ELECTRIC DIPOLE RESPONSE STUDIED BY PROTON INELASTIC SCATTERING: SYMMETRY ENERGY AND NEUTRON SKIN THICKNESS

Atsushi Tamii, Research Center for Nuclear Physics, Osaka University, Ibaraki, Japan

The responses of nuclei against external electromagnetic fields are of fundamental importance for the study of the nuclear equation of state (EOS). Among various external fields the electric dipole (E1) field produces displacement between the neutron and proton density distributions due to the different of their electric charges. The restoring force to the displacement is originated from the symmetry energy term of the nuclear EOS. Thus the electric dipole response of nuclei is naturally relevant to the symmetry energy and its density dependence.

The determination of the symmetry energy parameters is one of recent hot topics in nuclear physics and nuclear astrophysics. The radius-mass relation of neutron stars, their internal structure, their cooling process, X-ray burst, core-collapse supernova, neutron star merger and nucleosynthesis are all relevant to the symmetry energy. Also the density dependence of the symmetry energy has a strong correlation with the neutron skin thicknesses of heavy neutron-rich nuclei.

The E1 response of nuclei has been widely studied by gamma-ray induced reactions. However the full E1 response had not been fully obtained especially at around the neutron separation energy. Recent finding of the low-energy dipole strength, or pygmy dipole resonance, arose in the situation.

We have developed a method that is suitable for extracting the full E1 response from low to high excitation energies, above the giant resonance region across the neutron separation energy, by employing proton inelastic scattering at very forward angles as an electromagnetic probe [2]. The Missing mass spectroscopy method enabled us to probe the total strength independently on the various decaying channels. The multi-pole decomposition and spin-transfer analyses allowed the extraction of the full strength distribution including contributions from unresolved small strengths. The full E1 strength is connected to the static E1 response of nuclei, i.e. the electric dipole polarizability, through the inversely energy weighted sum-rule.

The method has been applied to ^{208}Pb [2], ^{120}Sn [3], and other representative stable nuclei. The full E1 strength distribution has been extracted for the excitation energies from 5 to ~20 MeV. The electric dipole polarizability has been precisely determined as 20.1(6) and 8.9(4) fm3 for ^{208}Pb and ^{120}Sn, respectively, by combining data at higher energies, and as 19.6(6) and 8.6(4) fm3 after subtraction of the quasi-deuteron excitation contribution. Constraints on the symmetry energy parameters have been extracted [4] with a help of mean field model calculations of the nuclear energy density functional approach [5]. The results are consistent among the two nuclei and the recently measured ^{68}Ni at GSI [6].

I will report on the recent results on the electric dipole response of nuclei from the proton inelastic scattering and on the projects planned in near future.

REFERENCES

[1] J.M. Lattimer and M. Prakash, Phys. Rep. 442, 109 (2007).
[2] A. Tamii et al., Phys. Rev. Lett. 107, 062502 (2011).
[3] T. Hashimoto et al., Phys. Rev. C 031305(R) (2015).
[4] A. Tamii et al., Euro. Phys. J. A 50, 28 (2014).
[5] X. Roca-Maza et al., Phys. Rev. C 92, 064304 (2015).
[6] D.M. Rossi et al., Phys. Rev. Lett. 111, 242503 (2013).