# RELATIVISTIC MANY-BODY CALCULATIONS AND LASER MEASUREMENTS FOR VARIOUS ATOMS

Abstract

by

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The current work includes the development of theoretical methods to calculate energies and transition rates together with experiments to test the calculations. The following new theoretical methods are developed: (1) third-order gauge independent many-body perturbation theory (MBPT) for transition amplitudes of monovalent atoms, (2) configuration-interaction (CI) averaging and Brueckner-orbital CI methods for divalent atoms, (3) a modified-denominator perturbation theory (MDPT) for a hole energy; and (4) mixed CI+MDPT for closed-shell atoms and ions. Those and other already existing relativistic many-body methods are applied to calculate energies and transition probabilities in several atomic systems: the helium sequence (CI), the alkalis and sodiumlike ions (3rd-order MBPT), divalent atoms such as Be, Mg, Ca, Sr (CI+MBPT), and particle-hole atoms such as Ne, Ar and neonlike ions (CI+MDPT). Other related aspects of relativistic many-body theory are studied: relativistic corrections beyond the *no-pair* Dirac Hamiltonian (negative-energy contributions) and the gauge dependence of transition amplitudes. Large negative-energy corrections for magnetic-dipole transitions are revealed for helium and the alkalis, and experiments to measure those corrections are proposed and discussed. Gas discharges needed for the helium M1 experiment are studied in detail with a helium lamp and lasers. Experimental techniques for measurements of ratios of

transition rates in noble gases are developed and applied in argon to test the new CI+MDPT theory. The agreement between our new measurement and theory is demonstrated.