Progress report of Gamow–Teller giant resonance studies at RIBF

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Among the collective modes$^{1)}$, the Gamow–Teller (GT) giant resonance is an interesting excitation mode. It is a $0\hbar\omega$ excitation characterized by the quantum-number changes in orbital angular momentum ($\Delta L = 0$), spin ($\Delta S = 1$), and isospin ($\Delta T = 1$), and it is induced by the transition operator $\sigma\tau$. In the stable nuclei in medium or heavier mass regions ($A > 50$), the collectivity in this mode exhibits the GT giant resonance (GTGR), which provides information that is critically important for understanding the isovector part of the effective nucleon-nucleon interaction$^{2)}$ and the symmetry potential of the equation of the state$^{3)}$.

We have been rapidly expanding the nuclear chart of GTGR studies at RIBF, since the development of a new method to study GT transitions on unstable nuclei via the charge-exchange (CE) (p, n) reaction with RI beams$^{4,5)}$. An experiment at RIBF was performed in Spring 2014 to extract the GT and spin-dipole (SD) transition strengths over a wide excitation energy range covering their giant resonances on the key doubly magic nucleus ^{132}Sn$^{6)}$. This is an essential step toward establishing comprehensive theoretical models for nuclei situated between ^{78}Ni and ^{208}Pb. The neutron-drip line in the light mass region is another topic in the GTGR study, for which the first experiment was performed on ^{12}Be by using the SHARAQ spectrometer$^{7)}$. In 2015, another experimental program including an exotic nucleus ^{11}Li (spokesperson: L. Stuhl) was newly approved in the NP-PAC meeting.

From an experimental point of view, we employ a low-energy neutron detection system, WINDS, to detect recoil neutrons produced via the (p, n) reaction in inverse kinematics, in combination with a magnetic spectrometer such as SAMURAI$^{8)}$. In the progress report last year, we, through a data analysis of the ^{132}Sn(p, n) experiment, showed that the SAMURAI spectrometer provided sufficient particle identification capability and enabled us to separate CE reaction channels from other background reactions. Further background reduction is possible through the upgrade of WINDS. The primary goal of the upgrade plan is to eliminate background due to gamma rays arising from the enviroment through the so-called neutron-gamma discrimination method. Such gamma rays are considered to not be synchronized with the reaction timing, therefore having a flat distribution in time. The contribution of such gamma rays is enhanced in a region of foward scattering angles in the center-of-mass system, because a wide TOF range having background events uniformly distributed in time is compressed to a narrow phase space in that region. The method is being tested using a prototype low-energy neutron detector made from novel plastic scintillator material for the application of the neutron-gamma method. Details of the test are given also in Ref.$^{9)}$.

References

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