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Nuclear deformation effects on fine structure of the Isoscalar Giant Quadrupole Resonance and 2⁺ level densities from (p,p') scattering at 200 MeV

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Abstract content
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A systematic experimental investigation was performed of the phenomenon of fine structure, with emphasis on the region of the Isoscalar Giant Quadrupole Resonance (ISGQR), for nuclei across the neodymium isotope chain. The 200 MeV proton beams were delivered by the Separated Sector Cyclotron (SSC) facility of iThemba LABS. Measurements were made using the state-of-the-art K600 magnetic spectrometer, where unique high energy-resolution (&Delta<i>E</i> ≈ 42 - 48 keV FWHM) proton inelastic scattering results were obtained on ¹⁴²Nd, ¹⁴⁴Nd, ¹⁴⁶Nd, ¹⁴⁸Nd and ¹⁵⁰Nd targets. The stable even-even neodymium (<i>Z</i> = 60) isotopes are used to investigate the influence of the onset of deformation on the excitation energy spectra in the ISGQR region (9 ≤ <i>E</i>_x ≤ 15 MeV), since they extend from the semi-magic <i>N</i> = 82 nucleus (¹⁴²Nd) to the permanently deformed <i>N</i> = 90 (¹⁵⁰Nd) nucleus. In order to emphasize the ISGQR in the measured excitation energy spectra, a Discrete Wavelet Transform (DWT) background subtraction was carried out. A comparison of the resonance widths extracted shows a systematic broadening of the ISGQR (&Gamma = 3.220 MeV to 5.100 MeV), moving from spherical ¹⁴²Nd to highly deformed ¹⁵⁰Nd nuclei as has already been observed for the Isovector Giant Dipole Resonance (IVGDR) excited by &gamma-capture. State of the art theoretical microscopic Quasiparticle-Phonon Model (QPM) calculations were performed for the ISGQR and for ^{142,144,146}Nd. Characteristic energy scales, extracted using the Continuous Wavelet Transform (CWT) technique, allowed a comparison to be made between the experimental data and theoretical predictions in order to determine the dominant damping mechanisms. In addition, experimental level densities of J^{&pi} = 2⁺ states were extracted from the measured data using the fluctuation analysis technique. Comparisons will be made with the latest theoretical models with reference to the limitations of the method.

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