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β-decay of ^{68}Mn: Probing the N=40 island of inversion

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Although the shell model is fundamental to our understanding of nuclear structure, the breakdown of traditional magic numbers far from stability provides insight into the nature of the underlying nuclear interactions and acts as a tool to test existing models. Islands of inversion (IoI) in the nuclear landscape are characterized by the presence of deformed multi-particle multi-hole (*npnh*) ground states instead of the (0*p*0*h*) configurations predicted by spherical mean-field calculations. This is typically driven by the strong nuclear quadrupole-quadrupole interaction that induces shape transitions, wherein these highly correlated "intruder" states become more bound than spherical ones.

In the *N*=40 region, the relatively large energy gap separating the *pf* shell from the $\nu g_{9/2}$ orbital points towards a strong sub-shell closure at *N*=40 which has been supported by the observation of a high-lying 2^+ state and low *B*(*E*2) value in ^{68}Ni (*Z*=28) [1]. However, systematics of *E*(2^+) and *B*(*E*2) values have indicated a sudden increase in collectivity below *Z*=28 when approaching *N*=40, seen especially in the rapid drop of *E*(2^+) in Fe (*Z*=26) and Cr (*Z*=24) isotopes [2,3]. This increase in collectivity is thought to be due to the neutron occupation of intruder states from a higher shell, similar to the IoI around *N*=20 [4,5].

Shape coexistence also manifests in nuclei at the boundaries of IoIs [6]. In the *N*=40 region, low-lying 0^+ excited states, which are traditional indicators of shape coexistence have been identified up to *A*=66 [7,8]. In ^{68}Fe, a state at 2035 keV is tentatively assigned as 0^+ or 2^+ and the confirmation of this spin would indicate whether this trend extends past *N*=40. Recent studies also suggest the occurrence of a new IoI at *N*=50 and a proposed merging of the *N*=40 and *N*=50 IoIs, equivalent to the one observed between *N*=20 and *N*=28 [9,10,11].

To explore these phenomena, an experiment was performed at TRIUMF-ISAC using the GRIFFIN spectrometer that utilized the β- and βn decay of ^{68}Mn to populate excited states in ^{67,68}Fe, ^{67,68}Co and ^{67,68}Ni. This experiment produced the highest-statistics data set to date for these isotopes. Consequently, we have greatly expanded the level scheme of ^{68}Fe and measured key observables such as γ-ray intensities and branching ratios. A comprehensive level scheme of ^{67}Fe populated through the βn decay has been established for the first time along with a re-measurement of the P_n value. Angular correlation analysis, which will provide firm assignments of spins and parities of low-lying excited states, is underway. We have new information on the spin assignment of the 2035 keV level in ^{68}Fe which leads to a reinterpretation of shape coexistence in this nucleus. This, along with other preliminary results, will be presented and discussed.

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