Observation of resonances in ^{14}C with ^{10}Be+α resonant elastic scattering at CRIB

H. Yamaguchi,[*1] D. Kahl,[*1] S. Hayakawa,[*1] Y. Sakaguchi,[*1] and K. Abe,[*1] for CRIB collaboration

A measurement of ^{10}Be+α resonant elastic scattering was conducted at CRIB on the interests of cluster structure in the ^{14}C nucleus[1–3]. In 2015, the main measurement was performed using the thick-target method in inverse kinematics. The ^{10}Be radioactive isotope (RI) beam was produced via the ^{11}B(d, ^{3}He)^{10}Be reaction in inverse kinematics using a 1.2-mg/cm^2-thick deuterium gas target and a ^{11}B beam at 5.0 MeV/u and 700 pnA accelerated with an AVF cyclotron. The ^{10}Be beam was separated and purified by magnetic analysis and velocity selection with a Wien filter. The experimental setup at the final focal plane was similar to the previous one in the ^{7}Be+α experiment[4], but we placed an extra silicon detector telescope instead of the NaI detectors, and we used two parallel-plate avalanche counters (PPACs) as the beam counter. The new setup enabled us to perform a reliable analysis on the angular distribution with a better position sensing of the beam and recoiled particles. The parallel-plate avalanche counters (PPACs) measured timing and position of the incoming ^{10}Be beam with a position resolution of 1 mm or better. The beam finally traveled into the gas target, a chamber filled with helium gas at 700 Torr and covered with a 20-μm-thick Mylar film as the beam entrance window. The ^{10}Be beam energy at the entrance of the helium gas target was 25 MeV, and the purity was better than 95%, with a typical intensity of 10^4 pps. α particles recoiling to the forward angles were detected by the ΔE-E detector telescopes. We used two sets of detector telescopes in the gas-filled chamber, where each telescope consisted of two layers of silicon detectors, which had thicknesses of 20 μm and 480 μm. The central telescope was located at 555 mm from the beam entrance window, and the other telescope was at an angle of 9°, looking from the entrance window position. Each detector in the telescope had an active area of 50 × 50 mm, and 16 strips for one side, making pixels of 3 × 3 mm^2.

The dominant particle measured at the telescopes was α particle, which was distinguished from other particles with the ΔE-E information. We selected events in which the beam particle was entering into the target and an α particle was detected at the telescope in coincidence with the ^{10}Be beam particle at the PPAC. A precise energy loss function of the ^{10}Be beam in the helium gas target was obtained by a direct energy measurement at seven different target pressures interpolated with a calculation using the SRIM code. The scattering position, or equivalently the center-of-mass energy $E_{\rm cm}$, was determined by a kinematic reconstruction on event-by-event basis, which uses the energy loss function, the beam trajectory measured with the PPACs, and the energy and position of the recoiled α particle at the telescope. The number of events for each small energy division was converted to the differential cross section $d\sigma/d\Omega$, using the solid angle of the detector, the number of beam particles, and the effective target thickness. The number of beam particles was precisely known by the single counting of the beam particle with the PPAC, simultaneously recorded in the measurement. The background contribution evaluated by the argon-target run data was subtracted from the helium-target spectrum. Finally we obtained the excitation function of the ^{10}Be+α resonant scattering for 14–19 MeV as shown in Fig. 1a, where events with the laboratory angle of the recoiled α particle $\theta_{\rm lab}$=0–8° (corresponding to the center-of-mass angle $\theta_{\rm cm}$=164–180°) were selected. The excitation function obtained here has a similar peak structure with a previous measurement[5]. The resonant information including J^π will be obtained with an analysis with R-matrix calculation.

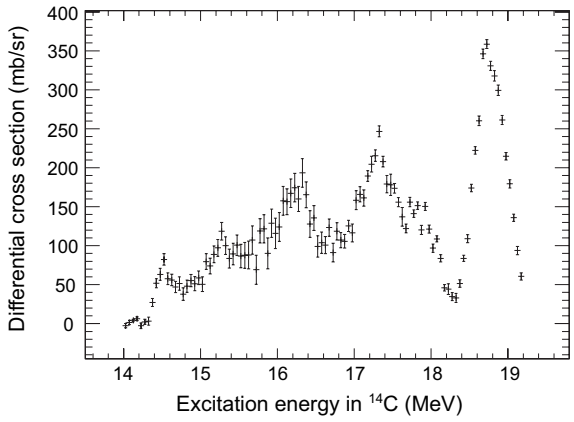

Fig. 1. Excitation function of the ^{10}Be+α resonant scattering for $\theta_{\rm lab}$=0–8°.

[*1] Center for Nuclear Study, University of Tokyo

References

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