WHAT CAN WE LEARN FROM NEUTRINOS?

In this page, we describe more precisely what we can learn about neutrinos when using KM3NeT. At the bottom of the page, you will also discover what the researchers from South Africa have decided to focus on!

- **Observe the sky with multi-messenger glasses!**

  For centuries we have been observing and trying to understand the sky through light. It has only been less than 10 years that we are also able to observe it also with neutrinos or gravitational waves!

  One of the main lines of research in modern astrophysics is to detect the same phenomenon in the universe thanks to several messengers: light + gravitational waves + neutrinos for example.

  This allows to see and thus to understand all the aspects and characteristics of a phenomenon. It's as if you could have several pairs of glasses that show you different details of the landscape: with a single pair you will only see the flowers close to you, with others you will see in the distance. Using both: 3D vision!

  We have already been able to observe the merger of neutron stars thanks to gravitational waves and light. And a few months later, we saw the first coincidence of light and neutrinos. However, we are still waiting for the triplet gravitational waves, light and neutrinos with a lot of impatience! Maybe it's coming soon…

- **Prepare for the next eruption of Supernova!**

  Supernovae, explosions of short duration but extremely luminous, are observed with the death of massive stars (much heavier than our Sun!). Although core-collapse supernovae observations are now routinely performed with light, the specific characteristics of gravitational collapse can only be diagnosed by neutrinos.

  Using state-of-the-art numerical simulations and theoretical developments, we are exploring the potential of KM3NeT's new optical modules in detecting nearby supernovae. The arrival of such an event close to us (in our galaxy or its neighborhood!) happens very rarely, on average once every 30 years. The last took place in 1987, so it is essential to be ready for the next one!

  We are not only working to prepare the detector to see low energy neutrino interactions, but also to understand how the numbers and energy of the detected neutrinos can tell us more about what happened during the explosion.

- **Unravel the mystery of neutrino oscillation!**

We have already learned that neutrinos have different flavors, and that this flavor could change over time and their journey into space. Although we know the phenomenon of oscillations, we still have to make precise measurements in order to understand it completely. The geometry of KM3NeT / ORCA sensors will allow us to identify the neutrino flavor and thus to be able to count how many neutrinos of each flavor have been detected. By knowing the number of neutrinos of each flavor produced in the atmosphere, we can therefore deduce how they transformed during their trip to ORCA!

Will we see more muon neutrinos than tauonic neutrinos? How does this transformation vary with the energy of the neutrino? The answers to these questions will allow us to better understand the oscillation phenomenon and all the parameters it contains!

Members of the North-West University (NWU) mainly contribute to the KM3NeT Collaboration in the field of neutrino astrophysics!

While, past projects developed a time-dependent neutrino point-source analysis, the NWU group currently focuses on theoretical model predictions of the expected high-energy neutrino flux.

Individual projects study the neutrino expectation from various astrophysical sources such as AGNs, GRBs or tidal-disruption events.

A new model to describe the proton-proton induced neutrino flux from AGNs is currently under development. Furthermore, the NWU group is involved in detector calibration work based on the always present atmospheric neutrino and muon flux and is frequently volunteering for detector shift duties.

Contribution of University of Johannesburg to KM3NeT!

University of Johannesburg (UJ) is full member of the collaboration since February 2018. UJ's group is led by Professor Soebur Razzaque and they work on two different tasks:

a) PID (Particle identifier) for ARCA

The shape of the neutrino events could be of two different types:

- Muon produces a linear light trajectory which is called track topology.
- Electron and Tau produce a cone light trajectory which is called shower topology.

For any ARCA study, it is necessary to distinguish the neutrino type, which can be found based on topology. UJ works on a Particle identifier of neutrino flavour in ARCA.

b) Sterile Neutrino Analysis with ARCA

Most of neutrino phenomenology is well explained due to the existence of the three neutrinos we have been talking so far. However, a small group of experiments (called anomaly experiments) cannot be fitted just with the three standard case. One plausible solution is the existence of an extra neutrino with mass order of approximately 1 eV. We call this extra neutrino: the sterile one. Sterile neutrinos cannot be detected directly with neutrino detectors, but it will affect the number of the other neutrinos detected by the telescope.

Will we have too many or too few neutrinos in KM3NeT? Maybe it will be the sign of a sterile!