Onset of collectivity in Neutron-Rich iron isotopes: Toward a new island of inversion?


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The lifetimes of the first excited $2^+$ states in $^{62}$Fe and $^{64}$Fe have been measured for the first time using the recoil-distance Doppler shift technique. A $^{238}$U beam of 6.5 AMeV impinged on $^{64}$Ni target, and the target like products were slowed down by degrader foil positioned at micrometer distance downstream of the target and identified in the VAMOS spectrometer on an event-by-event basis. The lifetimes were then determined from the intensities of the degraded and fully Doppler shifted components of the $2^+ \rightarrow 0^+$ transition detected in EXOGAM detectors positioned at backward angles.

The resulting lifetimes show a steep increase of the B(E2) values of the first excited $2^+$ state from $^{62}$Fe to $^{64}$Fe. A comparison with shell model calculations shows that the onset of collectivity is related to the occupation of neutron intruder orbitals. The large B(E2) value for $^{64}$Fe is only reproduced if the valence space includes both the neutron $g_{9/2}$ and $d_{5/2}$ orbitals. The transition from spherical $^{68}$Ni to more proton-deficient N 40 isotones has some similarity with the island of inversion around $^{32}$Mg. The developing quadrupole collectivity can in both cases be related to the occupation of neutron intruder orbitals which are at the same time quasi-SU(3) partners: $(f_{7/2}, p_{3/2})$ for $^{32}$Mg and $(g_{9/2}, d_{5/2})$ for the neutron-rich Fe.

Figure 1: $B(E2; 2_1^+ \rightarrow 0_1^+)$ values for neutron-rich iron isotopes. Values from this work are shown in black. New shell-model calculations clearly show the importance of the $g_{9/2}$ intruder orbital and its $d_{5/2}$ quadrupole partner.