New measurement of the ^{34}Si(p, p) reaction

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The evolution of shell structure as a function of the proton and neutron number has been observed throughout the nuclear chart. Although this evolution is visualized as shifts in the single-particle energies, the mechanism that changes the single-particle structures in the vicinity of the so-called island of inversion has not yet been fully revealed.

The most straightforward way to explore the single-particle structure is (d, p) one-neutron transfer reactions. In inverse kinematics, (d, p) experiments suffer from low statistics and/or poor resolution because there are two conflicting requirements; on the one hand, the thickness of the target needs to be limited to minimize the energy straggling, and on the other hand, thick targets increase the luminosity. The equivalent spectroscopic information is obtained by means of isobaric analog resonances (IARs) through proton resonant elastic scattering because IARs have the same configuration as the parent states except for the isospin part. This method is powerful, especially for investigations using RI beams in combination with the thick target inverse kinematics, and its effectiveness has been proven[1,2].

This method has already been applied to the ^{35}Si nucleus located just outside the island of inversion. Six IARs were observed by measuring the proton elastic scattering on ^{34}Si[3] and spectroscopic information was deduced for each resonance by R-matrix analysis[4]. More recently, a measurement of the ^{34}Si(d, p) reaction was reported by Burgunder et al.[5], and the resulting spectroscopic factors are in disagreement with the IAR results. This motivated us to perform a new measurement with a modified experimental setup.

The experiment was performed at the RIKEN Projectile fragment Separator (RIPS) facility. To gain more statistics than in the previous measurement, the primary beam species was changed from ^{40}Ar to ^{48}Ca. The primary beam at an energy of 63 MeV/nucleon impinged on a 1.25-mm beryllium production target. A secondary ^{34}Si beam was produced with a typical purity of 30 % and an intensity of 40 kpps. Note that the EPAX 2.15 parameterization[6] overpredicted the intensity by an order of magnitude. The beam particles were identified event-by-event by the TOF-ΔE method. The beam was slowed down to 6 MeV/nucleon using a carbon rotatable degrader and irradiated a proton target. The protons were detected downstream of the target in a stack of silicon detectors, 0.1, 1.0, 1.5, and 1.5 mm thick. In order to increase the excitation energy window, the configuration was optimized with respect to the original experiment.

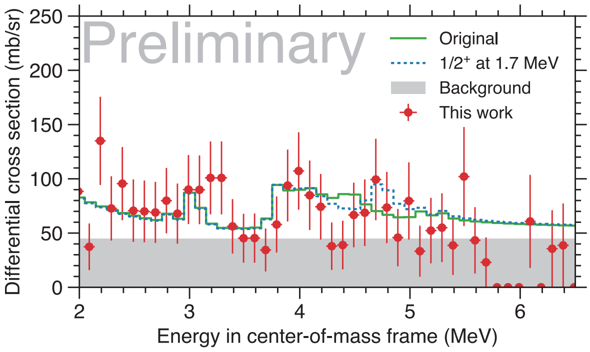

Fig. 1. Measured cross sections for ^{34}Si(p, p) (circles). The background contribution is assumed to be constant. The solid line is the R-matrix calculation from the original measurement[3]. A calculation assuming the $1/2^+$ state in ^{35}Si at 1.7 MeV is also shown (dotted).

The experimental excitation function is shown in Fig. 1, together with the R-matrix calculation. Although the statistics were very limited, the R-matrix curve reproduced our present result except for the strucuture around 4.5 MeV. In our previous measurement, a detector dead-layer could be present around this region, which potentially caused the distortion of the resonances. A peak at 4.7 MeV has been observed for the first time in this experiment, and this could correspond to the IAR of a $1/2^+$ state in ^{35}Si at 1.7 MeV, considering its shape. The energy is in good agreement with the 1688-keV $1/2^+$ state that was recently observed by an experiment of the one-neutron knockout from ^{36}Si[7].

References

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