Exploring shape coexistence between doubly magic ^{40}Ca and ^{56}Ni through pair-conversion spectroscopy

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The phenomenon of shape coexistence, whereby excited states of an atomic nucleus exhibit shapes that deviate dramatically from their ground states, appears to be ubiquitous across the nuclear landscape. Electric monopole (E0) transitions, the only possible decay paths between $J^\pi = 0^+$ states, provide a unique probe into nuclear structure. The E0 strength is large when there is a large change in the nuclear mean-square charge radius, and when there is strong mixing between states of different deformation. E0 transitions give us a probe to examine and understand shape coexistence [1, 2].

The region between ^{40}Ca and ^{56}Ni is virtually unexplored from the perspective of E0 transitions. Only the Ca isotopes and ^{54}Fe have been investigated [3]. Recent developments in the nuclear shell model allow for the calculation of the complete low-energy level structure and transition rates, including E0 transitions [4]. This region is then a perfect case to explore nuclear structure and shape coexistence through the lens of E0 transitions. In addition, the low-lying ($<$4 MeV) level structure of ^{50}Cr is not complete: there is a controversy over the position of the 0^+ states in ^{50}Cr [5, 6]. In searching for a non-analog branch in the superallowed beta decay of ^{50}Mn, two 0^+ states in ^{50}Cr at 3895.0(5) and 4733(5) keV were observed by Leach *et al.* [6]. We sought to confirm these 0^+ states through the observation of their E0 transitions.

The 0^+ states and E0 transitions in ^{40}Ca, ^{50,52,54}Cr, ^{54,56,58}Fe and ^{58,60,62}Ni were investigated with the Super-e pair spectrometer at the ANU [8, 9] using beams from the 14UD tandem accelerator. The Super-e pair spectrometer is a superconducting, magnetic-lens spectrometer for the measurement of conversion electrons and electron-positron pairs with excellent background suppression [7]. We will present the first pair spectra for ^{50,52,54}Cr, ^{54,56,58}Fe and the E0 transition strengths for these nuclei.

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