Activity of the Experimental Group at the RCNP Cyclotron Facility 2013

At the RCNP Cyclotron Facility as a national Joint Usage/Research Center, various research subjects in the fields of nuclear physics, fundamental physics, engineering, nuclear chemistry, and nuclear medicine are conducted in collaboration with various groups from universities and institutes in Japan and overseas. Student experiments for Osaka University and other universities are also performed. Selected topics from our activities in 2014 are briefly introduced below.

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Low-Energy Super Gamow-Teller States

We have been studying Gamow-Teller (GT) transitions systematically. The most famous GT excitation commonly observed is the GT resonance (GTR) situated in the high excitation energy region of 8–15 MeV. The GTRs were observed already in 1980s by pioneering work using (*p*, *n*) reactions and were found to consume 50–60% of the Ikeda sum-rule values of available GT transition strengths.

In our recent study of high-resolution (^{3}He, *t*) reactions using the Grand Raiden spectrometer, we have observed systematically the concentration of GT strengths in the lowest GT states below 1 MeV in nuclei consisting of two valence neutrons around *LS*-closed core-nuclei. The so-called "Low-Energy Super GT state (LESGT state)" is found to consume more than half of the Ikeda sum rule values.

The drastic change in the location of the GT strength can be understood in relation to the repulsive and attractive nature of isovector (IV) and isoscaler (IS) effective nuclear interactions (ENIs). In the case of GT transitions in N >> Z nuclei, final states are normally of proton-particle and neutron-hole πp-νh configurations, in which the repulsive IV-type ENIs are active. The repulsive effective interaction pushes up the GT strengths.

In the case of nuclei consisting of two neutrons and *LS*-closed core nuclei, such as ^{18}O and ^{42}Ca, the GT transitions lead to the configurations of the *LS*-closed-core plus a pair of proton and neutron (i.e., ^{18}F or ^{42}Sc) as illustrated in the figure. In this proton-particle

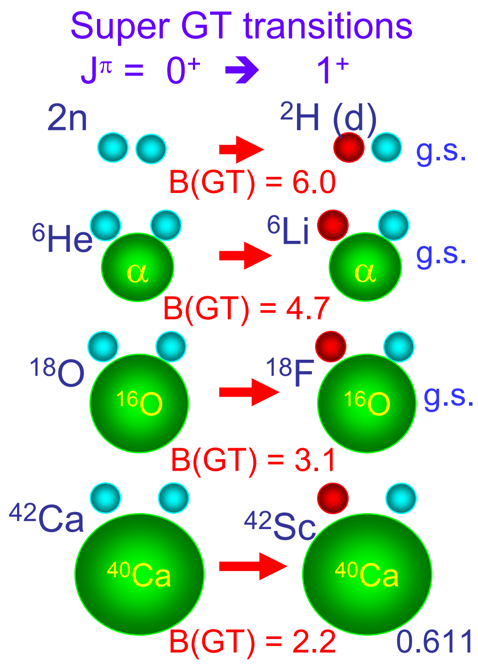

Figure: The structure of LESGT states (right hand side) having the structure of LS-closed-core nucleus plus a proton and neutron pair. They are induced by "super-allowed GT transitions" from nuclei having the structure of LS-closed-core nucleus plus two neutrons. The sum-rule GT strength B(GT) is 6 in these transitions.

and neutron-particle (πp-νp) configuration, the IS-type ENIs are active [3]. Since they are attractive, the GT transition strengths are pulled down to the low-energy region and are concentrated in the lowest GT state, i.e., the LESGT state. We also see that the GT strength in the ^{6}He→^{6}Li decay is much concentrated in the ground state (g.s.) of ^{6}Li, which can be regarded as the π p-ν p configuration on top of the ^{4}He *LS*-closed core.

In conclusion, we found that LESGT states are formed by the attractive IS ENIs, while GTRs are formed by the repulsive IV ENIs. Note that the existence of IS and IV ENIs, and thus, low- and high- energy GT phonon excitations, are attributed to the two-fermionic degrees of freedom, which is a unique feature in atomic nuclei.

EN course

Two experiments were successfully performed at the newly constructed third focal plane (F3) of the EN beam line. The first experiment aimed to study the intruder states in ^{12}Be, using the one-neutron transfer reaction of a radio-isotope ^{11}Be beam on a CD_2 target. The second experiment was the charge-changing cross section measurements of $^{10\text{-}15}$B and $^{12\text{-}18}$C using secondary beams at 50 MeV/nucleon to determine the proton-distribution radii. Marked improvements in the RI beam purities were achieved in both experiments; the ^{11}Be beam purity was almost 90% in the first experiment, while in the second experiment, up to six times better purity was achieved for some RI beams. The charge-changing cross sections for $^{12\text{-}18}$C have been determined and successfully reproduced using the extended Glauber model within the finite-range optical limit approximation, taking into account energy dependence of the range parameter. The proton-distribution radii for $^{12\text{-}16}$C thus extracted are consistent with the literature. Besides reporting two new experiment data on ^{17}C and ^{18}C, the present work provides important benchmark for the application of the Glauber model to the reaction and charge-changing cross section measurements at energy below 100 MeV/nucleon.

References

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