Title: The counterparts of high energy astrophysical neutrinos

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Scientific context

Over the last few years, multi-messenger (MM) studies have blossomed thanks to the coming online of gravitational wave and neutrino detectors, and to the efforts to achieve coordinated synergies with electromagnetic facilities and theoretical works. In the field of high energy neutrinos, this is opening the way to a revolution in understanding acceleration mechanisms in astrophysical sources, especially considering that neutrino emission is a direct proof of the presence of hadronic processes. As they are neutral particles, neutrinos are not affected by local nor large scale magnetic fields, and therefore travel unaffected across cosmic distances. Their weakly interacting nature requires the deployment of large and technologically advanced systems to detect them, and their direction of origin has so far remained characterised with limited precision, giving rise to a significant debate about the nature of their astrophysical counterparts.

In this context, our group has secured observing time with some of the premiere instruments in radio astronomy, with the goals of: (1) searching for the most promising counterparts of individual neutrino detections of astrophysical origin; (2) characterizing the physical properties of candidate counterparts from various populations. Taken together, these are essential steps to achieve a better understanding of the origin of astrophysical neutrinos, shedding light on the above mentioned ongoing debate.

Project outline

In the PhD Thesis project, the candidate will start with familiarising with the astrophysical background on neutrino emission, the existing detectors (IceCube and KM3NeT), the candidate counterparts, and the radio interferometry technique that is used for the follow up observations. In the rest of the first year, data analysis for recently acquired data will be carried out, with the goal of studying the physical properties of candidates of particular interest.

In the second year, when the KM3NeT real-time system will be active, the candidate will work on the direct search for new counterparts, especially thanks to data from MeerKAT (the precursor of the SKAO), obtained in the context of an approved triggered multi-epoch proposal (PI Giroletti).

Lastly, depending on the outcome of the work in the first two years, the third year will be devoted to the in-depth study of the most outstanding events, or on a population based statistical analysis, also considering multi-wavelength information, e.g. from the gamma-ray telescope Fermi or from CTAO.

During the activity, visits to top European institutions in the field of radio astronomy or neutrino detection will be offered to the candidate.