Title
AN ODD-ODD ISOTOPE HAVING ZERO SPIN

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ABSTRACT

The spin of an odd-odd nucleus, Ga^{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^{67} (78-hr) is reported as I = 3/2.

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*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°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.

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*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.

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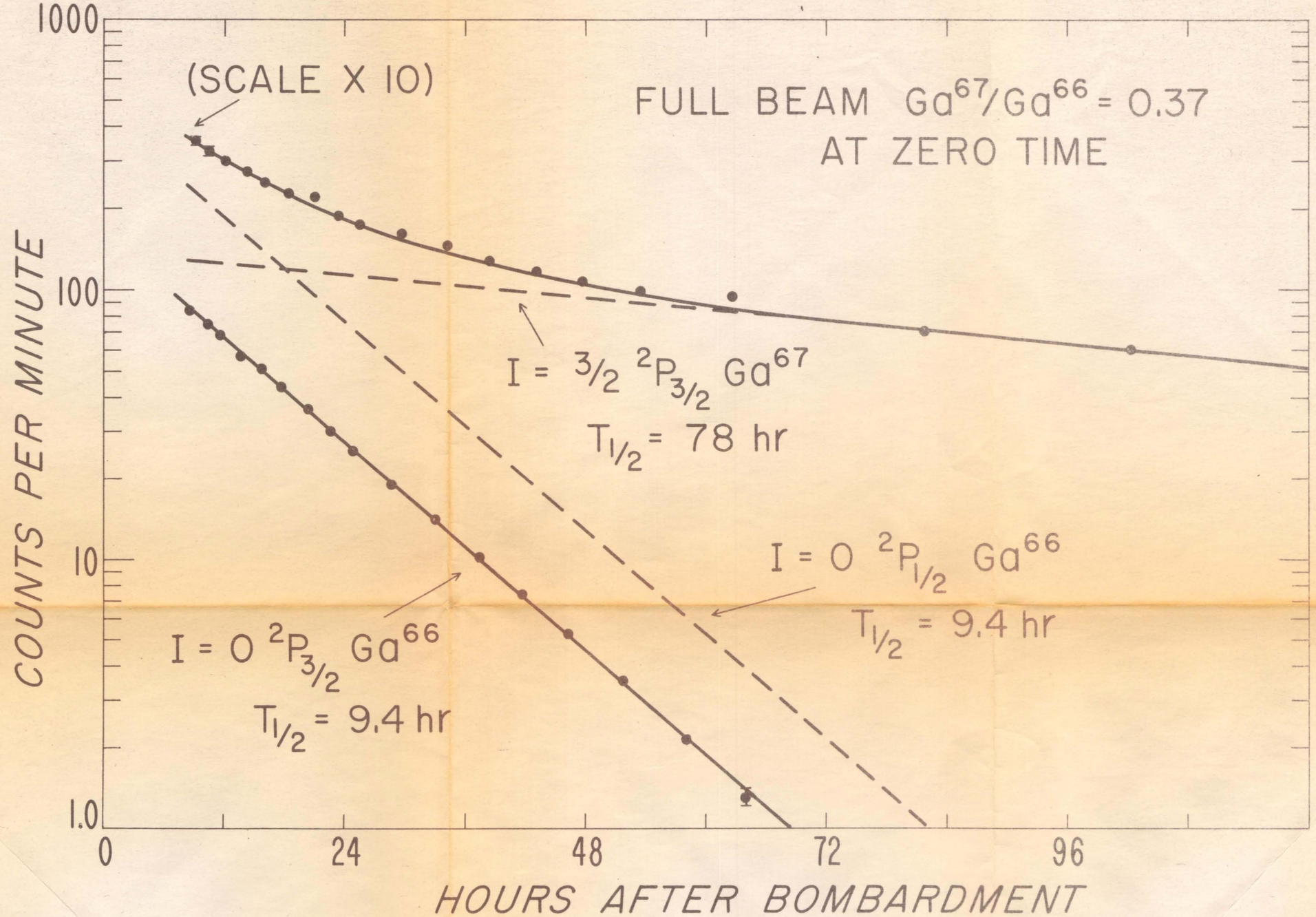
LEGENDS

