Neutrinos : from non standard frameworks to the discovery of the diffuse supernova neutrino background

The observation that neutrinos change flavor during propagation - termed neutrino oscillations - has shown that neutrinos are massive elementary particles with mixings which points to physics beyond the Standard Model and impacts astrophysics and cosmology. While the discovery dates 1998, key questions remain open concerning neutrino properties, how neutrinos change flavor in dense environments and their impact on future observations.

The Thesis is focussed on theoretical neutrino physics and astrophysics and involves both theoretical and phenomenological aspects. Unexpected novel flavor phenomena, that are still not well understood, have been shown to occur in core-collapse supernovae or compact binary objects (neutron star- neutron star or neutron star-black hole mergers). This is due e.g. to neutrino self-interactions that make neutrino evolution a non-linear many-body problem. The impact of strong gravitational fields nearby compact objects is still little explored. These aspects are intriguing in their own right and can influence observations. For example, predictions of the neutrino spectra are essential for the upcoming discovery of the diffuse supernova neutrino background, either by the Super-Kamiokande+ Gd (just started) or Hyper-Kamiokande (approved) experiments in Japan. Neutrinos also impact core-collapse supernovae explosions and r-process nucleosynthesis in supernovae and in kilonovae.

The Thesis will be devoted to the investigation of neutrino properties and neutrino flavor evolution theoretically and of their phenomenological impact, also in connection with the upcoming discovery of the diffuse supernova neutrino background to determine what we will learn from such an observation.

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