2020 NIST Precision Measurement Grants

Dr. Edmund G. Myers, Florida State University

Towards a test of CPT with the Antihydrogen Molecular Ion

Violation of the CPT theorem would have profound consequences for all quantum field theories, including those assumed in the determination of fundamental constants, and shed light on the universe's matter-antimatter asymmetry. A direct way to test CPT is to compare the properties of particles and antiparticles; these should be identical except for signs of quantum numbers. We aim to do this by developing ro-vibrational and Zeeman-hyperfine spectroscopy on single trapped H_2^+ and anti-H_2^+ ions, with the ultimate aim of atomic-clock precision: better than 10^{-16} for ro-vibrational transitions and better than 10^{-14} for hyperfine transitions. Compared to anticipated spectroscopy on antihydrogen or measurements on antiprotons, this will result in a 10^4 improvement in precision for testing the CPT invariance of m_e/m_p and the magnetic moment of the proton. We propose to produce single anti-H_2^+ ions by combining anti-H^- ions with antiprotons in a Penning trap, and, at least initially, to perform the spectroscopy in a Penning trap. By enabling precursor experiments with normal matter, the NIST PMG award will be used to address the outstanding challenges to this ambitious project: a) the development of precision RF and laser spectroscopy on anti-H_2^+ in a Penning trap, and b) the production of anti-H_2^+ in a Penning trap. More specifically, in the timeframe of the award, the funds will be used to construct a Penning trap system that will enable precision electron g-factor and hyperfine-Zeeman spectroscopy on a single H_2^+, and hence also demonstrate the detection technique for laser spectroscopy. It will also serve as a testbed for the synthesis of (anti-)H_2^+.

Dr. Saul Perlmutter, University of California, Berkeley

NIST-Traceable Flux Calibration of Standard Stars for Cosmology

The proposed work seeks to perform an experimental determination of the wavelength-dependent optical flux scale of standard stars at the 0.5% level required by modern cosmology and astrophysics. This involves transferring the SI flux system established by NIST to our SuperNova Integral Field Spectrograph (SNIFS) via our SNIFS CALibration Apparatus (SCALA), and from there to a network of stable standard stars faint enough to be observed with major new front-line telescopes such as LSST and WFIRST. Doing so will mitigate flux calibration as a major source of systematic uncertainty in measuring, e.g., the properties of dark energy and the age of the universe.