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From beta decays to nuclear clock: role of nuclear theory in searches of new physics

Precision measurements capture an increasing amount of attention in probing physics beyond the Standard Model (BSM). Worldwide, a multitude of experiments aim at reaching high precision, ˜0.1% , and will have comparable control over systematic uncertainties. By this, these experiments will augment LHC constraints on models of BSM physics.

These efforts entail a need in Standard-Model predictions of the pertinent observables of comparable accuracy. In this talk I will emphasize two main such efforts, namely beta-decay observables and the effort to build a 229Th based nuclear clock. I will describe the needed nuclear theory efforts. In the case of beta decays, these focus on identifying, characterizing and quantifying uncertainties in the challenging realm of nuclear physics as a strongly interacting effective field theory of QCD. This involves consideration of corrections that have not previously been thoroughly investigated, e.g., the effect of the nuclear finite size on Coulomb interactions, recoil corrections, etc. For many of these an accurate result requires forefront nuclear-structure calculations.

In addition I will describe the dawn of new physics searches using nuclear clocks. The recent demonstration of laser excitation of the ˜8 eV isomeric state of thorium-229 is a significant step towards a nuclear clock. The low excitation energy likely results from a cancellation between the contributions of the electromagnetic and strong forces. However, a ‘’nightmare scenario” is still possible. In this scenario all binding energy differences are small and the new physics sensitivity is poor. Nuclear clocks' sensitivity to new physics depends on the question of the plausibility of the nightmare scenario. Accurate predictions of the different contributions to nuclear transition energies, and therefore of the quantitative sensitivity of a nuclear clock, are challenging. I propose a d-wave halo model, inspired by effective field theory. We show that it reproduces observations and suggests the ‘’nightmare scenario” is unlikely. I finally propose auxiliary nuclear measurements to reduce uncertainties and further test the validity of the halo model.

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