Multi-Messenger AstroPhysics with the KM3NeT Neutrino Telescopes and Gravitational Wave Interferometers LIGO/Virgo

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The proposed PhD thesis will be performed in the framework of the european collaboration KM3NeT, which use underwater « neutrino telescopes » in the Mediterranean Sea, to detect and study GeV to PeV atmospheric/cosmic High Energy Neutrinos (HEN), and of the LIGO/Virgo Collaborations, which operate and develop Gravitational Wave (GW) interferometers.

IceCube has revealed in 2013 the existence of cosmic HEN, yielding information on the origin of cosmic rays. In July 2018, a possible connection of these cosmic neutrinos with astrophysical sources such as blazars was revealed. Moreover, the observation of GW and electromagnetic radiations from the merger of two neutron stars in 2017, and the search for possible coincident HEN, has opened the field of multi-messenger astrophysics: the combination of photons from all wavelengths, neutrinos, cosmic-rays and gravitational waves to improve our knowledge of astrophysical sources and discover new sources, in which IPHC has taken an active part.

From 2020, the next-generation HEN telescopes built by the KM3NeT collaboration will be upgraded with the deployment of new detection strings on both sites of the collaboration. The french site in Toulon will be dedicated to low energy GeV neutrinos, to determine the unknown neutrino mass hierarchy, with ORCA (**O**scillation **R**esearch with **C**osmics in the **A**byss). The italian site, in Sicily, will host ARCA (**A**stroparticle **R**esearch with **C**osmics in the **A**byss), dedicated, like ANTARES, to TeV-PeV neutrino astronomy. Both telescopes can be used jointly to study astrphysical neutrino sources from GeV to PeV energies. In parallel, the LIGO/Virgo Observing Run O3 will end in April 2020, before a period of upgrades and a new Observing Run to start in late 2021.

The IPHC « Multi-Messenger Astrophysics » group has a long standing experience in multi-messenger astronomy in ANTARES, through in particular the GWHEN program, devoted to the search for Gravitational Waves - High Energy Neutrinos correlation. It contributes to the construction and calibration of the ANTARES and KM3NeT Neutrino Telescopes. The group is now also member of the Virgo Collaboration, and contributes also in Data Analysis and Detector Calibration.

The proposed PhD will be dedicated to the development of optimized online and offline searches for correlated/coincident GW and HEN emissions, in the framework of ANTARES/KM3NeT and Virgo/LIGO.

He/She will also devote part of the PhD to the multi-messenger analyses that will be performed with the KM3NeT telescopes, in particular the combination of ORCA/ARCA results for the search for GeV-PeV neutrinos from, e.g., gamma-ray bursts, or other potential GW emitters, in coincidence with GW data. He/She will also be able to contribute to the calibration of the telescope(s) and interferometers. For what concerns KM3NeT, the expertise of IPHC with the Digital Optical Modules produced in the lab will be a great asset in this regard. Within VIRGO, the group is involved in the development of a Newtonian Calibrator for the absolute calibration of the GW interferometers, with consequences both for astrophysics and cosmology.