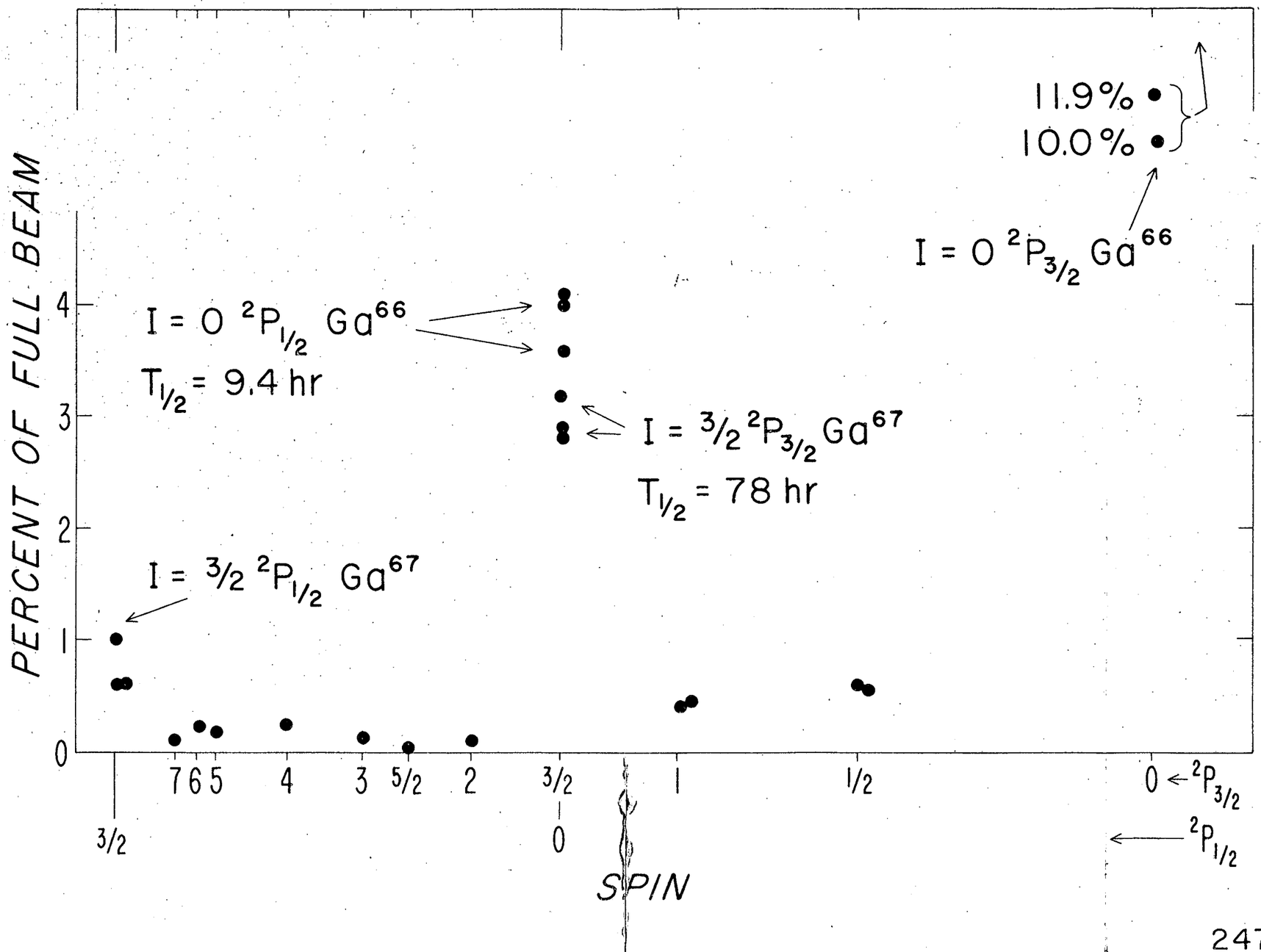
Fig. 1. Decay of gallium spin samples. Decay curve of a spin-0 sample and a spin-3/2 sample. The decay serves to identify the specific even-A and odd-A isotopes as Ga^{66} and Ga^{67}, respectively.

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.


1000
100
10
1.0
COUNTS PER MINUTE
(SCALE X 10)
FULL BEAM Ga^{67}/Ga^{66} = 0.37
AT ZERO TIME
I = 3/2 $^2P_{3/2}$ Ga^{67}
$T_{1/2}$ = 78 hr
I = 0 $^2P_{1/2}$ Ga^{66}
$T_{1/2}$ = 9.4 hr
I = 0 $^2P_{3/2}$ Ga^{66}
$T_{1/2}$ = 9.4 hr
0
24
48
72
96
HOURS AFTER BOMBARDMENT

24778-3

Fig. 1


PERCENT OF FULL BEAM
4
3
2
1
0
I = 0 $^2P_{1/2}$ Ga^{66}
$T_{1/2}$ = 9.4 hr
I = 0 $^2P_{3/2}$ Ga^{66}
11.9%
10.0%
I = $^3/_2$ $^2P_{3/2}$ Ga^{67}
$T_{1/2}$ = 78 hr
I = $^3/_2$ $^2P_{1/2}$ Ga^{67}
7 6 5 4 3 5/2 2 3/2 1 1/2 0 ← $^2P_{3/2}$
3/2
0
← $^2P_{1/2}$
SPIN

24779-2 fig 2