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Publication Date
1957-01-15
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UNIVERSITY OF CALIFORNIA
Radiation Laboratory
Berkeley, California
Contract No. W-7405-eng-48

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January 15, 1957

Printed for the U. S. Atomic Energy Commission
AN ODD-ODD ISOTOPE HAVING ZERO SPIN*

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ABSTRACT

The spin of an odd-odd nucleus, Ga\textsuperscript{66}, of half-life 9.4 hrs has been measured. The value is \( I = 0 \). Because the atomic-beam determination employed cannot be absolutely certain for zero spin, the result is stated as a magnetic dipole moment of less than \( 10^{-3} \) nuclear magnetons. The spin of Ga\textsuperscript{67} (78-hr) is reported as \( I = 3/2 \).

*This research was supported by the Office of Naval Research and the Atomic Energy Commission.
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The nuclear angular momenta of two neutron-deficient isotopes of gallium have been determined by the atomic-beam magnetic-resonance method. The results are that for 9.4-hr Ga$^{66}$, $I = 0$, subject to the qualification below, and that for 78-hr Ga$^{67}$, $I = 3/2$. The two isotopes are produced by alpha-particle bombardment of copper in the Berkeley 60-inch cyclotron, and identification made from a half-life analysis of beam exposures taken at appropriate values of radio-frequency and magnetic field. (Fig. 1.) The observed decay is in good agreement with assignments in the literature. 1, 2, 3, 4, 5

The ground-state fine structure of gallium is 826 cm$^{-1}$, and the beam temperature 1100$^\circ$C, therefore both the $4p \, 2P_{3/2}$ and $2P_{1/2}$ levels are appreciably populated. Gallium-66 and -67 resonances have been observed in both levels. Because of a coincidence between the Zeeman frequencies for spin $3/2$ in the $2P_{3/2}$ state and spin $0$ in the $2P_{1/2}$ state, exposures taken at this position show a compound decay. Two special runs were therefore made, one for which the 9.4-hr component was allowed to decay before the run was begun, the other for which the 9.4-hr component was selectively produced by differential bombardment. In each case the appropriate resonances were considerably enhanced.

Gross results of spin searches are shown in Fig. 2.

The atomic-beam method is unfortunately incapable of giving an unequivocal spin-zero assignment, because interactions between the electronic and nuclear systems may be too small for observation. It can, however, give an upper limit to the interaction. Observations on the Ga$^{66}$ resonance in the $2P_{1/2}$ state have been made at three values of magnetic field and from the observed data one can set a conservative upper limit to the magnetic dipole moment of $10^{-3}$ nuclear magnetons. It is therefore highly probable that the spin of Ga$^{66}$ is zero.

*This research was supported by the Office of Naval Research and the Atomic Energy Commission.
Work on gallium is continuing; a new upper limit to the magnetic moment of Ga$^{66}$ and the hyperfine structure of Ga$^{67}$ will be published later.


LEGENDS

Fig. 1. Decay of gallium spin samples. Decay curve of a spin-0 sample and a spin-3/2 sample. The decay serves to identify the specific even-A and odd-A isotopes as Ga$^{66}$ and Ga$^{67}$, respectively.

Fig. 2. Comparison of spin samples of Ga$^{66}$ and Ga$^{67}$. Results of spin searches are indicated by points at various values of frequencies corresponding to specific spins. The experimental points are extrapolated to a time shortly after cyclotron bombardment, and the observed resonances are normalized by the component of the appropriate isotope in the full beam. All possible resonances corresponding to an even-A isotope, $I = 0$, and an odd-A isotope, $I = 3/2$, were observed.
FULL BEAM $\Gamma^{67}/\Gamma^{66} = 0.37$ AT ZERO TIME

- $I = \frac{3}{2}^2P_{3/2} \text{ Ga}^{67}$
  - $T_{1/2} = 78 \text{ hr}$
- $I = 0^2P_{1/2} \text{ Ga}^{66}$
  - $T_{1/2} = 9.4 \text{ hr}$
$I = 0^2P_{1/2} \text{ Ga}^{66} \quad T_{1/2} = 9.4 \text{ hr}$

$I = 3/2^2P_{3/2} \text{ Ga}^{67} \quad T_{1/2} = 78 \text{ hr}$

$I = 0^2P_{3/2} \text{ Ga}^{66}$