Effect of ground-state shape deformation on the Isoscalar Giant Monopole Resonance in Nd isotopes

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Introduction

In recent years, the study of the effect of deformation on excitation energy and width of the giant resonances of the deformed nuclei has been of considerable interests [1]. Giant Resonances (GRs) are the collective excitations in nuclei that give strong evidence that nuclei display highly collective motion. Among all the giant resonances, Isoscalar Giant Monopole Resonance (ISGMR) and Isoscalar Giant Dipole Resonance (ISGDR) are important to study because their excitation energies are directly related to the incompressibility of finite nuclear matter. Nuclear incompressibility is an essential component of the nuclear Equation-of-State (EoS), which plays crucial role in the studies of myriad cosmological events such as the merger of the neutron stars and supernova explosions [2].

In the macroscopic picture, proton and neutron oscillate in-phase in the isoscalar mode, whereas out-of-phase in the isovector mode. Isoscalar giant resonances have been studied very well for the spherical nuclei, but very few data are available for the deformed nuclei [1, 3, 4]. In spherical nuclei, the strength of the giant resonance does not split due to the symmetry effect. However, in the deformed nucleus, the strength of the ISGMR splits into two parts due to the coupling of the ISGMR with the K=0 component of the Isoscalar Giant Quadrupole Resonance (ISGQR), where K is the projection onto the symmetry axis. This paper will discuss the effect of the ground-state shape deformation on the ISGMR of the even-A Neodymium(Nd) isotopes.

Experimental Setup

The experiment was performed at the Research Centre for Nuclear Physics (RCNP), Japan. The beam of α-particles was accelerated to an energy of 386 MeV with the AVF and ring cyclotron. The typical resolution of the beam is 175 keV, sufficient to investigate the giant resonance. The halo-free beam bombarded on the self-supporting thin (5 mg/cm^2) enriched metallic target of $^{142,146-150}$Nd (even A). Inelastically scattered α-particles were momentum analyzed in the Grand Raiden (GR) spectrometer and focused onto the focal-plane detector system comprising two position-sensitive multiwire drift chambers (MWDCs) and two plastic scintillators. Elastic scattering measurement was performed in the angular range 3.5° to 20.5° for ^{142}Nd to obtain the Optical Model Parameter (OMP). The inelastically scattered α-particles were measured at a very forward angle, over a range of 0°-10° CM angle. Calibration of energy spectra is carried out by measuring the low-energy excitation peaks of ^{24}Mg at every angle. The schematic setup of the GR spectrometer and the related detector arrangement is shown in Fig. 1.

Results and discussion

The excitation energy spectra of Nd isotopes were extracted after particle identification, instrumental background subtraction, and ion-optical corrections in the offline anal-

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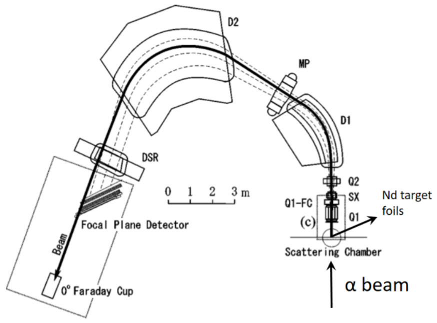

FIG. 1: GR spectrometer and associated detector.

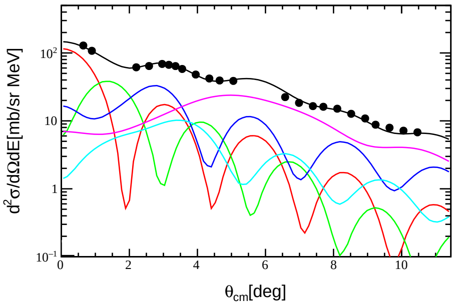

FIG. 2: (Color online) Fitting of angular distribution for ^{142}Nd at $E_x = 16$ MeV. The contributions from different multipolarities are shown with red (L = 0), green (L = 1), blue (L = 2), cyan (L = 3) and pink (L≥4) solid lines. The angular distributions of different multipolarities represent the actual EWSR which is less than 100%.

ysis. For the Distorted Wave Born Approximation (DWBA) calculation, the OMP is obtained from the α-elastic scattering off ^{142}Nd. There were a significant amount of contaminations from oxygen and hydrogen in each Nd isotope. The contribution of the scattering from the oxygen was subtracted using the high resolution ^{16}O(α,α') spectra from Ref [5],which was carried out at the same energy as in our case. In the case of hydrogen contamination, the elastic scattering off the protons has a large cross-section compared to the inelastic excitation of the target nucleus, so it is straightforward to identify and remove the affected data points. Due to the Coulomb excitation, Isovector Giant Dipole Resonance (IVGDR) is also populated. The contribution of IVGDR has to be subtracted before performing the Multipole Decomposition Analysis (MDA).

The oxygen subtracted spectra are used in the MDA to extract the multipole strength distributions of giant resonances (see Fig. 2). The cross-section at each angle is binned into a 1-MeV excitation-energy interval to reduce the statistical fluctuations. The experimental differential cross-section for each excitation energy bin was fitted with the linear combination of the theoretically calculated double-differential cross sections associated with different multipoles. In the case of the theoretical calculation, 100% Energy Weighted Sum Rule (EWSR) was considered. From the MDA, the strength distributions of different isoscalar giant resonances as functions of excitation energy will be extracted. This will allow the study of the effect of the ground-state shape deformation on the strength distributions.

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