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Session 3: Probing of the universe: neutrino astronomy

High-energy neutrino searches in the Mediterranean Sea: probing the Universe with ANTARES and KM3NeT/ARCA

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A primary goal of deep-sea neutrino telescopes (NT) is the search for astrophysical neutrinos in the TeV-PeV range. This covers generic searches for any diffuse cosmic neutrino flux as well as more specific searches for astrophysical sources such as Active Galactic Nuclei and Gamma-Ray Bursts or close-by Galactic sources. By adopting a multimessenger approach, based on time and/or space coincidences with other cosmic probes, the sensitivity of such searches can be considerably augmented. The NTs comprise an array of photomultipliers tubes housed in so-called optical modules, detecting the Cherenkov light induced by charged leptons produced by neutrino interactions in and around the instrumented volume.

The first generation NT, ANTARES, has been running in its final configuration since 2008. It is today the largest neutrino telescope in the Northern hemisphere. After the discovery of a cosmic neutrino diffuse flux by the IceCube NT, the understanding of its origin has become a key mission in high-energy astrophysics. ANTARES makes a valuable contribution thanks to its excellent angular resolution in both the muon channel and the cascade channel (induced by all neutrino flavours). The ANTARES sensitivity is sufficient to constrain the origin of the IceCube excess from regions extended up to 0.2 sr in the Southern sky. Assuming various spectral indexes for the energy spectrum of neutrino emitters, the Southern sky and in particular central regions of our Galaxy are studied searching for point-like objects and for extended regions of emission. As an example of the various multi-messenger searches, ANTARES has participated, with IceCube, to a high-energy neutrino follow-up of the gravitational wave signal GW150914, providing the first constraint on high-energy neutrino emission from a binary black hole coalescence. ANTARES has also performed indirect searches for Dark Matter, yielding limits for the spin-dependent WIMP-nucleon cross-section that improve upon those of current direct-detection experiments.

The high quality of the data provided by ANTARES and the competiveness of the results achieved, despite the modest size of the detector, demonstrate the tremendous potential of the new much larger array, KM3NeT, located in the Mediterranean abysses. KM3NeT is a distributed research infrastructure hosting a km-scale neutrino telescope for high-energy neutrino astronomy, ARCA, offshore Capo Passero in Italy and a megaton scale detector for the determination of the neutrino mass hierarchy with atmospheric neutrinos, ORCA, offshore Toulon in France. KM3NeT has developed a cost effective design for the optical module, based on many small 3” photomultiplier tubes. Recently, the first ARCA detection strings have been deployed and preliminary results will be presented. The latitude of KM3NeT-ARCA will allow for a wide coverage of the sky with optimal sensitivity to the region of the Galactic Centre. The expected sensitivity of the complete KM3NeT/ARCA detector will allow the observation of the IceCube flux in less than a year, providing new information on its origin, energy spectrum and flavour composition. After five years, KM3NeT/ARCA could also give indications at more than 3-sigma level on some Galactic sources.