SCIENCES SORBONNE UNIVERSITÉ

Ph.D. in Test of quantum electrodynamics in strong Coulomb field

INSP/ SU, Campus P. et M. Curie (Jussieu)
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Keywords: highly charged ions, bound states quantum electrodynamics, x-ray spectroscopy

Scientific description: This Ph.D. will be dedicated to a new experiment on high-accuracy x-ray spectroscopy of a few-electrons heavy ions for testing quantum electrodynamics (QED) in strong Coulomb field (the field of the highly charged ion). In this regime, perturbative methods cannot be used for theoretical predictions, and the contributions of the vacuum polarisation of the electron self-energy have to be calculated to all orders. At present, the most advanced calculations of bound state QED are limited to the two-loop contributions. This work follows a recent successful experiment on the x-ray spectroscopy of heliumlike (2 electrons), lithiumlike (3 el.) and berylliumlike (4 el.) uranium ($^{238}U^{92+}$) representing, at present, one of the most stringent tests of bound state QED. The proposed experiment will measure exclusively heliumlike uranium ions that are formed with different nuclear isotopes to investigate the effect of nuclear size and deformation. For this purpose, the twin Bragg spectrometer will be upgraded with two TIMEPIX3 detectors (developed by CERN, and commercialised by ASI) for coincidence measurements. Different uranium isotopes will be produced on-flight in the accelerator.
The experiments will take place a the GSI/FAIR facility in Darmstadt (Germany), where the ions will be produced and stored in a dedicated ring. The excited ions will be obtained by electron capture by the interaction with a gas-jet target, in which proximity our spectrometer will be positioned.
Preliminary preparation tasks will be performed here in Paris. The acquisition system for the new detector will be prepared and tested with fluorescence targets and (possibly) with highly charged ions in our SIMPA installation in the Pierre et Marie Curie campus. Calculations will also be performed to estimate the sensitivity to nuclear size and deformation and to select the most interesting uranium isotopes to be studied. Some calculations will require the use of the MCDFGME code.

Techniques/methods in use: The candidate will become familiar with the techniques of data analysis, X-ray spectroscopy, heavy ion structure. Eventually, the candidate will work on our ion source and transport line installation SIMPA.

Applicant skills: Knowledges in one or several following topics is required: atomic physics, x-ray spectroscopy, python.

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Ph.D. location: INSP, Sorbonne Université, 4 place Jussieu, 75005 Paris, GSI/FAIR, Darmstadt, Germany

Possibility for a Doctoral thesis: Yes (to be financed via the doctoral school or Initiative Physique Infinis, Alliance Sorbonne Université)