HIGH-PRECISION MEASUREMENTS IN ATOMIC CESIUM SUPPORTING A LOW-ENERGY TEST OF THE STANDARD MODEL

by

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The measurement of parity nonconservation (PNC) in atomic cesium provides the most precise low-energy test of the standard model of electroweak interactions. However, the test is limited by the uncertainty in the *ab initio* calculations that are required to interpret the measurement. This thesis describes one measurement that suggests that the accuracy of the theory may be better than its authors claim, and a second measurement that may be used in place of a less accurate calculation.

A 0.11% measurement of the dc Stark shift of the $6S \rightarrow 7S$ transition in cesium using high-precision laser spectroscopy removes the largest discrepancy between experiment and theory. With this new measurement, and several recently improved measurements by other groups, the uncertainty of the theory is re-evaluated. We find that the standard deviation of the differences between experiment and theory is 0.40%. This standard deviation suggests that the quoted uncertainty of the theory can be reduced from 1% to 0.40%.

A 0.16% measurement of $M_{\rm hf}/\beta$ using similar methods is also presented. The quantity $M_{\rm hf}$ is the off-diagonal hyperfine-interaction-induced magnetic dipole amplitude, and β is the tensor transition polarizability; both are for the $6S \rightarrow 7S$ transition in cesium. This ratio is combined with a 0.25% semi-empirical determination of $M_{\rm hf}$ from another group to determine the value of β with a precision of 0.30%. Previously, the value of β used in the test of the standard model was calculated using the *ab initio* theory, thus increasing the uncertainty due to theory in the final test. Using the new measured value of β, the current values of the theory with improved precision, and the previous measurement of PNC in cesium we make a 0.61% test of the standard model.

The precision of this test is likely to motivate further work in this field. Therefore, two experiments are discussed that may be useful in improving the signal-to-noise ratio on a future PNC measurement: an experiment that phase modulates the dye laser used to drive the $6S \rightarrow 7S$ transition to eliminate the spatial intensity variation inside a Fabry-Perot etalon, and an experiment that transversely cools the atomic cesium beam. Finally, a different–but related–PNC measurement is discussed.

For Rebecca.

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