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Short note

Lifetime measurement of the first excited state of ^{64}Ga

M. Tanigaki[1,a], K. Sekiguchi[2], M. Fujita[1], T. Hoshino[2], T. Baba[2], N. Kawamura[3], T. Shinozuka[1], M. Fujioka[1]

[1] Cyclotron and Radioisotope Center, Tohoku University, Sendai, Miyagi, 980-8578 Japan
[2] Department of Physics, Faculty of Science, Tohoku University, Sendai, Miyagi, 980-8578 Japan
[3] Department of Electronics and Information Engineering, Faculty of Engineering, Aomori University, Aomori, Aomori, 030-0943 Japan

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Abstract. The half-life of the first excited state of ^{64}Ga has been measured with a pulsed beam technique. The half-life was determined to be $T_{1/2} = 21.9 \pm 0.7 \mu$s. The corresponding $B(E2) = 13.6 \pm 0.4$ e^{2}fm^4 shows good agreement with the Weisskopf estimate, i.e., 15.2 e^{2}fm^4, thereby establishing the 2^+ assignment to this state and the single particle nature of the 42.89 keV transition.

PACS. 21.10.Tg Lifetimes – 21.10.HW Spin, parity, and isobaric spin

Because of the nature of the strong force, isospin is believed to be a good quantum number in nuclei in spite of the existence of the Coulomb force. In heavier nuclei (e.g. nuclei in fp-shell region) around the stable line, isospin is still a good quantum number regardless of the increase of the Coulomb force. This is due to the help of Pauli blocking, i.e., neutrons and protons at Fermi level no longer stay in the same orbit. Therefore, the effects of isospin mixing are expected to be observed for the nuclei around N = Z line in fp-shell region, where the blocking effect decreases. As expected, the strong deformation and the isospin forbidden $E1$ gamma-transition were found in ^{64}Ge [1], which attracts us to study the nuclear structure of ^{64}Ge and nuclei around it. We have measured the lifetime of the first excited state of ^{64}Ga(Z = 31, N = 33), which is one of the isobars of ^{64}Ge(Z = 32, N = 32) near N = Z line. The lifetime of the first excited state of ^{64}Ga was only known to be longer than 1 μs [2], so the assignment of spin and parity to this state was not completed. From the present result, the spin, parity and the single particle nature of this state are discussed.

The present experiment employed at the 34-course in Cyclotron and Radioisotope Center (CYRIC), Tohoku University. The primary beam of 16 MeV ^{3}He from 680 cyclotron at CYRIC bombarded a 5 mg/cm^2 foil target made of 99.86% ^{63}Cu. ^{64}Ga nuclei were produced through the reaction of ^{63}Cu(^{3}He, 2n)^{64}Ga in the target. Typical intensity of the primary beam was ∼5 nA. Since the lifetime of the first excited state of ^{64}Ga was much longer than the natural beam burst interval from the cyclotron (∼25 ns), a pulsed-beam technique was used. In this technique, the primary beam was chopped to a 15 μs beam burst with 150 μs interval by a pulse-type chopper at CYRIC. The total counting rate during the experiment was ∼700 cps. The 42.89 keV gamma ray from the first excited state of ^{64}Ga was detected by a 12.5 mm radius and 10 mm thick HP-Ge detector placed ∼10 cm away from the target. A 0.5 mm thick absorber made of stainless was put in front of the detector to reduce X-ray from the target. 30 % counting loss of the objective gamma ray was expected by the insertion of this absorber. The incidence time and the energy of incoming gamma ray were measured and stored in a computer for offline analysis. Typical energy spectra during the beam burst and the beam interval are shown in Fig. 1. To obtain the time spectrum of the 42.89 keV gamma ray, energy spectra were reconstructed for every 3 μs time bin and the size for the photo peak at 42.89 keV in each spectrum was obtained. The data for the first 5 μs after every beam stop were not used for the analysis in order to reduce the influence of the production time of ^{64}Ga nuclei coming from the burst width of 15 μs. Obtained time spectrum is shown in Fig. 2. The half-life of the first excited state of ^{64}Ga was determined to be

$$T_{1/2} = 21.9 \pm 0.7 \mu\text{s}$$

by fitting a simple exponential curve to this time spectrum. Correcting the internal conversion coefficient ($\alpha = 12.1$) [3], the reduced transition probability $B(E2)$ for the first excited state of ^{64}Ga was deduced to be 13.6 ± 0.4 e^{2}fm^4. This result is very close to the Weisskopf unit, 15.2 e^{2}fm^4, where the spin and parity of this state is assumed to

[a] *Present address:* Research Reactor Institute, Kyoto University, Kumatori, Osaka, 590-0494

