Abstract Submitted
for the DAMOP07 Meeting of
The American Physical Society

Optical transitions among Rydberg states—an ideal avenue for measuring both the fine structure and Rydberg constants accurately

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The fine structure and Rydberg constants play crucial roles in tests of QED and the Standard Model, in the International System of units (SI), and in the CODATA evaluation of fundamental constants. The extraordinary precision of femtosecond-laser frequency combs opens the possibility of directly measuring both the fine structure and Rydberg constants in an atomic system with high accuracy provided that the atomic system is engineered to be essentially free from poorly-understood complexities (such as nuclear structure). This new approach is attractive because optical frequency metrology has attained such high precision as to outpace the most detailed theory for even the simplest atom in nature, hydrogen. One avenue to explore involves the synthesis of hydrogen-like ions in special high-orbital states engineered to make them better suited for measuring these two constants. In particular, the fine structure splitting would be magnified by a large nuclear charge Z, which is selected so that the measurements—transitions among these high orbital states—are in the domain of optical frequency combs. Progress in assessing the QED corrections to the Dirac theory for $^{20}Ne^{9+}$ as a test case is discussed. The advantages and challenges in realizing this new approach for accurately measuring both the fine structure and Rydberg constants are presented.

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Date submitted: 02 Feb 2007 Electronic form version 1.4