Journal of Physics: Conference Series

OPEN ACCESS

Proton inelastic scattering on 32Mg

To cite this article: S Takeuchi *et al* 2006 *J. Phys.: Conf. Ser.* **49** 153

Institute of Physics Publishing Journal of Physics: Conference Series **49** (2006) 153–154
doi:10.1088/1742-6596/49/1/033 Structure of Exotic Nuclei and Nuclear Forces

Proton inelastic scattering on ^{32}Mg

S. Takeuchi[1], N. Aoi[1], H. Baba[2], T. Fukui[3], Y. Hashimoto[4], K. Ieki[5], N. Imai[6], H. Iwasaki[7], S. Kanno[5], Y. Kondo[4], T. Kubo[1], K. Kurita[5], T. Minemura[6], T. Motobayashi[1], T. Nakabayashi[4], T. Nakamura[4], T. Okumura[4], T. K. Onishi[7], S. Ota[3], H. Sakurai[7], S. Shimoura[2], R. Sugou[5], D. Suzuki[7], H. Suzuki[7], M. K. Suzuki[7], E. Takeshita[5], M. Tamaki[2], K. Tanaka[1], Y. Togano[5], and K. Yamada[1]

[1] The Institute of Physical and Chemical Research (RIKEN)
[2] CNS, University of Tokyo
[3] Department of Physics, University of Kyoto
[4] Department of Physics, Tokyo Institute of Technology
[5] Department of Physics, Rikkyo University
[6] High Energy Accelerator Research Organization (KEK)
[7] Department of Physics, University of Tokyo

E-mail: `takesato@riken.jp`

Abstract. Proton inelastic scattering was applied to ^{32}Mg located at the island of inversion to study higher excited states. Angle-integrated and differential cross sections for $E_x = 885$ keV and 2321 keV states were obtained by measuring de-excitation γ rays and scattering angles of ^{32}Mg. From the present analysis, the transferred angular momentum from the ground state to 2321 keV state was close to $\Delta L = 4$ rather than $\Delta L = 3$.

Experimental studies on collective motions in ^{32}Mg using the Coulomb excitation have been focused on low-lying excited state [1]. In those experiments, large B(E2) value for the 2^+ state was reported, and the disappearance of the neutron magicity $N = 20$ and its deformed nature were discussed. Although excitation energies for higher excited states were obtained by β-γ spectroscopy [2], the spins and parities of the states other than the 2^+ state are still unknown. The spin and parity of 3^- or 4^+ have been suggested for the 2321-keV state, but no decisive evidence have been given. In order to study collective motions in ^{32}Mg, the excitation energy, spin and parity of each state are important observables. In the present experiment, proton inelastic scattering was applied to ^{32}Mg in inverse kinematics to obtain cross sections and information on the spin and parity of each state.

A ^{32}Mg beam was produced by projectile fragmentation reaction of a 94-MeV/nucleon ^{40}Ar primary beam with a 370-mg/cm^2 ^{9}Be production target. The ^{32}Mg beam was separated by using RIPS [3]. The particle identification was made event-by-event using the ΔE measured by a Si detector, and the time-of-flight (TOF) information between two foci (F2 and F3) obtained with two plastic scintillators. The energy and intensity were 56 MeV/nucleon and 700 cps, respectively. The ^{32}Mg beam bombarded the liquid hydrogen target [4] with a thickness of 160 mg/cm^2. Inelastically scattered particles were analyzed using the recently developed TOF spectrometer [5]. The obtained mass resolution for Mg isotopes was around 1.5% in FWHM. With this high mass resolution, contaminations in ^{32}Mg mass gate were reduced to as low as 1%. De-excitation γ rays were detected using DALI2 [6] which consists of 160 NaI(Tl) crystals

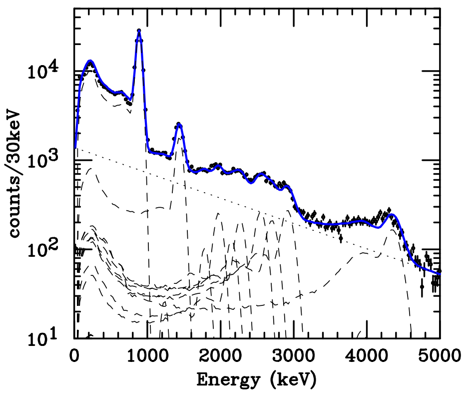

Figure 1. Doppler-corrected γ-ray spectrum.

