Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **249** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

High precision theory for the Rydberg states of helium up to n = 30: a critical test of QED

Tuesday 10 June 2025 16:15 (30 minutes)

Recent measurements for the ionization energies of the Rydberg singlet-P and triplet-P states of helium for principal quantum number $n = 24$ to 100 [1] present a new challenge to high-precision atomic theory. A long-standing obstacle is that the accuracy of variational calculations for two-electron systems rapidly declines with increasing n. The problem has now become urgent with the publication of the Clausen *et al.* measurements. We will present new variational techniques that allow high-precision results to be extended as high as $n = 30$ [2], thereby setting a new record of accuracy for high-lying Rydberg states. The combination of theory and experiment provides absolute points of reference for transitions to lower-lying states where there is an 8σ disagreement between theory and experiment. Relativistic and quantum electrodynamic (QED) corrections are included by perturbation theory up to order $\alpha^5 mc^2$. Higher-order QED uncertainties are strongly suppressed due to their $1/n^3$ scaling, thereby resulting in total theoretical uncertainties as low as ± 2 kHz.

[1] G. Clausen *et al.*, Phys. Rev. A **111**, 012817 (2025).
[2] A. Bondy *et al.*, Phys. Rev. A **111**, L010803 (2025).

Keyword-1

Atomic theory

Keyword-2

Rydberg states

Keyword-3

Relativistic and QED energy

Author: DRAKE, Gordon (University of Windsor)

Co-authors: Dr BONDY, Aaron (University of Windsor); Mr NAJEM, Benjamin (University of Windsor); Mr PETRIMOULX, Evan (University of Windsor); Mr HALLETT, Oliver (Univerwity of Windsor)

Presenter: DRAKE, Gordon (University of Windsor)

Session Classification: (DAMOPC) T3-3 Rydberg Atoms and Radiative Transfer | Atomes de Rydberg et transferts radiatifs (DPAMPC)

Track Classification: Technical Sessions / Sessions techniques: Atomic, Molecular and Optical Physics, Canada / Physique atomique, moléculaire et photonique, Canada (DAMOPC-DPAMPC)