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 2013 are briefly introduced below.

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Evidence of Tensor Interactions in ^{16}O

The tensor interactions are some of the most important nuclear interactions acting between a neutron and a proton in an atomic nucleus. Despite the importance, experiment evidences are scarce and limited to nuclei with masses equal to or lighter than the alpha particle. In a recent experiment measuring the one-neutron transfer (p,d) reaction at large momentum transfer on an ^{16}O target using the RCNP Grand Raiden spectrometer, we observed a possible evidence on the effect of the tensor interactions in the ^{16}O nucleus [1]. The (p,d) cross sections populating the $5/2^+$ and/or $1/2^+$ excited state in ^{15}O were found to be increased compared to the cross sections populating the ground $1/2^-$ state with increased momentum transfer. Because (i) the tensor interactions can generate proton-neutron pairs with large relative momentum, and (ii) the population of the $5/2^+$ and/or $1/2^+$ excited state via the direct (p,d) reaction is only possible if the ground-state of ^{16}O has mixed configurations which may be attributed to the tensor interactions (see Fig. 1), the observation of large components of high-momentum neutrons in the ground-state of ^{16}O indicates possible evidence on the tensor interactions.

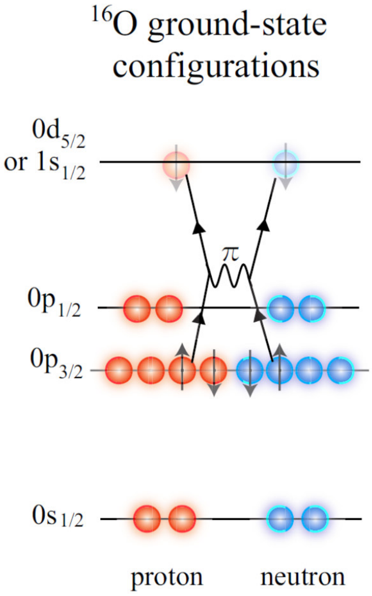

Figure 1: Possible two-particle two-hole configuration in the ground state of ^{16}O due to the tensor interactions.

EN course

The newly constructed third focal plane (F3) of the EN course was successfully commissioned using secondary beams produced via projectile fragmentation reactions of a 53A MeV ^{36}Ar beam on a ^{9}Be target. Equipped with two Parallel-Plate Avalanche Counters (PPACs) as the position sensitive detectors, and a silicon detector as the ΔE detector, the extended beam line will be used for experiments with radio-isotope beams from the 2014 fiscal year.

An experiment using the ^{12}C-induced one-neutron knockout reaction from ^{14}O to study the nucleon knockout reaction mechanisms from exotic nuclei was performed at the EN course [2]. In this experiment, a radio-isotope ^{14}O beam was produced and separated by the EN course fragment separator before being directed onto a graphite target. The heavy residues and decaying light particles were detected using a hodoscope, which consists of thin (ΔE) and thick (E) plastic scintillators, as well as six silicon telescopes placed 3.8 m and 24.6 cm downstream of the target respectively. The successful determination of the knockout cross sections populating both bound and unbound states of ^{13}O will help shed light on the reaction mechanisms.

Ultracold Neutron

The energies of ultracold neutrons (UCN) are lower than the nuclear potential of material, which is referred to as Fermi potential, therefore, UCN can be confined in a material bottle. This property is useful for fundamental physics experiments like a precise measurement of neutron electric dipole moment (EDM).

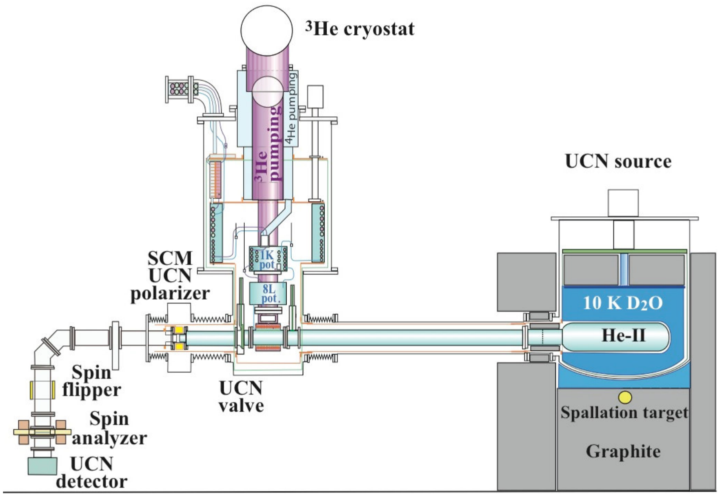

Figure 2: New He-II UCN source.

UCN density in the bottle is crucial for the experiment. KEK-RCNP-Osaka group has constructed the second generation UCN source shown in Fig. 2 based on the first generation UCN source [3], which realized a world competitive UCN density. A superfluid helium (He-II) bottle is placed in the horizontal direction. UCN are extracted through an aluminum window, which is placed in a superconducting magnet (SCM). The magnetic potential for the neutron is much higher than the Fermi potential of aluminum so that UCN transmission through the window is enhanced. UCN are polarized upon the transmission.

The group has produced fast neutrons by spallation reactions induced by 400 MeV protons on a tungsten target, moderated these neutrons to cold neutrons in the 300K and 10K heavy water (D_2O), and converted to UCN in He-II. The UCN valve was opened after UCN production. UCN were guided to the UCN detector through the spin flipper and analyzer. A significant number of UCN was observed. UCN polarization was higher than 70%. The UCN density is proportional to the proton beam power. We have carried out a cooling test for the cryostat, and confirmed the cryostat can remove γ heating at higher proton beam powers. The present cryostat will produce 10 times higher UCN density than the first generation UCN source.

References

[1] H. J. Ong, I. Tanihata, A. Tamii et al., Phys. Lett. B**725**, 277 (2013).

[2] Y. L. Sun, J. Lee, A. Obertelli et al., RCNP Ann. Rep. 2013

[3] Y. Masuda, K Hatanaka, S.C. Jeong, S. Kawasaki, R. Matsumiya, K. Matsuta, M. Mihara, and Y. Watanabe: Phys. Rev. Lett. **108**, 134801 (2012).