Challenging nuclear vibrations with particle-gamma spectroscopy

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Atomic nuclei are complex many-body quantum systems which demonstrate a wide range of excitation modes. Analogous to electrons in atomic systems, nuclei exhibit closed shells of protons and neutrons at particular ‘magic numbers’. Close to the magic numbers, nuclei are usually spherical, and are dominated by single-particle excitations, while far from the closed shells they often excite via ‘collective’ motions, such as rotations of a deformed shape. Observed excitation energies of near-spherical nuclei are often described by a vibrational model, proposed in the 1950s [**?**]. Cadmium isotopes, with two protons below the Z=50 shell closure, have historically been labeled as vibrators based on energy levels, though recent investigations have found that measured shape and collectivity observables do not agree with the vibrational model [**?**]. Tellurium isotopes, two protons above the Z=50 shell closure, are expected to exhibit similarities to the cadmium isotopes, but these are less well-studied, and of interest in evaluating the success of the vibrational model.

A new research program at the Australian Heavy Ion Accelerator Facility will utilise Coulomb excitation to examine the nature of vibrations in near-spherical nuclei. Coulomb excitation, the excitation of a nucleus via the Coulomb interaction at energies below the Coulomb barrier, is ideal for probing vibrational modes as it preferentially populates low-energy collective states. To facilitate these measurements, a new particle detector system with particle-identification capabilities is being developed and integrated into the Compton-suppressed array (CAESAR) of 16 HPGe and $LaBr_3$ gamma-ray detectors. Results of testing particle-identification capability of new ‘phoswich’ detectors for the array will be presented, along with preliminary Coulomb-excitation measurements of the isotope ^{124}Te using the CAESAR array with a single phoswich chip and silicon photodiodes for particle detection.

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[2] P. E. Garrett, J. L. Wood, and S. W. Yates, “Critical insights into nuclear collectivity from complementary nuclear spectroscopic methods”, *Physica Scripta* **93** 063001 (2018).