Neutrinos as possible probes for quantum gravity

Marco Danilo Claudio Torri

Università degli Studi di Milano
Istituto Nazionale di Fisica Nucleare – sezione di Milano
Via Celoria 16 – 20133 – Milano - Italy

COST Action 18108

King’s College – London – UK – 18-20 December 2023

Study motivation

1. **Necessity of testing the Planck scale structure of spacetime**
   - **Necessity of testing the universality of the supposed Quantum Gravity (QG) corrections**
2. **Advantages of using atroparticles in a multimessenger approach:**
   - **High energies** (useful for testing the Planck scale)
   - **Long propagation path** (allowing accumulation of tiny QG perturbations during propagation)
3. **Neutrinos can be ideal candidates**
   - **Possibility of testing different combinations of energies and baselines**
   - **Neutrino weak interactions: advantages in pointing to the sources**

Testable scenarios

Kinematical symmetry group modification models	Lorentz Invariance Violation models
DSR (Doubly Special Relativity) HMSR (Homogeneous Modified Special Relativity)	SME (Standard Model Extension)

The main phenomenological effects introduced by the QG models pertain to the modification of the dispersion relations:

- **Universal modifications scenario - differences in the time of flight of astrophysical neutrinos:**
  QG perturbations can affect the in-vacuum dispersion relations introducing an energy dependence of the particle velocity. The effect can be detected in
  - **GRB candidate accelerated neutrinos**
  - **Supernova spectrum**

- **Non universal modifications scenario – differences in the envisaged oscillation pattern of atmospheric neutrinos:**
  Introduction of mass eigenstate-dependent QG perturbations may alter the oscillation probability.

- **CPT-odd scenario –** challenges in distinguishing QG CPT-odd perturbations from Non-Standard Interactions.