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Isoscalar giant monopole resonance in 24Mg and 28Si: Effect of coupling between the isoscalar monopole and quadrupole strength

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Background: In highly deformed nuclei, there is a noticeable coupling of the Isoscalar Giant Monopole Resonance (ISGMR) and the $K = 0$ component of the Isoscalar Giant Quadrupole Resonance (ISGQR), which results in a double peak structure of the isoscalar monopole (IS0) strength (a narrow low-energy deformation-induced peak and a main broad ISGMR part). The energy of the narrow low-lying IS0 peak is sensitive to both the incompressibility modulus K_∞ and the coupling between IS0 and isoscalar quadrupole (IS2) strength.

Objective: This study aims to investigate the two-peaked structure of the ISGMR in the prolate ^{24}Mg and oblate ^{28}Si nuclei and identify among a variety of energy density functionals based on Skyrme parameterisations the one which best describes the experimental data. This will allow for conclusions regarding the nuclear incompressibility. Because of the strong IS0/IS2 coupling, the deformation splitting of the ISGQR will also be analysed.

Methods: The ISGMR was excited in ^{24}Mg and ^{28}Si using α-particle inelastic scattering measurements acquired with an $E_\alpha = 196$ MeV beam at scattering angles $\theta_{\text{Lab}} = 0^\circ$ and 4°. The K600 magnetic spectrometer at iThemba LABS was used to detect and momentum analyse the inelastically scattered α particles. An experimental energy resolution of ≈ 70 keV (FWHM) was attained, revealing fine structure in the excitation-energy region of the ISGMR. The IS0 strength distributions in the nuclei studied were obtained with the Difference-of-Spectrum (DoS) technique. The theoretical comparison is based on the quasiparticle random-phase approximation (QRPA) with a representative set of Skyrme forces.

Results: IS0 strength distributions for ^{24}Mg and ^{28}Si are extracted and compared to previously published results from experiments with a lower energy resolution. With some exceptions, a reasonable agreement is obtained. The IS0 strength is found to be separated into a narrow structure at about $13 - 14$ MeV in ^{24}Mg, $17 - 19$ MeV in ^{28}Si and a broad structure at $19 - 26$ MeV in both nuclei. The data are compared with QRPA results. The results of the calculated characteristics of IS0 states demonstrate the strong IS0/IS2 coupling in strongly prolate ^{24}Mg and oblate ^{28}Si. The narrow IS0 peaks are shown to arise due to the deformation-induced IS0/IS2 coupling and strong collective effects. The cluster features of the narrow IS0 peak at 13.87 MeV in ^{24}Mg are also discussed. The best description of the IS0 data is obtained using the Skyrme force SkP$^\delta$ with an associated low nuclear incompressibility $K_\infty = 202$ MeV allowing for both the energy of the peak and integral IS0 strength in ^{24}Mg and ^{28}Si to be reproduced. The features of the ISGQR in these nuclei are also investigated. An anomalous deformation splitting of the ISGQR in oblate ^{28}Si is found. The observed structure of ISGQR in ^{24}Mg is described.

Conclusions: The ISGMR and ISGQR in light deformed nuclei are coupled and thus need to be described simultaneously. Only such a description is relevant and consistent. The deformation-induced narrow IS0 peaks can serve as an additional sensitive measure of the nuclear incompressibility.

Attendance Type

In-person

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