Measurements of ISGMR in Sn, Cd, and Pb isotopes and the asymmetry of nuclear matter incompressibility

M. Fujiwara[1], T. Li[2], D. Patel[2], U. Garg[2], G.P.A. Berg[2], Y. Liu[2], R. Marks[2], J. Matta[2], B.K. Nayak[2], P.V. Madhusudhana-Rao[2], A. Long[2], K. Sault[2], R. Talwar[2], H. Hashimoto[1], K. Nakanishi[1], S. Okumura[1], M. Yosoi[1], M. Ichikawa[3], M. Itoh[3], R. Matsuo[3], T. Terazono[3], M. Uchida[4], Y. Iwao[5], T. Kawabata[5], T. Murakami[5], H. Sakaguchi[5], S. Terashima[5], Y. Yasuda[5], J. Zenihiro[5], H. Akimune[6], C. Iwamoto[6], A. Okamoto[6], K. Kawase[7], T. Adachi[8], and M.N. Harakeh[8,9]

[1]Research Center for Nuclear Physics, Osaka University, Osaka 567-0047, Japan
[2]JINA and Physics Department, University of Notre Dame, Notre Dame, Indiana 46556, USA
[3]Cyclotron and Radioisotope Center, Tohoku University, Sendai 980-8578, Japan
[4]Tokyo Institute of Technology, 2-12-1 O-Okayama, Tokyo 152-8550, Japan
[5]Department of Physics, Kyoto University, Kyoto 606-8502, Japan
[6]Department of Physics, Konan University, Hyogo 658-8501, Japan
[7]Advanced Photon Research Center, Japan Atomic Energy Agency, Kyoto 619-0215, Japan
[8]KVI, University of Groningen, NL-9747 AA Groningen, The Netherlands,
[9]GSI Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany

The compression-mode isoscalar giant monopole resonance (ISGMR) has been studied in the Sn, Cd and Pb isotopes using inelastic scattering of 400 MeV α-particles at extreme forward angles, including 0°.We have obtained completely ``background-free" inelastic-scattering spectra for the Sn, Cd, and Pb isotopes for a wide angular and excitation-energy range. The various giant resonances excited with different transferred angular momenta were extracted by a multipole-decomposition analysis (MDA). It was found that the centroid energies of the ISGMR in Sn isotopes are significantly lower than the theoretical predictions. The K_τ in the empirical expression for the nuclear incompressibility has been determined to be $K_\tau = -550 \pm 100$ MeV from the moment ratios [1]. The extracted value for the Cd isotopes is $K_\tau = -500 \pm 50$ MeV. These numbers are consistent with values of $K_\tau = -370 \pm 120$ MeV obtained from an analysis of the isotopic transport ratios in medium-energy heavy-ion reactions [2], $K_\tau = -500^{+120}_{-100}$ MeV obtained from constraints placed by neutron-skin data from anti-protonic atoms across the mass table [3], and $K_\tau = -500 \pm 50$ MeV obtained from theoretical calculations using different Skyrme interactions and relativistic mean field (RMF) Lagrangians [4].

Stringent constraints on interactions employed in nuclear structure calculations are obtained on the basis of the experimentally determined values for K_∞ and K_τ. These parameters constrain as well the equation of state (EOS) of nuclear matter. However, a significant discrepancy still remains. The ISGMR positions in Sn and Cd isotopes are systematically lower than the predictions obtained on basis of K_∞ determined from the ISGMR in ^{208}Pb. This raises the question "why are Sn and Cd nuclei so soft?", an important problem that has to be solved [5]. For a clue to solve the problem, the exact positions of the ISGMR in $^{204, 206, 208}$Pb have to be measured [6].

In this talk, we will review the current status of the experimental studies on the compression-mode giant resonances, and the possible implications for astrophysics and physics with exotic nuclei.

[1] T. Li *et al.*, Phys. Rev. Lett. 99, 162503 (2007), and Phys. Rev. C 81, 034309 (2010).
[2] Lie-Wen Chen *et al.*, Phys. Rev. C 80, 014322 (2009).
[3] M. Centelles *et al.,* Phys. Rev. Lett. 102, 122502 (2009).
[4] H. Sagawa *et al.*, Phys. Rev. C 76, 034327 (2007).
[5] J. Piekarewicz, J. Phys. G: Nucl. Part. Phys. 37, 064038 (2010).
[6] E. Khan, Phys. Rev. C 80, 011307 (2009).