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QED and the Hyperfine-structure Puzzle in Hydrogen-like and Lithium-like Bismuth

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The possibility of testing quantum electrodynamics (QED) in very strong fields by laser spectroscopy on heavy highly charged ions has been opened by the first observation of the hyperfine splitting in hydrogen-like bismuth in 1994 [Klaft et al. Phys. Rev. Lett 73, 2428 (1994)]. The electrons in these systems experience the strongest magnetic fields available in the laboratory, but the significance as a test for QED of this and following experiments on other species was limited by the unknown magnetic moment distribution inside the nucleus. However, it was suggested that a so-called specific difference between the hyperfine splittings in hydrogen-like and lithium-like ions of the same isotope can be used to cancel nuclear structure effects and provide an accurate test of QED [Shabaev et al., Phys. Rev. Lett. 86, 3959 (2001)]. The transition in Li-like Bismuth was observed for the first time in 2011 at the Experimental Storage Ring ESR located at the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt [M. Lochmann et al., Phys. Rev. A 90, 030501 (2014)]. Yet the accuracy of the result was limited by the calibration of the electron cooler voltage, determining the ion velocity. Here, we report on improved laser spectroscopic measurements on bismuth ions of both charge states (209Bi82+ and 209Bi80+) at the ESR. The accuracy was improved by about an order of magnitude compared to the first observation in 2011. We will present the measured transition energies of both hydrogen- and lithium-like bismuth and the experimentally determined value for the specific difference in 209Bi which is in contradiction with theoretical predictions. Possible reasons will be discussed and ways to further investigate this puzzle by laser spectroscopy on radioactive species will be discussed.

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