Beta-delayed γ-ray studies of $\pi f_{7/2} - \nu pf$ shell nuclei

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We have utilized the selective process of β decay to populate low-energy excited states in the neutron-rich $_{22}$Ti, $_{23}$V, $_{24}$Cr, and $_{25}$Mn nuclei. The goal was to systematically track the monopole shift of the $\nu f_{5/2}$ single-particle level with increased occupancy of the $\pi f_{7/2}$ orbital [1]. The appearance of a sub-shell gap at $N = 32$ for the neutron rich Cr [2], Ti [3], and Ca [4] isotopes is one consequence of the migration of the $\nu f_{5/2}$ orbital and a large $\nu p_{3/2} - \nu p_{1/2}$ spin-orbit splitting.

The β-decay properties of the parent nuclides, along with the low-energy structure of the daughters, were compared with the results of shell model calculations employing the GXPF1 interaction [5,6]. This interaction is derived from a microscopic calculation based on renormalized G matrix theory with the Bonn-C interaction and refined by systematic adjustment of the important linear combinations of two-body matrix elements to low-energy states in nuclei from $A = 47$ to $A = 66$. Excellent agreement between the shell model results, calculated in the full pf-model space, and the experimental observations was noted in most cases, and representative examples will be presented for the A = 57, 59, and 60 decay chains. One exception was the low-energy structure of ^{56}Ti$_{34}$, where the first excited 2^+ energy [7,8,9] and measured B(E2) value for the $2^+_1 \rightarrow 0^+_1$ transition [10] deviated from the shell model expectations based on the GXPF1 interaction. A large $\nu p_{1/2} - \nu f_{5/2}$ energy gap at $N = 34$, expected from the GXPF1 calculations, was not observed to materialize in the Ti isotopes. Future experimental efforts to search for evidence of an $N = 34$ shell gap in the Ca isotopes will be discussed.

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