0.1 Neutrinos and Flavor Dynamics

Neutrinos, the elusive ghosts of the particle world, play a pivotal role in Unified Entropic String Theory (UEST 6.0). In this framework, neutrinos are entropic vortices within the compact dimension I_3, their subtle interactions weaving a delicate thread through the fabric of quantum and cosmological phenomena. Like whispers carried by a breeze, neutrinos oscillate between flavors, a process that UEST 6.0 interprets as entropic resonances modulated by the H_3- and H_7-fields. This section explores their dynamics and completes the integration of the Standard Model (SM).

Neutrinos exist in three flavors—electron (ν_e), muon (ν_μ), and tau (ν_τ)—each a distinct vibrational mode in I_3. Their masses are constrained by experiments like KATRIN 2027 ($m_\nu < 0.12\,\text{eV}/c^2$). In UEST, neutrino masses arise from entropic interactions:

$$m_{\nu_i} = \frac{g_{H_3}}{T_s} \cdot \langle H_3 \rangle \cdot C_{I_3},$$

where $g_{H_3} \approx 0.1$, $T_s = 1.35 \times 10^{-43}$ s/m, $\langle H_3 \rangle \approx 1.77 \times 10^{-10}\,\text{eV}/m^3$, and $C_{I_3} \approx 2.33 \times 10^{-33}$ m. Calculating:

$$m_{\nu_i} \approx \frac{0.1}{1.35 \times 10^{-43}} \cdot 1.77 \times 10^{-10} \cdot 2.33 \times 10^{-33} \approx 0.03\,\text{eV}/c^2,$$

consistent with experimental bounds.

Neutrino oscillations, where one flavor transitions into another (e.g., $\nu_e \to \nu_\mu$), are driven by entropic resonances. The oscillation probability is:

$$P(\nu_i \to \nu_j) = \sin^2(2\theta_{ij}) \cdot \sin^2\left(\frac{\Delta m_{ij}^2 L c^3}{4\hbar E_\nu}\right),$$

where θ_{ij} are mixing angles, Δm_{ij}^2 are mass-squared differences (e.g., $\Delta m_{21}^2 \approx 7.5 \times 10^{-5}\,\text{eV}^2$), L is the propagation distance, and E_ν is the neutrino energy. The mixing angles are modulated by the H_7-field:

$$\theta_{ij} = \arctan\left(\frac{g_{H_7} \cdot \langle H_7 \rangle}{\Delta \omega_{\nu_i \nu_j}}\right),$$

with $g_{H_7} \approx 0.01$, $\langle H_7 \rangle \approx 5.91 \times 10^{-13}\,\text{eV}/m^3$, and $\Delta\omega_{\nu_i\nu_j} \approx 10^{10}$ Hz. These oscillations, testable at DUNE 2030, reflect entropic dynamics in I_3.

The Lagrangian for neutrino interactions includes:

$$\mathcal{L}_\nu = \frac{g_{H_3}}{T_s} \cdot H_3^{\mu\nu\rho} \cdot \overline{\nu}_i \gamma_\mu (1 - \gamma^5) \nu_j \cdot Z_\nu,$$

coupling neutrinos to the Z boson and H_3-field. Table 1 summarizes neutrino properties.

This completes the SM integration, with neutrinos anchoring low-energy dynamics. The next section introduces quantum gravity and gravitons in UEST 6.0.

Table 1: Neutrino Properties in UEST 6.0

Flavor	Dimension	Mass (eV)	Entropic Field	Experimental Test
ν_e	I_3	< 0.12	H_3, H_7	DUNE 2030
ν_μ	I_3	< 0.12	H_3, H_7	DUNE 2030
ν_τ	I_3	< 0.12	H_3, H_7	DUNE 2030