On the way to collectivity: Two-phonon excitations in light and heavy atomic nuclei

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1. Experiment Summary

We propose to measure the decay properties of candidates for two-phonon \((2^+ \otimes 3^-)_{1^-}\) states in the nuclei \(^{40}\text{Ca}, ^{140}\text{Ce},\) and \(^{208}\text{Pb}\) at HI\(\gamma\)S. The knowledge of the decay pattern of the coupled phonons to the single constituents is mandatory to establish the existence of collective quadrupole-octupole states in these nuclei. It will be of great interest to see, how the collectivity develops from the sd shell nucleus \(^{40}\text{Ca}\) towards doubly-magic \(^{208}\text{Pb}\). The important observable is the E2-decay of the 1\(^-\) state into the 3\(^-\) octupole excitation. Due to a very low branching ratio of this decay compared to the E1 ground state transition, a \(\gamma\)-ray spectroscopy setup with high efficiency at HI\(\gamma\)S is needed to test the validity of the harmonic phonon picture predicting the branching ratio. The coincidence setup proposed by D. Savran et al. (“A new high-efficiency \(\gamma\)-ray spectroscopy setup for HI\(\gamma\)S”) would be crucial for the background-free measurement of low branching ratios of about 1\%. This setup would allow us to perform the proposed challenging experiments in the proposed different mass regions to study the \(J^\pi=1^-\) two-phonon state in an unprecedented efficiency and accuracy.

This experiment will be part of the PhD thesis of Vera Derya who will stay for a time period up to six month at TUNL to contribute to the implementation of the proposed coincidence setup.