Measuring the fine-structure constant by kicking atoms

R. H. Parker, C. Yu, W. Zhong, B. Estey, and H. Müller[1]

[1]Department of Physics, 366 Le Conte Hall MC 7300, University of California, Berkeley, CA 94720, USA.

Measurements of the fine-structure constant are powerful tests of the consistency of theory and experiment across physics. We have used the recoil frequency of cesium-133 atoms in an atom interferometer to measure h/M, the ratio of the Planck constant and the mass of the atom, from which we derive the most accurate measurement of the fine-structure constant to date [1]: $\alpha = 1/137.035999046(27)$. To reach this accuracy, we have used multiphoton interactions (Bragg diffraction and Bloch oscillations) to increase the phase shift in the interferometer, and to control systematic effects.

The measurement is sensitive to interesting physics, both within the Standard Model and beyond. By combining it with Standard-Model theory [2], we can predict the anomaly of the magnetic moment of the electron. Comparison between theory and experiment confronts a number of Standard-Model predictions with experiment, some of them for the first time. These include the fifth-order influence of QED, the influence of virtual muons, as well as hadronic effects. The measurement also enables a search for physics beyond the standard model, including scalar particles and vector bosons.

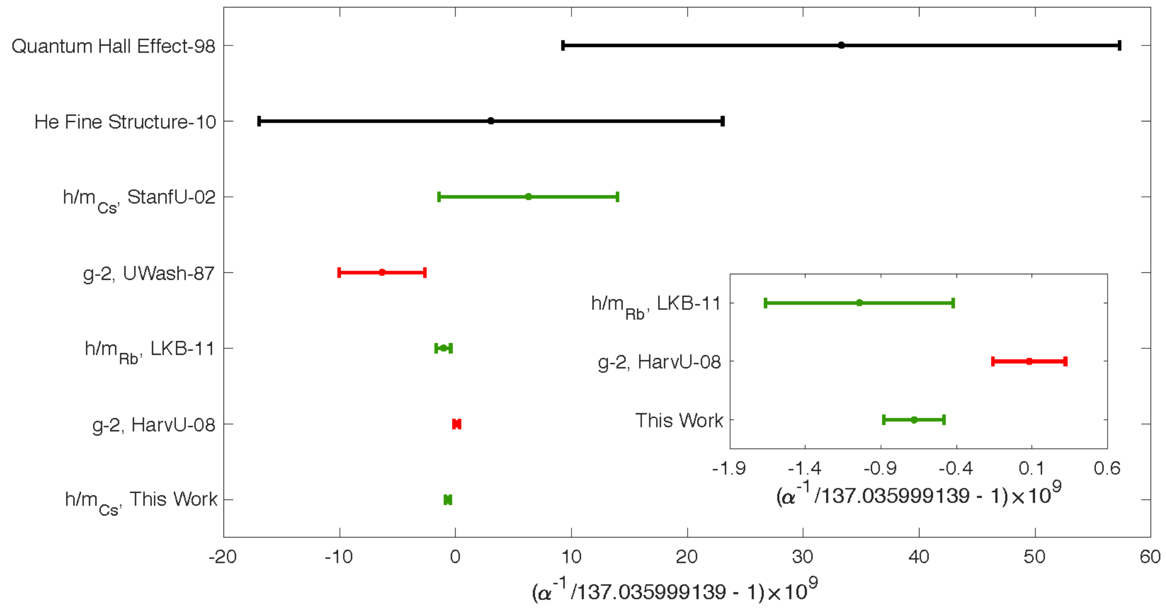

Figure 1. Our recent result alongside previous measurements of α based on quantum Hall effect, He fine structure, h/m_{Cs}, h/m_{Rb}, and electron g-2. Zero on the x-axis is the CODATA 2014 recommended value. Green points indicate photon recoil experiments; red ones, electron g-2 measurements.

[1] Parker, Richard H., Chenghui Yu, Weicheng Zhong, Brian Estey, and Holger Müller. 2018. "*Measurement of the Fine-Structure Constant as a Test of the Standard Model*." Science 360 (6385): 191–95.

[2] Aoyama, Tatsumi, Toichiro Kinoshita, and Makiko Nio. 2018. "*Revised and Improved Value of the QED Tenth-Order Electron Anomalous Magnetic Moment.*" Physical Review D 97 (3): 036001.