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 state[3)].

We have been rapidly expanding the domain of GTGR studies at RIBF in the nuclear chart, since our 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 March 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 located between ^{78}Ni and ^{208}Pb. The data analysis of this experiment has been finalized and we are preparing a draft for publication. In 2016, the experimental program for ^{48}Cr and ^{64}Ge was reevaluated and approved by the NP-PAC meeting. A study on these nuclei will provide a unique opportunity to elucidate the role of isoscalar pairing in nuclei along the N=Z line.

From an experimental point of view, we employ a low-energy neutron detection system, WINDS[7)], to detect recoil neutrons produced via the (p, n) reaction in inverse kinematics, in combination with a magnetic spectrometer such as SAMURAI[8)]. Since last year, we have been working on the upgrade of WINDS to reduce background events in the detectors. The primary goal of the upgrade plan is to eliminate background events due to gamma rays arising from the environment by the so-called neutron-gamma discrimination method. Such gamma rays are considered not to be synchronized with the reaction timing, and therefore they have a flat distribution in time. The contribution of such gamma rays is enhanced in the region of forward 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 a novel plastic scintillator material for application of the neutron-gamma method. Details of the test are also given in Ref.[9)].

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References
1) M. N. Harakeh and A. M. van der Woude: Giant Resonances (Oxford University Press, Oxford, 2001).
2) S. Fracasso and G. Colo, Phys. Rev. C**72**, 064310 (2005).
3) P. Danielewicz, Nucl. Phys. A **727**, 233 (2003).
4) M. Sasano et al., Phys. Rev. Lett. **107**, 202501 (2011).
5) M. Sasano et al., Phys. Rev. C **86**, 034324 (2012).
6) J. Yasuda et al., in this report.
7) K. Yako et al., RIKEN Accel. Prog. Rep. **45** (2012).
8) T. Kobayashi et al., Nucl. Inst. Meth. B **317**, 294-304 (2013).
9) L. Stuhl et al., in this report.