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Neutrino Theory: List of topics

Theory of Neutrino Physics

1. What is the origin of nonzero neutrino masses. Open questions, models, and how can we learn more? How does this connect with other open questions in particle physics and cosmology (dark matter puzzle, baryogenesis, stability of the Higgs boson mass)?
2. Is there a theory of flavor? What is it? How do we learn more? How well do we need to know the elements of the mixing matrix (including CP), and why? How are leptons and quarks connected?
3. Solving current (and future!) neutrino puzzles, including the short-baseline anomalies.

These include connections to experiments that will help piece the neutrino mass puzzle, including searches for kinematical effects of nonzero neutrino masses and understanding the neutrino mass ordering, searches for new neutrino states and new neutrino properties and interactions, searches for charged-lepton flavor-violation, searches for lepton number violation (e.g. neutrinoless double-beta decay), searches for baryon number violation (proton decay, neutron-antineutron oscillations), high energy collider experiments, low-energy observables, including searches for permanent EDMs, other experiments that will help shine light on the flavor puzzle (e.g., rare meson decays and other flavor observables in the quark sector).

Theory for Neutrino Physics

1. Simulating astrophysics sources of neutrinos and computing neutrino transport in these environments (supernova neutrinos sources of ultra-high energy neutrinos and cosmic rays);
2. BSM neutrino physics in early universe cosmology (neutrino properties from cosmology and solve “puzzles” in cosmological data);
3. Computing neutrino-nucleon and neutrino-nucleus scattering, from low-energy scattering — including CEvNS — solar and supernova neutrinos up to DIS, including implementation (and validation against electromagnetic data);
4. Neutrino phenomenology for neutrino experiments. Understanding how well different neutrino properties including BSM effects can be measured and constrained by future neutrino experiments of all stripes (oscillations, both long- and short-baselines, CEvNS, solar, atmospheric, SN, and UHE neutrinos, direct detection experiments);
5. Non-neutrino phenomenology for neutrino experiments (e.g., searches for DM in neutrino experiments, searches for hidden sectors, etc);
6. Computing matrix elements for neutrinoless double-beta decays.