Precision spectroscopy of transitions from the metastable 2 $^3S_1$ state of ^{4}He to high *n*p Rydberg states

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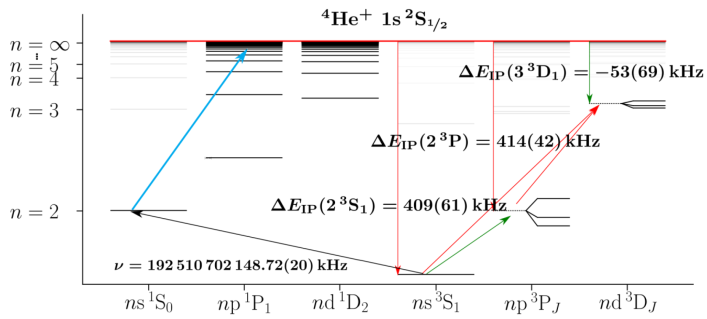
The metastable He ($(1s)^1(2s)^1$) atom in its singlet ($^1S_0$) or triplet ($^3S_1$) states is an ideal system to perform tests of *ab-initio* calculations of two-electron systems that include quantum-electrodynamics and nuclear finite-size effects. The recent determination of the ionization energy of the metastable 2 $^1S_0$ state of ^{4}He [1] confirmed a discrepancy between the latest theoretical values of the Lamb shifts in low-lying electronic states of triplet helium [2] and the measured 3 ^{3}D ← 2 $^3S_1$ [3] and 3 ^{3}D ← 2 ^{3}P [4] transition frequencies. This discrepancy could not be resolved in the latest calculations [5,6].

Currently, we focus on the development of a new experimental method for the determination of the ionization energy of the 2 $^3S_1$ state of ^{4}He via the measurement of transitions from the 2 $^3S_1$ state to *n*p Rydberg states. Extrapolation of the *n*p series yields the ionization energy with sub-MHz accuracy.

In this poster, we present the progress in the development of our experimental setup, which involves (i) the preparation of a cold, supersonic expansion of helium atoms in the 2^3S state, (ii) the development and characterization of a laser system for driving the transitions to the np Rydberg states and (iii) the implementation of a new sub-Doppler, background-free detection method. We present this new spectroscopic method, with which we cancel the ^{1}st-order Doppler shift and illustrate its power with a new determination of the ionization energy of 2 $^3S_1$ metastable He.



[1] Gloria Clausen, Paul Jansen, Simon Scheidegger, Josef A. Agner, Hansjürg Schmutz, and Frédéric Merkt, Phys. Rev. Lett. **127**, 093001 (2021).
[2] Voijtěch Patkóš, Vladimir A. Yerokhin, and Krzysztof Pachucki, Phys. Rev. A. **103**, 042809 (2021).
[3] Christophe Dorrer, François Nez, Béatrice de Beauvoir, Lucile Julien, and François Biraben, Phys. Rev. Lett. **78**, 3658 (1997).
[4] Pei-Ling Luo, Jin-Long Peng, Jinmeng Hu, Yan Feng, Li-Bang Wang, and Jow-Tsong Shy, Phys. Rev. A. **94**, 062507 (2016).
[5] Vladimir A. Yerokhin, Voijtěch Patkóš, and Krzysztof Pachucki, Eur. Phys. J. D. **76**, 142 (2022).
[6] Vladimir A. Yerokhin, Voijtěch Patkóš, and Krzysztof Pachucki, Phys. Rev. A. **107**, 012810 (2023).