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Innsbruck Physics Colloquium

Precision measurements in two- and three-body atoms: nuclear-charge-radii puzzles and tests of first-principles calculations

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High-resolution spectroscopic measurements in few-electron atoms and molecules are increasingly used as a means to test the foundations of the theory of atomic and molecular structure. Modern first-principles calculations of the energy-level structure of few-electron atomic and molecular systems consider all known interactions [1-4]. Systematic comparisons of the results of such calculations with precise spectroscopic measurements in simple atoms and molecules such as H, He, H_2^+, H_2 and He_2^+ aim at searching for effects not yet included in the theory (see, e.g., Refs. [5,6]) and at reducing the uncertainties of physical constants, (see e.g., Refs. [7,8]).

This talk will present precision spectroscopic measurements of transitions to high Rydberg states of H, He, and H_2, which we use to determine accurate values of their ionization energies and, in the case of H_2, also of the spin-rovibrational energy-level structure of H_2^+. The talk will describe our experimental strategy to overcome limitations in the precision and accuracy of the measurements originating from the Doppler effect, the Stark effect, and the laser-frequency calibration. The experimental results will then be compared with the results of first-principles calculations that include the treatment of finite-nuclear-size effects and relativistic and quantum-electrodynamics corrections up to high order in the fine-structure constant. Recent aspects of these investigations include a new determination of the Rydberg constant [9] as a contribution to the resolution of the proton-size puzzle [10], a new method to record Doppler-free single-photon excitation spectra in the visible and the UV spectral ranges [11], a “zero-quantum-defect” method to determine the energy-level structure of homonuclear diatomic molecular ions such as H_2^+ [12], and a 9σ discrepancy between theory and experiment in the ionization energies of metastable (1s2s $^3S_1$) ^{4}He [13] and ^{3}He [14].

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DK-ALM Pre-Talk: Krzysztof Zamarski

Ground-state transfer of ultracold KCs molecules

Time & Location: Tuesday, 13.01.2026, 16:30 h, HS C

Snacks will be provided in between the pre-talk and the colloquium.

Innsbruck Physics Colloquium, Organisation: K. Erath-Dulitz, H.-C. Nägerl, T. Schrabback