PHD project - Searches for kilonovae in gravitational waves phenomena

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Kilonovae are the optical signatures of extreme events such as the coalescence of two neutron-stars. They are due to the thermal radiation in the near-by ejecta of the event, thermalized by the radioactive decay of freshly synthetized elements. The electromagnetic brightness decays rapidly after the collision. Over the last 10 years, several claims of observations have been reported in the literature. But only in 2017, a clear signal of a kilonova, AT2017gfo, was observed due to a very intensive campaign monopolizing more than 70 international telescopes. The “lanceur d’alerte” came from gravitational waves (detected by the LIGO-Virgo collaboration), also emitted during binary neutron star coalescences. The next observing run of gravitational waves will start in December 2022, well-time for this PhD project. It promises to detect several binary system coalescences for which we might expect an associated kilonova signal.

Artemis at Observatoire de la côte d’Azur is involved and leads the GRANDMA network (originally created at IJCLAB) that embeds more than 25 telescopes covering all time zones and both hemispheres. Over the last 3 years, GRANDMA has demonstrated its observational expertise to search for kilonova signals post gravitational-wave alerts. In this PhD, we will optimize observational strategies to efficiently cover the event in space, in color and in time several days post-merger with the GRANDMA telescopes. Catching the very first moments of the kilonova emission is important for extracting the most physics from the observations and constraining the astrophysical scenario of the coalescences.
To do this, the student will contribute to the development of an online, multi-physics modelling framework that uses information from the gravitational-wave signal to calculate the expected luminosity and color of the kilonovae. This then will be compared with our GRANDMA telescope observations. The student will also use public data to complement our observations. It requires the creation of software capable of sending queries to get the data as quickly as possible and a smart orchestrator to guide observations. Data reduction of optical observations will therefore be the main focus of the work. We will extract the temporal and color properties of the optical signal. The multi-physics modelling framework will be used once again but using both optical and gravitational-wave signals to give the best vision of the coalescence of neutron stars.

This thesis covers multiple areas of physics (gravitational-wave physics, high-energy astrophysics), with a strong aspect of observations and online analysis, and the ideal prospective student will desire to be involved in emerging astrophysics techniques in a collaborative and international context.

An associated internship is offered prior to the PhD (February - March 2022).