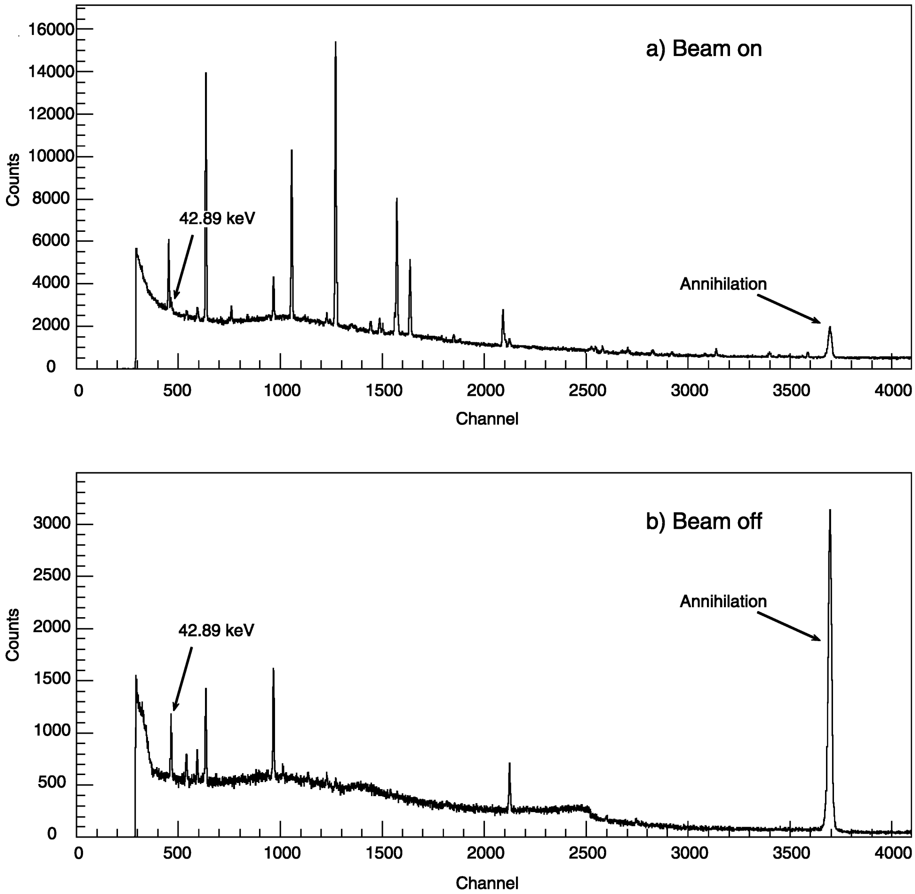

Fig. 1. Typical energy spectra observed during a)15 μs beam burst and b)150 μs beam interval, respectively. As shown, the peak corresponding to the first excited state of ^{64}Ga is clearly observed during the beam interval

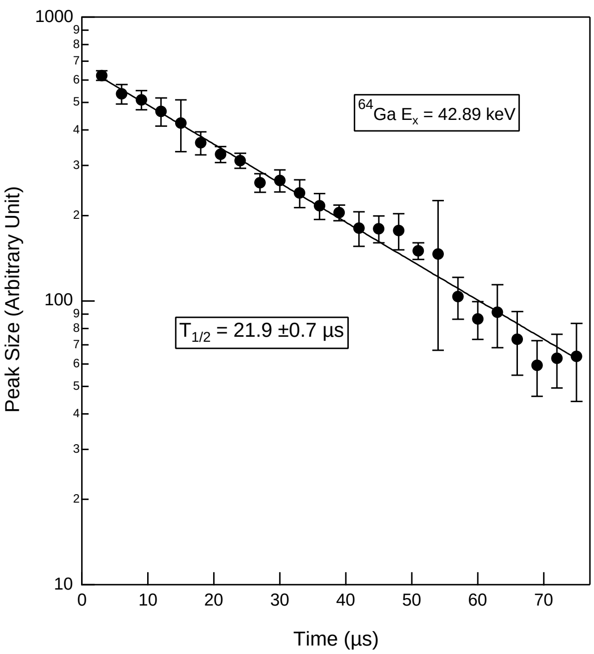

Fig. 2. Time spectrum of the 42.89 keV gamma ray. 5 μs after the beam burst was set to 0 μs in this graph

be 2^+. The present good agreement between these two values is rather a surprise because the Weisskopf unit is based on the simplest single-particle model, while ^{64}Ga is rather a complicated odd-odd nucleus. More precise calculation of $B(E2)$ based on the shell model is now in progress by Ogawa et al. The lower excited states of ^{64}Ga is reasonably treated as the system consisted of the ^{56}Ni core + 3 valence protons and 5 valence neutrons, therefore, we expect the configuration of the low-lying states of ^{64}Ga as the ^{56}Ni core + $|\pi(f_{5/2})^2(p_{3/2})^3;3/2\rangle|\nu(f_{5/2})^2(p_{3/2})^1;3/2\rangle$ to explain the spins and parities of the ground and the lowest three excited states. We are planning to employ g-factor measurement of the first excited state of ^{64}Ga as soon as the replacement of cyclotron is completed at CYRIC.

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