Contribution ID: **59** Type: **not specified**

Recent results from hyperfine spectroscopy experiment at the ESR

Saturday, 17 September 2016 11:55 (35 minutes)

While quantum electrodynamics (QED) is usually referred to as the most accurately tested theory, its validity for electrons in very strong fields is still not tested with high accuracy. The strongest magnetic fields available in the laboratory are experienced by electrons in the groundstate of highly charged heavy ions which can be probed by hyperfine spectroscopy. Even though the ground state hyperfine transition in hydrogen-like bismuth was observed already in 1994 [1], the significance of the experiment as a test for QED 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 [2]. 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 f¨ur Schwerionenforschung in Darmstadt [3]. 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 of the hyperfine splittings in hydrogen- and lithium-like bismuth ions (209Bi82+ and 209Bi80+) at the ESR. The accuracy was improved by about an order of magnitude compared to the first observation in 2011 [3]. The most important new feature was an in-situ high voltage measurement system with an accuracy at the 10-ppm level provided by German metrology institute Physikalisch-Technische Bundesanstalt. As the dominant systematic effect, the space charge effect of the electron cooler current on the ion velocity was determined with two independent techniques that provided consistent results. We will discuss systematic effects, present the measured transition energies of both hydrogen- and lithium-like bismuth and show the experimentally determined value for the specific difference in 209Bi.

References
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Primary author: ULLMANN, Johannes (TU Darmstadt, IKP)

Co-authors: DAX, Andreas (Paul Scherrer Institute, Villigen, Switzerland); MAASS, Bernhard (Institut fur Kernphysik, Technische Universitat Darmstadt, Germany); BRANDAU, Carsten (GSI, Darmstadt); Mr GORGES, Christian (Institut für Kernphysik TU Darmstadt); Mr TRAGESER, Christian (IKF); Prof. WEINHEIMER, Christian (Institut für Kernphysik, University of Münster); GEPPERT, Christopher (Institut fur Kernphysik, Technische Universitat Darmstadt, Germany); Dr WINTERS, Danyal (GSI, Darmstadt); MEISNER, Johann (Physikalisch-Technische Bundesanstalt, Braunschweig, Germany); Mr VOLLBRECHT, Jonas (Westfälische Wilhelms-Universität Münster); KRISTIAN, Konig (Institut fur Kernphysik, Technische Universitat Darmstadt, Germany); Dr STECK, Markus (GSI, Darmstadt); LOCHMANN, Matthias (Institut fur Kernphysik, Technische Universitat Darmstadt, Germany); SCHMIDT, Matthias (Physikalisch-Technische Bundesanstalt, Braunschweig, Germany); HAMMEN, Michael (Helmholtz Institut Mainz, Germany); THOMPSON, Richard C. (Department of Physics, Imperial College London, UK); Dr SANCHEZ ALARCON, Rodolfo Marcelo (GSI, Darmstadt); Mr KAUFMANN, Simon (Institut für Kernchemie Uni-Mainz); Mr SCHMIDT, Stefan (Technische Universität Darmstadt); KÜHL, Thomas (GSI, Darmstadt); STÖHLKER, Thomas (GSI, Darmstadt); Mr MURBÖCK, Tobias (TU Darmstadt); Dr HANNEN, Volker (Institut für Kernphysik, Uni Münster); Prof. NOERTERSHAEUSER, Wilfried (TU Darmstadt); GEITHNER, Wolfgang (GSI, Darmstadt); Dr LITVINOV, Yury (GSI, Darmstadt); ANDELKOVIC, Zoran (GSI, Darmstadt)

Presenter: ULLMANN, Johannes (TU Darmstadt, IKP)

Session Classification: SPARC and FAIR