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Probing the island of inversion at N=40 through beta-decay of Mn isotopes

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One of the best-known divergences from the independent-particle shell model description of the atomic nucleus is the existence of islands of inversion [1]. The IoI of the region N=40 draws particular attention since the neutron number 40 was postulated as a non-traditional "magic"number and N = 40 represents the boundary between the pf and g shells.
Measurements of B(E2) values and E(2+) in the neutron-rich region show increased collectivity through the N = 40 shell gap, with the clear exception of 68Ni [2,3]. Deformation and shape coexistence have been identified in the area and RIKEN experiments suggest the N=40 IoI extends toward N=50, paralleling the merging of N=20 and N=28 IoIs. LNPS calculations predict triple shape coexistence for 67Co (N=40), with three rotational bands [4]. And recent experiments on 67Fe (N=41) propose a spin-parity of 5/2+ or 1/2− for its ground state [5] which indicates a significant deformation. In addition, shape coexistence is also expected for 67Fe.
Detailed spectroscopic information of the iron, cobalt, and nickel isotopes is crucial to accurately mapping the transition to the N = 40 island of inversion and serves as a test for accuracy of theories. However, very limited information is available, so to this end, an experiment was performed at the TRIUMF-ISAC facility utilizing the GRIFFIN spectrometer [6], where the β and βn decay of 69Mn, 68Mn, and 67Mn, populates the corresponding Fe, Co and Ni isotopes. This data set contains orders of magnitude more statistics than previous studies allowing us to build for the first time a complete level scheme of 68Fe and 67Fe and to improve upon the known β- decay level schemes of 67Co, by expanding the number of transitions and levels, as well as by improving the precision of branching ratios and ground-state half-life measurement. In addition, measurements of level lifetimes down to the picosecond range will allow us to investigate the band structure in these nuclei. For the 67Fe isotope, the good level of statistics will make it possible to measure the energy of the identified isomeric state and improve the lifetime measurement. These results can provide further insight into the detailed structure of the states by comparison to simple models and large-scale shell model calculations in order to confirm or refute the shape coexistence picture predicted by LNPS calculations and the shrinking of the N=40 gap just one proton below 68Ni.

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