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Core-excited configurations of extreme isomers in Pb and Bi isotopes

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The nuclear shell model has been quite successful in describing the microscopic structure of nuclei, particularly those which are proximate to magic numbers. While spin isomers at low excitation in nuclei approaching shell closures are well known and appropriately described by the shell model, advances in experimental techniques have enabled the study of metastable states at very high excitation and spin in recent times. In this context, the region of the nuclear chart in the vicinity of the heaviest, doubly-magic nucleus 208Pb is noteworthy. Owing to the presence of a number of high-j orbitals embedded with low-j ones for both protons and neutrons, metastable states at high spin analogous to spin isomers at low excitation are realized. Further, in nuclei with a few valence nucleons, at very high energy (>6-7 MeV), excitations across the Z = 82 and N = 126 shell gaps make it feasible to open up another set of high-j orbitals for occupation. These core-excited configurations have been found to be even more favorable for the realization of long-lived states at very high excitation and spin.

Three of the longest-lived states across the nuclear chart above an excitation energy of 7 MeV were recently discovered by this collaboration in 204Pb, 205Bi and 206Bi, with half-lives of 220(20) µs, 8(2) ms and 27(2) µs, respectively. Data on these and other such isomers will be reported at the conference, with one of them being the newly-identified T1/2 = 1.46(10) µs state at Ex = 8.835 MeV in 207Pb. All of these results have been obtained using the Gammasphere detector array and the ATLAS accelerator at the Ar- gonne National Laboratory. The properties of these isomers (half-life, excitation energy and spin) are at the extremes of what is presently known. It is challenging to obtain a satisfactory description of these isomers and their decay characteristics using large-scale shell-model calculations and the available effective interactions. These experimental re- sults are expected to serve as crucial inputs for improving effective interactions used in large-scale shell-model calculations.

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Presenter: KONDEV, Filip (Argonne National Laboratory)

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