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The g Factor of the 7⁺ Isomeric State in ²⁰²Tl*

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A series of low-lying 7⁺ isomeric states in odd-odd Tl nuclei from A = 194 to 204 have been reported previously (see Fig. 1).¹⁾ In order to investigate the configuration of the 7⁺ states in even Tl, the *g* factor of the 7⁺ state in ²⁰²Tl was measured by the time differential spin-rotation method. The 7⁺ state was populated via the ²⁰⁴Hg(p, 3n)²⁰²Tl reaction with a 28-MeV proton beam from the INS synchrocyclotron. The target was liquid mercury of natural abundance, which was flowing through the beam to reduce the background due to long-lived radio-activities such as ²⁰⁰Tl. In order to observe the *y*-rays following the 7⁺ isomeric state ($t_{1/2} = 0.57$ msec) in the msec region, macroscopic beam bursts (width ~40 μ sec, interval ~1.2 msec) were used.

Since it was anticipated that the period of spin precession might be comparable or even shorter than the width of the beam burst, a pulsed magnetic field was used to prevent the attenuation of the γ -ray anisotropy. The magnetic field was applied by an air core magnet just after the beam burst as shown in the lower part of the Fig. 2, so that all aligned spins start to rotate synchronously. The current of the coil was pulsed by use of a switching transister and the direction of the magnetic field was reversed every 20 seconds so as to average out possible fluctuations of experimental conditions.

The γ -ray spectra were detected by a 30 cc-Ge(Li) detector at 135 degree with respect to the beam axis. The macroscopic beam burst was so intense that the prompt γ -flashes blocked the Ge(Li) detector system over several hundreds μ sec after every beam burst. To shorten the recovery time of the detector system, a feedback resister in charge-sensitive preamplifier, usually 1000 M Ω , was changed to 10 M Ω . Thus the γ -ray spectra were able to be detected from several tens μ sec after the beam burst.

A typical example of the time differential patterns, $R(t) = (N\uparrow - N\downarrow)/(N\uparrow + N\downarrow)$ is shown in Fig. 2. As can be seen the alignment of the spin was kept at least for 300 µsec. The Larmor frequency of the 7⁺ state was determined to be $\omega_{\rm L} = 48.6 \pm 1.0$ kHz at $H = 80 \pm 3$ Gauss, and the g factor of the state was deduced to be $g(7^+) = 0.126 \pm 0.006$.

Later, the g factor was remeasured with the static magnetic field since it was easier to calibrate the



Fig. 1. Energy levels of even Tl isotopes from A = 194 to A = 204.

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Fig. 2. A time differential pattern of 460 keV γ -ray angular distribution observed at 135 degrees to the beam axis and a time pattern of a pulsed magnetic field.

magnetic field strength with better accuracy. Once the g factor was determined by the pulsed field, it was possible to choose an appropriate field so as to observe the spin rotation. The g factor obtained in this measurement was; $g(7^+) = 0.130 \pm 0.007$.

Taking the average of these two results we obtain

$$g(7^+, {}^{202}\text{Tl}) = 0.128 \pm 0.006.$$

Since the effect of the Knight shift is almost cancelled by the diamagnetism,²⁾ we do not make any correction to this value.

The possible main configuration of the 7⁺ isomeric state is expected to be $\pi h_{11/2} \otimes \nu p_{3/2}^{-1}$, $\pi h_{9/2} \otimes \nu f_{5/2}^{-1}$ or $\pi s_{1/2} \otimes \nu i_{13/2}^{-1}$. The *g* factors calculated for these configurations by the theory of Arima and Horie³) are 0.87, 0.72, and 0.05 respectively. The calculated value for the $\pi s_{1/2} \otimes \nu i_{13/2}^{-1}$ configuration with the use of empirical *g* factors of the $\pi s_{1/2}$ state of ${}^{203}\text{Tl}^{4}$) and the $\nu i_{13/2}^{-1}$ state of ${}^{2^{05}\text{Pb}^{5}}$ is 0.09, which is closer to 0.05. High spin proton state such as $h_{11/2}$ and $h_{9/2}$ makes a large contribution to the *g* factor and only $s_{1/2} \otimes i_{13/2}^{-1}$ gives such a small *g* factor as obtained in the present experiment. Thus, the main configuration of the 7⁺ state should be $s_{1/2} \otimes i_{13/2}$, though the observed g factor is larger than the calculated value. Using the wave function by Kuo and Herling⁶ the g factor of the 7⁺ state in ²⁰⁶Tl is able to be calculated. The wave function of the 7⁺ state is

$$\begin{array}{l} |7^{+};\,^{206}Tl> = 0.796s_{1/2}i_{13/2}\,+\,0.389h_{11/2}p_{3/2} \\ &+\,0.324d_{3/2}i_{13/2} \\ &-\,0.230h_{11/2}f_{5/2}\,+\cdots\cdots\end{array}$$

and the calculated g factor is g = 0.17, where the contribution of the $h_{11/2} \otimes p_{3/2}$ is the largest. This suggest that the larger g factor of the 7⁺ state in ²⁰²Tl than that calculated by the assumption of the simple configuration $s_{1/2} \otimes i_{13/2}^{-1}$ is due to the admixture of $h_{11/2} \otimes p_{3/2}^{-1}$ configuration.

In the isomer-shift-experiment a hyperfine splitting was not observed in ¹⁹⁸Tl^m atom and the upper limit of the g factor of the 7⁺ state was determined to be 0.012.⁷) Also in ¹⁹⁶Tl^m and ¹⁹⁴Tl^m atoms hyperfine splittings were not observed⁸) and it might be assumed that the g factors of the 7⁺ state in these nuclei are as small as that in ¹⁹⁸Tl. There seems to exist a discontinuity of the g factor of the 7⁺ state in going from ²⁰²Tl to ¹⁹⁸Tl, but the explanation of this discontinuity is an open problem.

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