GPMFC APS Workshop

Report of Contributions

https://indico.global/e/699

Contribution ID: **1** Type: **not specified**

Searching for new physics at the precision frontier

Friday 14 April 2023 09:30 (30 minutes)

In this talk I will present a theoretical perspective on low-energy searches for physics beyond the Standard Model. After an overview of the field of precision measurements and the search for rare processes, I will focus on two examples that illustrate the breadth of the field: precision studies of beta decays and the search for permanent electric dipole moments.

Presenter: Prof. CIRIGLIANO, Vincenzo (University of Washington)

Contribution ID: **2** Type: **not specified**

Fundamental Physics with Nuclei

Friday 14 April 2023 10:00 (30 minutes)

Next-generation experiments are poised to explore lepton-number violation, discern the neutrino mass hierarchy, understand the particle nature of dark matter, and answer other fundamental questions aimed at testing the validity and extent of the Standard Model. Nuclei are used for these high-precision tests of the Standard Model and for searches of physics Beyond the Standard Model. Without a thorough understanding of nuclei, including electroweak structure and reactions, we will not be able to meaningfully interpret the experimental data nor can we disentangle new physics signals from underlying nuclear effects. To describe nuclear properties, I use many-body nuclear interactions and electroweak currents derived in chiral effective eld theory, and Quantum Monte Carlo methods to solve for the nuclear structure and dynamics of the many-body problem for nuclei. This microscopic approach yields a coherent picture of the nucleus and its properties, and indicates that many-body effects are essential to accurately explain the data. In this talk, I will report on recent progress in Quantum Monte Carlo calculations of electron and neutrino interactions with nuclei in a wide range of energy and momentum transfer and their connections to current experimental efforts in fundamental symmetries and neutrino physics.

Presenter: Prof. PASTORE, Saori (Washington University)

Contribution ID: **3** Type: **not specified**

Coffee Break

Friday 14 April 2023 10:30 (30 minutes)

Contribution ID: **4** Type: **not specified**

Direct Neutrino Mass Searches Covering the Inverted Ordering Scale

Friday 14 April 2023 11:00 (30 minutes)

State-of-the-art direct neutrino mass searches have recently achieved sensitivity below 1 eV. The KATRIN experiment will run through 2025 projecting sensitivity to reach down to m_β of 200 meV. But KATRIN's MAC-E filter technology and molecular tritium source are reaching their limitations in this experimental phase. Sensitivity to cover the inverted neutrino mass ordering and beyond requires new experimental techniques and considerable R&D. In this talk, I will outline the programs being pursued for next-generation neutrino mass sensitivity over the coming LRP period and the R&D challenges ahead. I will particularly highlight recent advances by Project 8 employing the Cyclotron Radiation Emission Spectroscopy (CRES) technique, charting its phased program towards an experiment sensitive down to m_β of 40 meV.

Presenter: Prof. PETTUS, Walter (Indiana University)

Contribution ID: **5** Type: **not specified**

Precision beta decay measurements in nuclei

Friday 14 April 2023 11:30 (30 minutes)

Presenter: Prof. MELCONIAN, Dan (Texas A&M University)

Contribution ID: **6** Type: **not specified**

Neutron Beta Decay as a test of the Standard Model and probe for new physics

Friday 14 April 2023 12:00 (30 minutes)

Precision studies of beta decay can provide stringent tests of the standard model, and probes for new physics, at a level that is competitive with constraints from high energy particle colliders. Recent evaluations of the "inner radiative correction"have led to a 3-sigma departure from unitarity in the first row of the CKM matrix. Neutron beta decay is an ideal system for making high-precision measurements of Vud, and thus testing the tension with unitarity, as it is free from nuclear structure effects. In this talk I will discuss the motivation for neutron beta decay experiments. I will also cover recent results and future efforts toward improved determinations of Vud from neutron beta decay.

Presenter: Dr HOOGERHEIDE, Shannon (National Institute of Standards and Technology)

Contribution ID: **7** Type: **not specified**

Lunch

Friday 14 April 2023 12:30 (1h 30m)

Contribution ID: **8** Type: **not specified**

Studying fundamental symmetry violations with molecules

Friday 14 April 2023 14:00 (30 minutes)

The extreme electromagnetic environments present in polar molecules make them highly sensitive to fundamental symmetry violations, both within and beyond the standard model. In this talk I will review the current status of the field, discuss ongoing developments, and provide an outlook for the future.

Presenter: Prof. HUTZLER, Nick (Caltech)

Contribution ID: **9** Type: **not specified**

The Nuclear Pear Factory: Searching for Time-Reversal Violation Using Pear-Shaped Nuclei in the FRIB Era

Friday 14 April 2023 14:30 (30 minutes)

Experimental tests of fundamental symmetries using nuclei and other particles subject to the strong nuclear force have led to the discovery of parity (P) violation and the discovery of charge-parity (CP) violation. It is believed that additional sources of CP-violation may be needed to explain the apparent scarcity of antimatter in the observable universe. A particularly sensitive and unambiguous signature of both time-reversal- (T) and CP-violation would be the existence of an electric dipole moment (EDM). The next generation of EDM searches in a variety of complimentary systems (neutrons, atoms, and molecules) will have unprecedented sensitivity to physics beyond the Standard Model. This talk will focus on current and planned experiments that use radioactive isotopes with pear-shaped nuclei. This uncommon nuclear structure significantly amplifies the observable effect of T, P, & CP-violation originating within the nuclear medium when compared to isotopes with relatively undeformed nuclei such as Mercury-199. Certain isotopes of Radium (Ra) and Protactinium (Pa) are both expected to have greatly enhanced sensitivity to symmetry violations and will be produced in
abundance at the Facility for Rare Isotope Beams currently operating at Michigan State University. I will describe the current status of ongoing searches and the prospects for next generation searches for time-reversal violation possibly using radioactive molecules to further enhance the new physics sensitivity in the FRIB-era.

