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The Nature of 0+ Sates in Deformed Nuclei

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The existence and characterization of multi-phonon vibrational modes in deformed nuclei remains an open question in nuclear structure. The question revolves around the possible degrees of freedom in deformed nuclei [1-4]. Rotational motion is an expected feature of deformed nuclei, the open challenge is whether the granularity of nuclei allows single or multiple quanta of vibrational oscillations or excitations superimposed on the equilibrium deformed shape of the nucleus.

The lowest lying such shape effecting oscillations or vibrations would be quadrupole in nature, resulting in two types of vibrations: beta (K=0+) with no projection on the symmetry axis and gamma with a projection of K=2+. Vibrational spectra can, in principle, be constructed from one or more quanta of these states resulting in two-phonon betabeta$ (K=0+), betagamma (K=2+), and gammagamma (K=0+ and 4+) types of vibrational excitations. Single phonon gamma vibrational bands and low-lying K=0+ bands have been known for some time and they are abundant in various regions of deformation, including the rare-earth region of nuclei, albeit without systematic knowledge of level lifetimes. The gamma vibration seems to be well characterized as the first excited K= 2+ band and exhibits a systematic behavior across the region of deformed nuclei with typical B(E2; 2+ −> 0+g.s. values of a few Weisskopf units (W.u.). The energies of the first excited K=0+ bands and their B(E2) values show a different picture. The energies and associated B(E2) values of the first excited K = 0+ bands vary greatly throughout the deformed region. There are several examples of two-phonon quadrupole vibrational excitations in a number of nuclei exhibiting various degrees of the full collective transition strength with wide ranges in energy anharmonicities.

Yet, the question regarding the viability of the K= 0+ excitations as the beta-vibration in deformed nuclei remains open to discussion and debate. I would like to present some of our recent lifetime measurements across isotopic chains of the Gd, Dy, and Er isotopes to contribute to the discussion.

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