events from the merger of compact objects (black holes BH and/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. The team is also involved in the validation and release of these public alerts.

In addition, as calibration is essential for accurate source localization and correct astrophysical interpretation of observed gravitational waves, the group is also dedicated to improving the calibration accuracy of the Virgo interferometer and has developed a Newtonian Calibrator (NCal) which, in conjunction with other techniques, enables to reach a sub-percent calibration accuracy.

The proposed internship will build on these fundamental activities by studying an independent cross-calibration method between the GW detectors, based on astrophysical event data from the current O4 observing campaign. The results will be compared with individual calibration methods of each detector. Their physical implication will also be investigated and, as the efficiency of the method is expected to improve with increasing numbers of observed events, the internship will also explore its implications for future observing campaigns.

This work could be extended and enlarged during a PhD Thesis.

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