Theoretical predictions of the structure of heavy muonic atoms and access to the nuclear properties

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When coming close to an atom, a muon can be captured by the nucleus and form a hydrogen-like muonic ion, which is typically also surrounded by atomic electrons. This atomic system is commonly referred to as a muonic atom. Due to the muon's high mass, it is located much closer to the nucleus; and, especially for heavy nuclei, this results in big nuclear size effects and a strong dependence of the muon bound-state energies on the nuclear charge and current distributions, as well as in large relativistic effects [1, 2]. A combination of the knowledge about the level structure and experiments measuring the transition energies in muonic atoms enabled the determination of nuclear parameters like charge radii, electric quadrupole and magnetic dipole moments [3].

In this work, we present up-to-day theoretical predictions of the muonic atoms' level structure. State-of-the-art techniques from both nuclear and atomic physics are brought together in order to perform the most comprehensive to date calculations of the quantum-electrodynamics and nuclear contributions. Finally, a long-standing problem of fine-structure anomalies in muonic atoms is revisited in the light of the last improvements on nuclear-polarization [4] and self-energy calculations [5], and discuss its importance for the nuclear structure predictions.

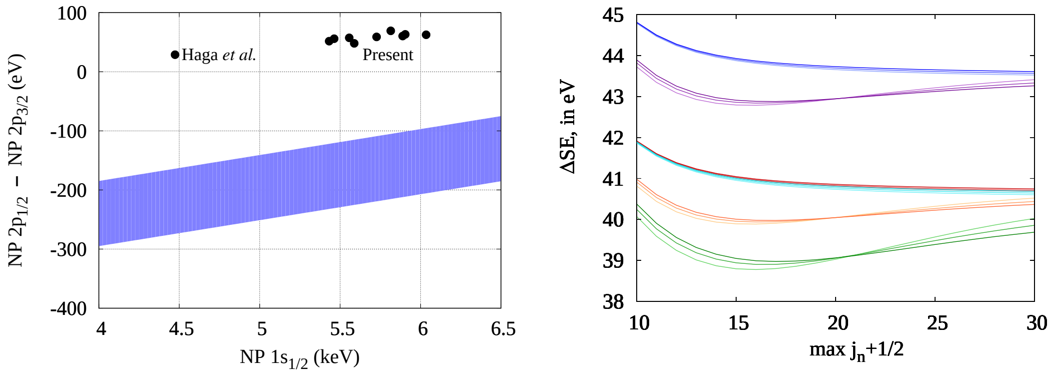

FIG. 1: (left) Theoretical values of the nuclear polarization correction for muonic lead in relation to the experimentally allowed range for $\Delta 2p = |\Delta E^{\rm NP}_{2p_{1/2}} - \Delta E^{\rm NP}_{2p_{3/2}}|$ as a function of $|\Delta E^{\rm NP}_{1s_{1/2}}|$ [4].
(right) Self-energy contribution to the $2p_{1/2}$ state of muonic tin in units of eV as a function of maximal intermediate angular momentum j_n for different nuclear models and numerical grids [5].

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