Beta decay and electron capture in heavy and superheavy nuclei*

A. Ravlić[1] and W. Nazarewicz[1,2]
[1]*Facility for Rare Isotope Beams, Michigan State University, East Lansing, Michigan 48824, USA and*
[2]*Department of Physics and Astronomy, Michigan State University, East Lansing, Michigan 48824, USA*

Superheavy elements (SHE) comprise a region of the nuclide chart with proton number $Z \geq 104$ [1,2]. Up to now, the heaviest experimentally discovered element is oganesson ($Z = 118$), while the quest for heavier elements is ongoing. The SHEs discovered so far are short-lived, decaying primarily via α-decay, fission, and electron capture (EC). In general, α-decay and fission occur on a shorter timescale compared to EC. However, as the nuclear charge increases and shell effects evolve, EC rates can become competitive [3].

In this talk, the first quantified predictions of weak decays in SHEs will be presented, both EC and β^-, and nuclei for which EC may compete with α-decay or fission identified [4]. The calculations are based on the relativistic nuclear energy density functional (NEDF) theory to describe the nuclear ground state, while the EC rates are obtained within the quasiparticle random-phase approximation (QRPA). The couplings of time-odd currents in the QRPA residual interaction are carefully calibrated with experimental data using β^- and EC/β^+-decay half-lives, as well as Gamow-Teller resonance energies. Calculations include both allowed and first-forbidden transitions; the latter dominate the EC rates and are essential for accurately modeling this process. Further, the sensitivity of EC rates on the details of the electron wave functions is investigated. Results are compared between assuming the single-particle approximation for the electron wave functions and more sophisticated Dirac-Hartree-Fock (DHF) calculations [5]. This approach is contrasted with the lowest-order (LO) approximation often adopted in the literature due to its simplicity. It is demonstrated that using the improved lepton wave functions, compared to LO, reduces the EC rates by up to 40% in oganesson. Interestingly, because of screening of the inner-most electron by large nuclear charge, the difference between the EC rates obtained with the DHF and single-particle wave functions is relatively small.

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