Future plan to study light nuclei near the neutron drip line via charge-exchange (p,n) reactions in inverse kinematics

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We plan to investigate the isovector response of ^{11}Li and ^{14}Be nuclei near the neutron drip line. The variation of spin-isospin residual interaction and the effect of spatial distribution of neutron skin or halo on spin-isospin responses will be studied using charge-exchange (p,n) reactions, at intermediate energies (260-280 MeV/nucleon) in inverse kinematics. The Gamow-Teller (GT) and spin-dipole (SD) transitions including their giant resonances will be measured. Experimentally, the (p,n) reactions at intermediate beam energies can selectively excite GT states up to high excitation energies in the final nucleus. There is a close proportionality between the cross-sections at 0° and the transition strengths B(GT) in these reactions[1]. Therefore, the (p,n) reactions provide a powerful method to study the B(GT) distributions.

An experimental approach to study the variation of the spin-isospin collectivity is the energy difference between the GT giant resonance (GTGR) and isobaric analog state (IAS) over a wide range of (N-Z)/A. Measurements on stable nuclei show that the GTGR is a few MeV higher than the IAS. This difference gives access to spin-isospin residual interaction strength. However, it is expected to differ at high (N-Z)/A[2,3]. According to predictions for (N-Z)/A values greater than 0.3, the GTGR energy decreases below the IAS energy. It is a compelling interest to obtain new experimental data on nuclei with high (N-Z)/A along the neutron drip line to clarify how the spin-isospin residual interaction strength changes and whether it is related also to the skin or halo structures. With only two pioneer experiments[4,5] this effect is not well studied and further experimental data are needed.

A new experimental technique developed at NSCL, MSU[6,7] will be applied to measure the (p,n) reaction in inverse kinematics which enables us to achieve a high luminosity using a thick target without losing the information on the recoil neutron momentum necessary for the missing mass reconstruction. The setup using BigRIPS, WINDS (Wide-angle Inverse-kinematics Neutron Detectors for SHARAQ) and the SAMURAI spectrometer together with a 10-mm thick liquid hydrogen target will allow us to extract the GT and SD transition strengths from the low-lying region up to 40 MeV excitation energies. The use of the SAMURAI is crucial for covering all decay channels simultaneously and for obtaining conclusive data on the GT strengths of the nuclei of interest.

By using WINDS placed at a distance of 1 m (1.25 m) from the target position both on left and right (top and bottom) sides with respect to the beam line, we detect recoil neutrons from the (p,n) reaction. From the measured neutron TOF and recoil angle, the excitation energy and center-of-mass scattering angle can be deduced. The reaction products will be momentum-analyzed by the SAMURAI spectrometer. The particle identification for the reaction residues will be made using the TOF and energy loss information measured by hodoscopes (HODF, HODP). The energy loss information will be complementary used. The NEBULA detector will be used for tagging the neutron decay of the reaction products.

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