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JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Physikalisches Kolloquium

July 4, 2023 at 4:15 p.m.
HS KPH

Prof. Paul Indelicato
University of Sarbonne - France

Strong field quantum electrodynamics in highly charged ions and exotic atoms

Quantum electrodynamics (QED) is part of the standard model and the best understood quantum field theory. Many tests exist, from free particles (electron and muon anomalous magnetic moment) to bound states. From the historical measurement of the Lamb-shift which lead to the advent of QED and field theories, many systems have been studied and compared to the most advanced calculations. One can cite hydrogen, positronium, muonium, highly charged, few electron ions[1] and exotic atoms (atoms in which the electron is replaced by a heavier particle like a muon, a pion or an antiproton).
In this talk I will present a few cases of highly charged ions high-precision results (few ppm accuracy) obtained with our Double Crystal Spectrometer in Paris[2-4] for medium-Z elements, and preliminary results obtained at GSI on few-electron uranium. I will then present new ideas [5] and first demonstration results on QED tests using muonic atoms and transition-edge sensor micro-calorimeter at JPARC [6, 7], and their extension to antiprotonic atoms at ELENA in the future. Detailed comparison with QED and relativistic many-body calculations when relevant will be made.
[1]Topical Review: QED tests with highly-charged ions, P. Indelicato. J. Phys. B 52, 232001 (2019).
[2]High-precision measurements of n=2->n=1 transition energies and level widths in He- and Be-like Argon Ions, J. Machado, C.I. Szabo, J.P. Santos et al. Phys. Rev. A 97, 032517 (2018).
[3]Reference-free measurements of the 1s 2s 2p 2P1/2,3/2 → 1s2 2s 2S1/2 and 1s 2s 2p 4P5/2 → 1s2 2s 2S1/2 transition energies and widths in lithiumlike sulfur and argon ions, J. Machado, G. Bian, N. Paul et al. Phys. Rev. A 101, 062505 (2020).
[4]Absolute measurement of the relativistic magnetic dipole transition in He-

like sulfur, J. Machado, N. Paul, G. Soum-Sidikov et al. Phys. Rev. A in press, (2023).
[5]Testing Quantum Electrodynamics with Exotic Atoms, N. Paul, G. Bian, T. Azuma et al. Phys. Rev. Lett. 126, 173001 (2021).
[6]Deexcitation Dynamics of Muonic Atoms Revealed by High-Precision Spectroscopy of Electronic K X Rays, T. Okumura, T. Azuma, D.A. Bennett et al. Phys. Rev. Lett. 127, 053001 (2021).
[7]Proof-of-Principle Experiment for Testing Strong-Field Quantum Electrodynamics with Exotic Atoms: High Precision X-ray Spectroscopy of Muonic Neon, T. Okumura, T. Azuma, D.A. Bennett et al. Phys. Rev. Lett. in press, (2023).

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MATERIALS IN MAINZ SCIENCE

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