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Precision spectroscopy of helium atoms

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Precision spectroscopy in few-body atomic systems, like hydrogen and helium, enables the testing of the quantum electro-dynamics (QED) theory and determination of the fundamental physical constants, such as the Rydberg constant, the proton charge radius, and the fine-structure constant. It also sets constraints on new physics beyond the standard Model (BSM). High precision spectroscopy of atomic helium, combined with ongoing theoretical calculations for the point nucleus may allow an alternative determination of the helium nuclear charge radius, which could be more accurate than from the electron scattering. Moreover, the comparison of results from electronic and muonic helium will provide a sensitive test of universality in the electromagnetic interactions of leptons.
Our group has performed laser spectroscopy measurement of the 23S-23P transition of helium atoms, in the past decade [1,2]. Recently, we updated our atomic beam setup, adding a Zeeman deceleration system, we implemented a new metastable atomic helium beam with high brightness and adjustable speed [3]. In this setup, the influence of first-order Doppler effect can be significantly reduced. At the same time, we have improved the probe laser system, by using a switching traveling wave field instead of the standing wave field that used in the original experiment, to probe the atomic beam [4]. This improvement effectively reduces the light force induce shift in our previous measurement [5]. Based on that setup, the issue of post-selection in precision spectroscopy of the 23S–23P transition of 4He has first revealed. We experimentally observed a discrepancy between the results with and without post-selection, which is validated by our simulations and theory. Our findings reveal the extra bias of weak signals when applying WVA and indicate a correction of previously experimental results obtained under post-selections. Our work highlights the significance of quantum mechanics and technologies in modern precision measurement and appeals to more attention to evaluate and interpret experiments in the framework of quantum optics and quantum metrology.

Key words: Helium Spectroscopy, Post-Selection, Weak Measurement, Isotope Shift, Nuclear Charge Radius
[1] X. Zheng, Y. R. Sun, J.-J. Chen, W. Jiang, K. Pachucki, and S.-M. Hu. Phys. Rev. Lett., 118:063001, Feb 2017.
[2] X. Zheng, Y. R. Sun, J.-J. Chen, W. Jiang, K. Pachucki, and S.-M. Hu. Phys. Rev. Lett., 119:263002, Dec 2017.
[3]J.-J.Chen, Y.R.Sun, J.-L.Wen, and S.-M.Hu Phys.Rev.A,101:053824(2020)
[4]Jin-Lu Wen, Jia-Dong Tang, Jun-Feng Dong, Xiao-Jiao Du, Shui-Ming Hu and Y.R.Sun, Phys.Rev.A,107,042811(2023)
[5] X. Zheng, Y. R. Sun, J.-J. Chen, J.-L. Wen, and S.-M. Hu. Phys. Rev. A, 99:032506, Mar 2019

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