Search for low-lying resonances in ^{10}N structure with proton resonant scattering

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Theoretically, four low-lying ^{10}N levels are expected as broad and overlapping resonances[1,2]. The level structure of ^{10}N is very important to understand the structure of its mirror nuclei,^{10}Li. The information of ^{10}Li levels can be used to constrain the ^{9}Li+n potential, which is required for constructing the three-body model of the borromean nucleus ^{11}Li.

We proposed the measurement of the excitation function of the (differential) cross section and vector analyzing power (A_y) for the ^{9}C+p resonant scattering reaction to determine these broad resonances[3].

In September 2015, a test ^{9}C+p resonant scattering experiment was conducted at RIPS[4], where the production of a low-energy ^{9}C beam was tested and the excitation function was measured. The production of the 4.17 MeV/nucleon ^{9}C beam is described in Ref.[5].

The thick-target method in inverse kinematics[6] was used for the measurement, where the excitation function of the cross section is scanned with a single beam energy utilizing the energy loss of the beam particle in the target. The range of center-of-mass energy is set to $1-5$ MeV to cover the theoretically expected ground state of ^{10}N and several excited states.

A 14.85 mg/cm^2 polyethylene film with a size of 50×50 mm^2 was used as the secondary target. An 18.78 mg/cm^2 thick carbon film was used as well to evaluate the number of background events produced in the interaction of ^{9}C with carbon in the polyethylene target. The outgoing particles were detected by two telescopes placed at 22.5° and −16°. The distances between the target and telescopes were 18 cm and 24 cm for the 22.5° telescope (Tel.1) and −16° telescope (Tel.2) respectively. Each telescope consisted of three layers of silicon semiconductor detectors (SSDs). The respective thicknesses of SSDs were 46 μm, 1.5 mm, and 1.5 mm for Tel.1 and 57 μm, 1.5 mm, and 1.5 mm for Tel.2. The sensitive area of each SSD was 48×48 mm^2 which covered ±6.2° and ±4.8° in the laboratory frame for Tel.1 and Tel.2, respectively. Double-sided strip silicon detectors were used as the first layer of the SSDs in the telescopes to determine the scattering angle of the particles. The particles were identified by the $\Delta E-E$ method. The protons with energy below 2.2 MeV were identified by the TOF $-\ E$ method using the timing information of the event.

Center-of-mass energy spectra were deduced from the measured proton energy and the scattering angle on an event-by-event basis by assuming the kinematics of elastic scattering and by considering the energy losses of both the incident heavy ion and the outgoing proton in the target. The energy resolution in the center-of-mass frame was estimated to be 150 keV in sigma.

The main background sources in the experiment were reactions of beam particles with carbon in the target and beta-delayed protons from the decay of ^{9}C ions stopped in the target. The latter contribution was evaluated by selecting events with a shifted timing, since the coincidence rate for a beam particle and a beta-delayed proton has an accidental character. The excitation spectrum (Fig. 1) of the ^{9}C+p resonant scattering was obtained by subtracting the carbon contribution and the "beta-delayed" background from the spectrum measured on the polyethylene target.

Resonance parameters will be extracted by an R-matrix analysis of the spectra.

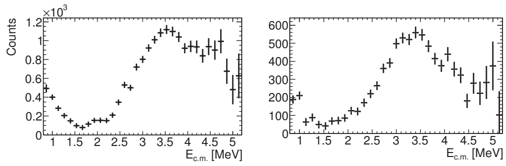

Fig. 1. Preliminary excitation spectra of the ^{9}C+p resonant scattering measured by Tel.1 (left) and Tel.2 (right).

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