NF08/TF11 – Theory of Neutrino Physics

Co-Conveners: André de Gouvêa (Northwestern), Irina Mocioiu (Penn State), Saori Pastore (Washington U.), Louis Strigari (TAMU)

Topical Group Report Feedback Meeting

February 9, 2022

Some White Papers with Strong TF11 Connection (incomplete list!):

- Theoretical tools for neutrino scattering: interplay between lattice QCD, EFTs, nuclear physics, phenomenology, and neutrino event generators (commissioned by TF11/NF08, NF06, TF05, RF04)
- Theory of neutrinoless double beta decay (commissioned by TF11/NF08, TF05, RF04)
- Neutrino Factories (including Synergy with Muon Colliders) (commissioned by EF, TF11/NF08)

Some Workshops and Presentations:

- Mini-workshop on Neutrino Theory. September 21–23, 2020;
- Snowmass mini-workshop in preparation for the white paper Theoretical tools for neutrino scattering: the interplay between lattice QCD, EFTs, nuclear physics, phenomenology, and neutrino event generators. August 23–25, 2021;
- Theory of neutrinoless double beta decay WP presented at NF WP meeting, Oct 22, 2021;
- Snowmass Joint Workshop on New Physics Opportunities with Neutrino Experiments: Theoretical & Experimental Perspectives. February 10–12, 2022.
- Theory Frontier Meeting. February 23–25, 2022.

Draft Outline for Discussion

1 Introduction

2 Neutrino mass and flavor model-building

2.1 What is the Mechanism Behind Non-Zero Neutrino Masses?

2.2 Neutrinos and the Flavor Puzzle

3 Neutrino Phenomenology

The role of theory in providing guidance for experiments sensitive to neutrino properties and interactions.

We expect other TGs to discuss the experimental and operational aspects.

3.1 Neutrino Oscillations

3.2 The Short-Baseline Anomalies

3.3 Neutrino Scattering

3.4 High Energy Colliders

3.5 Charged-Lepton and Meson Processes

4 Not-Neutrino Phenomenology for Neutrino Experiments

This discusses other phenomenology opportunities for next-generation neutrino experiments

4.1 Near-Detector Opportunities

4.2 Far-Detector Opportunities

5 Neutrinos in Astrophysics and Cosmology

5.1 High-energy neutrinos (sub-GeV to supra-PeV)

5.2 Diffuse supernova neutrinos and galactic supernova

5.3 Solar Neutrinos

5.4 Cosmic neutrino background

5.5 Clustering and large-scale structure

5.6 Hubble Tension and N_{eff}

5.7 Absolute neutrino mass measurements

6 Neutrino cross sections

6.1 The needs of the neutrino experimental program

6.2 Nucleon cross sections

6.3 Coherent elastic neutrino-nucleus scattering

6.4 Nuclear cross sections from QE regime to pion-production and resonance regions

6.5 Neutrino-induced shallow and deep inelastic scattering

6.6 Interface with generators

7 $0\nu\beta\beta$ and other nuclear-physics probes of neutrino properties

7.1 Introduction

7.2 Neutrino mass models

7.3 Bridging particle and nuclear physics with EFTs

7.4 Lattice QCD calculations for neutrinoless double beta decay

7.5 *Ab initio* and many-body calculations of $0\nu\beta\beta$ nuclear matrix elements

8 Outlook: 10 years deliverables and assessment of required resources