Invariant mass spectroscopy of ^{17}C at SAMURAI

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Many properties of nuclei away from the β-stability line are important to better understand nuclear processes that control stellar nucleosynthesis and energy balance. These nuclei often exhibit exotic structures. For example, the appearance of anomalous parity intruder states at a low excitation energy region provides evidence for the shell-gap quenching and/or large nuclear deformation.

The present study focuses on low-lying negative parity states in ^{17}C above the neutron decay threshold. Two β-delayed neutron emission measurements of ^{17}B have reported such states: Raimann et al.[1] indicated states at 2.25(2), 2.64(2), 3.82(5), and 1.18(1) MeV with no definite spin-parity (J^{π}) assignment. Achieving higher sensitivity for the β-n-γ coincidence yield, Ueno et al.[2] was successful to locate states at 2.71(2), 3.93(2), and 4.05(2) MeV with the suggested J^{π} values of $1/2^-$, $3/2^-$, and $(5/2^-)$, respectively. This study aimed to populate these states and to examine their properties by the one-neutron knockout reaction of an energetic beam.

The measurement was performed using the SAMURAI spectrometer[3] during the first physics run of the apparatus. A beam of ^{18}C at approximately 250 MeV/nucleon provided by BigRIPS at RIBF impinged on a carbon target with a thickness of 1.8 g/cm^2. The unbound states in ^{17}C produced by the one-neutron removal processes subsequently decayed into a ^{16}C fragment and a neutron. These decay products were detected in coincidence. There should be some background events by the neutrons arising from the one-neutron removal processes; however, such background is expected to be relatively featureless and would not affect the resonance. The momentum vector of the ^{16}C fragment was determined by (1) position information in the two drift chambers (FDCs) placed at the entrance and exit of the SAMURAI dipole magnet and (2) energy loss and timing information in the plastic scintillator hodoscope (HODF). The momentum vector of the neutron was determined using the position and timing information in the plastic scintillator neutron hodoscope (NEBULA). The energy spectrum of ^{17}C was reconstructed using the invariant mass method involving the momentum vectors of the fragment and neutron.

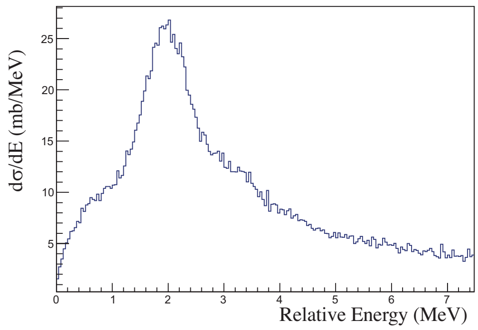

Fig. 1. Preliminary relative energy spectrum of the $^{16}C+n$ unbound system.

A preliminary relative energy spectrum for the ^{16}C + n system is shown in Fig.1. A clear peak structure was observed at 2 MeV in relative energy, which corresponds to the excitation energy of $E_x = 2.7$ MeV. This energy is close to the energy of the first $1/2^-$ state at $E_x = 2.71(2)$ MeV reported in Ueno et al.[2]. To examine the identity of these two states, an analysis is being carried out (1) to compare the populating cross section with the theoretical value based on the corresponding shell-model spectroscopic factor together with the Glauber model and (2) to extract the orbital angular momentum of the knocked-out neutron from the parallel momentum distribution. A search for the other reported states will also be performed.

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References

1) G. Raimann et al.: Phys. Rev. C **53**, 453 (1996).
2) H. Ueno et al.: Phys. Rev. C **87**, 034316 (2013).
3) K. Yoneda et al.: RIKEN Accel. Prog. Rep. **45**, i (2012).