

Nuclear Deformations Relevant for Neutrinoless Double-Beta Decay

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Neutrinoless double-beta decay ($0\nu\beta\beta$) is a speculated and extremely rare process in which a nucleus undergoes two simultaneous beta decays without emitting neutrinos. Observation of this decay would demonstrate that neutrinos are Majorana particles and provide direct evidence of lepton number violation—an essential ingredient for explaining the matter-antimatter asymmetry in the universe. As such, $0\nu\beta\beta$ decay is a central focus of modern nuclear and particle physics, with numerous experimental efforts worldwide dedicated to its detection. Since the interpretation of any future signal depends critically on the Nuclear Matrix Element (NME), understanding the nuclear structure of the involved decay partners is essential.

In this context, recent theoretical studies have highlighted the strong impact of the nuclear deformation of the decay partners on the NME magnitude. In particular, shape differences between the initial and final nuclei can introduce significant suppression of the decay probability. However, theoretical models currently disagree on the structure of many $0\nu\beta\beta$ candidates and predict divergent NME values. Therefore, new experimental constraints on nuclear structures and shapes of the decay partners are crucial to validate and guide theoretical efforts.

In this contribution, I will present recent Coulomb-excitation measurements aimed at determining the ground-state deformation of ^{116}Sn and ^{130}Te , two key nuclei for double-beta decay studies. The ^{130}Te experiment was performed at ATLAS (USA) using the GRETINA+CHICO2 setup and complemented by an independent measurement with AGATA+SPIDER at INFN-LNL (Italy). The ^{116}Sn campaign, instead, was carried out at INFN-LNL with GALILEO+SPIDER and recently followed by a second experiment at ATLAS employing the GRETINA+CHICO-X setup to extend the level scheme toward higher-lying states.

The analysis of the ^{116}Sn data has revealed that, in addition to a near-spherical ground state, multiple excited 0^+ states with distinct deformations coexist within the same nucleus—an indication of multiple-shape coexistence. These findings provide important input for structure models used in NME calculations. Preliminary data from additional studies on other $0\nu\beta\beta$ candidates will also be briefly discussed.

These results highlight the role of precision Coulomb-excitation studies in mapping shape evolution across $0\nu\beta\beta$ decay partners and in constraining the nuclear-structure ingredients necessary for reliable matrix element predictions.

This research was partially supported by the European Union's Seventh Framework Programme for Research and Technological Development (grant no. 262010), and by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under contract number DE-AC02-06CH11357. This study used resources of ANL's ATLAS facility, which is a DOE Office of Science User Facility.