PRECISION SPECTROSCOPY OF TRANSITION FROM THE METASTABLE 2 ^{3}S$_1$ STATE OF TO HIGH NP RYDBERG STATES

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The metastable He ((1s)^1(2s)^1) atom in its singlet (^{1}S$_0$) or triplet (^{3}S$_1$) 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 ^{1}S$_0$ 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 ^{3}S [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 ^{3}S$_1$ state of ^{4}He via the measurement of transitions from the 2 ^{3}S$_1$ state to np Rydberg states. Extrapolation of the np 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 ^{3}S$_1$ 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 ^{3}S$_1$ metastable He.

References

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