Presenter: Prof. SINGH, Jaideep (Michigan State University)

Contribution ID: **10** Type: **not specified**

Neutron EDM searches

Friday 14 April 2023 15:00 (30 minutes)

Despite being electrically neutral, the neutron can exhibit an electric dipole moment if its center of charge offsets from its center of mass. The resulting static electric dipole moment (EDM) probes new CP-violating physics at energy scales well beyond those reached directly at high-energy colliders. The latest experimental limit on the nEDM, reported by the PSI group, is (0.0 ± 1.1stat ± 0.2sys)×10ˆ−26 e.cm [PRL124, 081803 (2020)]; this was achieved using an NMR measurement on polarized ultracold neutrons with a frequency precision of < 2 ppb. In this talk, I will report on the progress of ongoing efforts to continue pushing the nEDM sensitivity over the next decade.

Presenter: Prof. LIU, Chen-Yu (University of Illinois)

Contribution ID: **11** Type: **not specified**

Coffee Break

Friday 14 April 2023 15:30 (30 minutes)

Contribution ID: **12** Type: **not specified**

Parity Violating Electron Scattering Measurements

Friday 14 April 2023 16:00 (30 minutes)

The technique of parity-violating electron scattering (PVES) can be used to make relatively clean measurements of nuclear and nucleon properties. Electrons have long been used as clean nuclear probes because they do not interact via the strong force. Much of what we know about nuclei, nucleons and their constituents is from electromagnetic scattering. The parity-violating asymmetry in the scattering of longitudinally polarized electrons from a variety of targets gives us access to properties ranging from the role of sea quarks in nucleons to the density dependence of the symmetry energy of neutron matter. Perhaps most interestingly, precision measurements of the weak charges of electrons as well as protons can provide a low energy test of the Standard Model by determining the resulting value of the weak mixing angle $sin^2\theta_W$ in both leptonic and semi-leptonic channels. These searches are sensitive to mass scales of new physics up to 42 TeV, depending on the model of the new physics. In addition, the quark coupling constants can be determined from the semi-leptonic measurements. In this talk I will describe the technique of PVES and summarize upcoming future measurements.

Presenter: Prof. MAMMEI, Juliette (University of Manitoba)

Contribution ID: **13** Type: **not specified**

Current and planned precision studies of rare pion decays

Friday 14 April 2023 16:30 (30 minutes)

As we mark the passage of 75 years since the discovery of the pi meson, the role that the pion plays in the strong interaction remains clear and central. The pi meson also presents a rich subject of study when it comes to weak interaction processes, in particular exploring the limits of the validity of the Standard Model, and searches for its possible extensions. Thanks to few and simple final states, and strict symmetry protections, rare decays of the charged pion play an exceptional role in this respect. We will review the current status of the theoretical implications for the rare decay channels: $\pi^+ \to e^+\nu(\gamma)$, and $\pi^+ \to \pi^0 e^+\nu(\gamma)$, the status of their experimental study to date (particularly the PiBeta, PEN, and PiENu experiments), and plans for the PIONEER experiment, currently under preparation.

Presenter: Prof. POCANIC, Dinko (University of Virginia)

Contribution ID: **14** Type: **not specified**

Precision Measurements in neutron optics

Friday 14 April 2023 17:00 (30 minutes)

Neutrons have a long history at the forefront of precision metrology, from the first experiment demonstrating the effect of gravity on a quantum particle (the C.O.W. experiment), to demonstrations of the spinor's 4\pi -periodicity, on to recent searches for chameleon dark energy fields. Compared to photons, electrons, and other wave-particle probes, neutrons offer a unique penetrating ability. Following in the footsteps of the C.O.W. experiment, we aim to generate structured neutron momentum profiles and apply these states to tackle difficult problems. One such problem is to measure the gravitational constant, G, currently the least precisely measured fundamental constant of nature. The significant discrepancy between G experimental results underscores the need for new experiments whose systematic uncertainties can be decoupled from existing techniques. Previously, perfect-crystal neutron interferometers were used to measure local gravitational acceleration, g, unfortunately, the low neutron flux (a few neutrons per second) of these devices makes them impractical for precision measurements of G. The recently demonstrated Phase-Grating Moiré Interferometer (PGMI) offers an increase in neutron flux of several orders of magnitude while preserving the large interferometer area, and thus the sensitivity, of a perfect-crystal interferometer. This device possesses a set of systematic uncertainties that are independent from existing techniques which measure G. In this talk, I will demonstrate how one can structure a neutron wave, show examples of the interference seen in a 3-grating PGMI, and discuss the feasibility of measuring G using a similar apparatus with a test mass on the order of 1 tonne. Further, I will address how we can optimize this setup to maximize the phase shift from a 1-tonne mass and consider some of the systematic effects.

Presenter: Prof. PUSHIN, Dmitri (University of Waterloo)