Searches for DM with the ANTARES and KM3NeT neutrino telescopes

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The nature of dark matter is one of the hottest topics in physics nowadays. Neutrino telescopes have an important role in this quest, given their specific characteristics. For instance, the detection of high energy neutrinos from the Sun would be a smoking gun for the presence of dark matter, since the astrophysical uncertainties are small, contrary to what happens with most of other indirect searches, where interpretation of excesses over background is complex. Another very interesting case is the Galactic Centre, where the ANTARES neutrino telescope has already set the best limits in WIMP annihilation cross section for large masses. In this presentation we will review the recent results of ANTARES on dark matter and show the foreseen performance of KM3NeT, which will be the largest neutrino telescope in the world, already in construction. This new detector has two configurations, ORCA (dense) and ARCA (sparse), which complement each other for a wide coverage of WIMP masses.

Neutrino telescopes: ANTARES and KM3NeT

- Neutrino telescopes have unique advantages in the search for dark matter, since neutrinos are neutral, stable and only interact weakly.
- The operation principle is based on detection of the Cherenkov light induced by the relativistic leptons produced in the interaction of high energy neutrinos in the water.
- In the analyses presented here, only events corresponding to CC interaction of muon neutrinos are used, since they offer the best angular resolution.
- The ANTARES detector [1], located in the French coast close to Toulon and completed in 2008, has shown the feasibility of under water Cherenkov detectors.
- The KM3NeT Detector [2], next step after ANTARES, is already under construction. It will have two configurations:
  - ORCA: dense array 115 lines, located close to Toulon (France)
  - ARCA: sparse array of 230 lines (1 km³), close to Sicily (Italy)
- The plan for KM3NeT foresees the construction of ORCA and the first building block of ARCA (115 lines) by 2020

Dark matter detection

- The nature of dark matter is one of the most important topics in Physics nowadays.
- It constitutes about 89% of the matter of the Universe but their properties are quite unknown.
- Neutrino telescopes complement the search for dark matter, with unique advantages:
  - WIMPs detected after their self-annihilation when they accumulate in celestial bodies.
  - The most promising sources for neutrino telescopes are the Sun and the Galactic Center.
- Neutrinos fluxes are produced in the annihilation of W⁺, Z, H bosons, c, b, t quarks; τ⁺, τ⁻, τ⁰;
- We consider the b and W⁺/W⁻ channels as benchmarks. In the results presented here, 100% branching ratio is assumed for any considered channel.

Sun

- WIMPs crossing the Sun could scatter with nucleons in the Sun and become gravitationally trapped.
- After the annihilation of WIMPs and the production of secondaries, only neutrinos would escape.
- The signal from the Sun is not subject to significant astrophysical background, contrary to other indirect searches. A potential detection of high energy neutrinos above the (measured) atmospheric background would be a smoking gun.
- Searches, with neutrino telescopes are complementary to direct searches: most sensitive for low velocities.

Galactic Centre

- Dark matter has gravitationally accumulated in the Galactic Center (GC), where annihilates, producing neutrinos.
- Contrary to the case of the Sun, limits are set on the WIMP annihilation cross-section.
- The location in the Northern Hemisphere offers a very good visibility of the GC.
- ANTARES has set the best limits worldwide for masses above 30 TeV.

Earth

- Earth can also capture WIMPs, as in the case of the Sun. Scattering occurs mainly with nuclei of iron and nickel, limits are set in the spin independent cross-section.
- The most constraining limits are set for masses of WIMPs close to those of iron and nickel nuclei.
- In order to set limits on the scattering cross section, a relic abundance has to be assumed, since there is no equilibrium between capture and annihilation.

Conclusions

- The search for dark matter is one of the main goals of neutrino telescopes.
- Neutrino telescopes have specific advantages as complementary strategy in these searches, giving the best limits for spin-dependent WIMP-nucleon cross-section. Moreover, a signal in the Sun would be a smoking gun.
- The ANTARES neutrino telescope, has been taking data for a decade, has shown the feasibility of the underwater technique, providing results on the Sun, the Galactic Center and other sources. ANTARES has set the best limits worldwide in the DM annihilation cross section for masses above 30 TeV, taking advantage of the excellent angular resolution reachable in the water and its location in the Northern Hemisphere (better visibility).
- KM3NeT, already in construction, will improve these results in the near future, both at low masses (ORCA) and large masses (ARCA).