Measurement of isoscalar giant monopole resonance in ^{132}Sn using CNS active target

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The equation of state (EoS) of nuclear matter not only governs the femto-scale quantum many-body system, namely nuclei, but also plays an important role in the structure of neutron stars and in supernova phenomena. In particular, the EoS of isospin asymmetric nuclear matter attracts much interest from the view point of the existence of heavy neutron stars. The asymmetric term of incompressibility, K_τ, can be a benchmark for various EoSs because it can be directly deduced from the the energies of the isoscalar giant monopole resonance (ISGMR) measured along an isotopic chain, such as tin isotopes.[1)] The present value of K_τ is -550±100 MeV and its error is relatively larger than those of other parameters of the EoS. In order to improve the K_τ value, the measurement on the isotopic chain should be extended to unstable nuclei. A doubly magic tin isotope, ^{132}Sn, has been chosen as a flagship for the measurements of unstable tin isotopes because of its large isospin asymmetry and double magic nature.

The excitation energy and scattering angle in the center-of-mass frame are extracted by means of missing-mass spectroscopy, where the low-energy recoil deuteron has to be measured. In order to measure such low-energy recoils, a gaseous active target system, CNS active target (CAT), has been employed. The CAT consists of a time-projection chamber (TPC) and an array of silicon detectors on both sides of TPC. A stack of thick gas electron multipliers (THGEM) is used for electron multiplication in the TPC. The THGEM has three-fold segmented electrodes. The center electrode is used for measuring the beam particles and the side electrodes are used for measuring the recoil particles. The multiplication factors at the beam and recoil region can be controlled independently, which enables us to operate the CAT with a beam of high intensity such as 10^6 particles per second.[2)]

The experiment was performed at RIBF at RIKEN. A secondary ^{132}Sn beam was produced as a fission fragment of a ^{238}U beam impinging on the primary beryllium target. The maximum intensity of the primary beam was 37 pnA. The typical intensities of the secondary beam at F3 and F7 were 8.5×10^5 and 3.2×10^5 particles per second, respectively. In order to identify the particles in such a high-intensity beam on an event-by-event basis, a new method called TOF-$B\rho$-$B\rho$[3)] was introduced. The TOF was measured by 200-μm-thick diamond detectors located at F3 and F7. Bρ was determined using the positions and angles measured by low-pressure multi-wire drift chambers at F3, F5, and F7. The main components of the secondary beam were ^{132}Sn, ^{133}Sb, and ^{134}Te with the purities of 21%, 46%, and 25% at F7, respectively. The data from the beam-line detectors at each focus are taken using MOCO[4)]. The CAT was placed at F8 with a collimator in front of it. The CAT was operated with deuterium gas at 0.4 atm and a stack of three THGEMs. The signals from the CAT were digitized using the V1740 modules (CAEN) and digitized samples were transfered through optical links to two computers. The physics trigger for the data acquisition was made using the trigger out from V1740 and HIMP, which is the readout system used for the silicon detectors. The ESPRI system was placed at F12[5)] to measure the deuteron elastic scattering off ^{132}Sn for large scattering angles to determine the optical potential parameters.

The excitation-energy resolution for the ground state, determined from the analysis of recoil particles stopped in TPC, is 1 MeV in one standard deviation. The energy of ISGMR will be deduced from the multipole-decomposition analysis of double-differential cross sections. The analysis is in progress.

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