2016 NIST Precision Measurement Grants

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Precise determination of the fine structure constant α for the new International System of units .

This project aims to improve the precision and the reliability of the measurement of the ratio h/m_{Rb} between the Planck constant and the mass of a rubidium atom using a new experimental setup based on a Bose-Einstein condensate, taking advantage of the recent concepts of atom interferometry. This ratio is directly linked to the molar Planck constant hN_{A} and indirectly to the fine-structure constant α. Those two fundamental constants play an important role in metrology: the molar Planck constant allows a comparison of the watt balance experiment (determination of h) to the XRCD method (determination of N_{A}) and therefore plays an important role in the redefinition of the International System of Units (SI). The fine-structure constant is also important for the CODATA (Committee on Data for Science and Technology) because it is used for the determination of many other physical constants. In addition determinations of α using the ratio h/m provides a precise test of quantum electrodynamics (QED). The goal is to achieve a reliable determination of α with a relative uncertainty at the level of 10^{-10}.

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Spectroscopy of the Hydrogen 2S-8D Transition using a Cryogenic Atomic Beam.

This project aims to address the proton radius puzzle that is a problem for the determination of the proton radius and the Rydberg constant for the CODATA recommended values of the fundamental constants. The inconsistency in the determination of the proton charge radius through spectroscopic comparisons of hydrogen and muonic hydrogen has persisted since 2010 [R. Pohl et al., Nature **466**, 195 (2010)]. In response, this project proposes a series of measurements on the hydrogen 2S–8S/D transitions which would utilize a cryogenic atomic beam and would populate the 2S metastable state through optical excitation. The aim is to reduce the uncertainty in these transitions to about 1 kHz–a factor of about 5 improvement over previous measurements [B. de Beauvoir et al., Phys. Rev. Lett. **78**, 440 (1997)]. When combined with the 1S–2S transition frequency, a precise measurement of the 2S–8S/D transitions can determine the Rydberg constant and proton size, and would provide valuable insight into the ongoing proton radius puzzle.