LIFETIME MEASUREMENTS IN NEUTRAL ALKALIS

Abstract

by

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Precision measurements of transition probabilities and energies provide a means for testing atomic structure calculations. The most accurate atomic structure calculations employ many-body perturbation theory (MBPT) and are used for the interpretation of atomic parity nonconservation (PNC) measurements and for testing of quantum electrodynamics (QED). Our group's measurement of the $6p\ ^2P_{3/2,1/2}$ state lifetimes in atomic cesium provides constraints for recent MBPT calculations in cesium and electric dipole (E1) matrix elements. These E1 matrix elements contribute a large fraction to the weak-interaction-induced $6S-7S$ transition amplitude in cesium. Part of this thesis has been motivated by our desire to reduce the uncertainties in the measured $6p\ ^2P_{3/2,1/2}$ state lifetimes in atomic cesium using improvements in our fast-beam apparatus. Thus, a new fiber optic detector system is designed to provide better collection efficiency and reduce beam tracking errors. Also, a new method of measuring the atomic beam velocity using a solid etalon is demonstrated to improve the velocity precision by a factor of seven. Additionally, this thesis describes measurements of the cesium $5d\ ^2D_{5/2}$, $5d\ ^2D_{3/2}$, and $11s\ ^2S_{1/2}$ state lifetimes using pulsed-dye laser excitation of cesium vapor. The $5d\ ^2D_{3/2}$ lifetime measurement, along with its branching ratio, provides the electric dipole reduced matrix element between the $5d\ ^2D_{3/2}$ state and the $6p\ ^2P_{1/2}$ state. Furthermore, a previous $5d\ ^2D_{5/2}$ experimental value is compared with our new value and recent theoretical calculations.