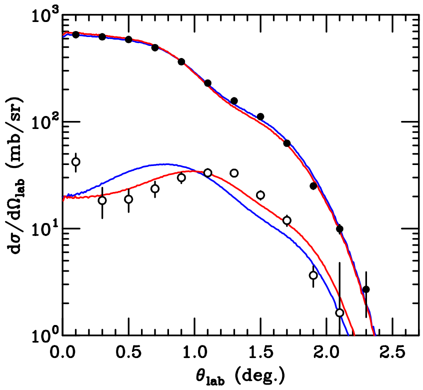

Figure 2. Angular distributions of scattered ^{32}Mg particle for the γ rays from 885 keV(●) and 2321 keV(○) states.

surrounding the secondary reaction target.

Figure 1 shows the Doppler-corrected γ-ray spectrum by ^{32}Mg(p,p') reaction in inverse kinematics. De-excitation γ rays with E_γ = 885 keV from known 885-keV (2^+) state to the ground state, and E_γ = 1436 keV from 2321-keV state to 885-keV state are clearly seen in the spectrum. The solid curve shows the result of a fit consisting of the response functions obtained by Monte-Carlo simulation shown by dashed curves and an exponential background shown by dotted curve. The γ-γ analysis was performed to confirm the level scheme and to estimate the feeding contributions. In the analysis it was found that the high-energy γ ray with $E_\gamma \simeq$ 4300 keV is coincident with the 885-keV γ ray. Combining above analysis, angle-integrated cross sections were obtained from the measured γ-ray yields after correcting for the detection efficiencies. The deduced angle-integrated cross sections were 45.5(55) mb and 4.2(6) mb for transitions from the ground state to the 885-keV state and to the 2321-keV state, respectively.

In order to obtain transferred angular momenta (ΔL) for these states, DWBA calculations were performed with CH89 optical parameters [7] by using a coupled channel calculation code ECIS97 [8]. Figure 2 shows the angular distributions of scattered ^{32}Mg particle for the γ rays from the 885-keV state to the ground state and from the 2321-keV state to the ground state. Possible spin and parity (J^π) of the 2321-keV state are 3^- or 4^+. For $J^\pi = 4^+$ case, the excitations to these states were calculated by using symmetric rotational model taking into account a two-step excitation, as shown by red curves. For $J^\pi = 3^-$ case, the excitations to the 885-keV and 2321-keV states were calculated by using symmetric rotational model and harmonic vibrational model, respectively, as shown by blue curves. The angular distribution for transition to the 2^+ state was well reproduced by DWBA calculation for both cases. Comparisons between the data and the calculated distributions for the 2321-keV state show that the $\Delta L = 4$ transition is favored over the $\Delta L = 3$ transition. Further detailed analysis is now in progress.

References

[1] Church J A *et al.* 2005 *Phys. Rev.* C **72** 054320 and references therein
[2] Klotz G *et al.* 1993 *Phys. Rev.* C **47** 2502 and references therein
[3] Kubo T *et al.* 1992 *Nucl. Instrum. Methods Phys. Res.* B **70** 309
[4] Ryuto H *et al.* 2005 *Nucl. Instrum. Methods Phys. Res.* A **555** 1
[5] Aoi N *et al.* 2005 *RIKEN Accel. Prog. Rep.* **38** 176
[6] Takeuchi S *et al.* 2003 *RIKEN Accel. Prog. Rep.* **36** 148
[7] Varner R L *et al.* 1991 *Phys. Rep.* **201** 57
[8] Raynal J unpublished *coupled-channel code ECIS97*