Spin of Rubidium-81m†

J. C. Hubbs, W. A. Nierenberg, H. A. Shugart, and H. B. Silsbee
Radiation Laboratory and Department of Physics, University of California, Berkeley, California
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The nuclear spin of 31.5-min Rb^{81m} has been measured by the atomic beam resonance method. The result is $I=9/2$.

INTRODUCTION

THE spins of rubidium isotopes 81 through 87 have been measured.[1–4] All but perhaps Rb^{82} are ground-state measurements. Rb^{81} has an isomeric state whose half-life is 31.5 minutes.[5] Rb^{84} has an isomeric state with a half-life of 23 minutes.[6] An attempt has been made to measure the spins of these two isomers. Since the experiment is marginal, the Rb^{81m} research was successful; the Rb^{84m} research was not. The spin of Rb^{81m} is 9/2, in agreement with Doggett's prediction.[5]

EXPERIMENT

The experimental technique is essentially the same as that reported in reference 4. The isotopes are prepared by bombarding $BaBr_2$ with 45-Mev alphas and performing a chemical extraction of the rubidium. Even with the best efforts, the time required to demount the target, perform the chemistry, load the oven, make a beam, and collect three to five samples corresponding to different spins is approximately 1.5 hours. Since the number of atoms of Rb^{81m} produced in a half-hour bombardment is approximately the same as the number of Rb^{81} atoms produced, and, in addition, there is an approximately equal amount of Rb^{82} made, the relative activity of Rb^{81m} is not large with respect to Rb^{81} and Rb^{82}. As a result a beam sample collected at a frequency corresponding to an arbitrary spin is expected to show a background of a short-lived component superimposed on a long-lived component of greater magnitude. Therefore the samples collected at different frequencies are each placed in different K x-ray counters to obtain the best possible decay curves with an initial activity of about 10 counts per minute.

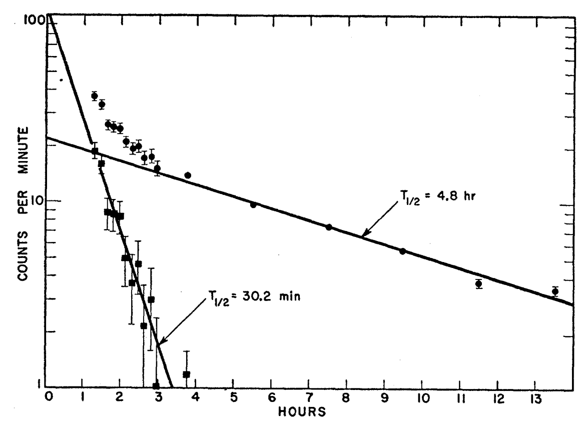

Fig. 1. Least-squares analysis of spin-9/2 decay curve. The spin-9/2 decay (circular points) is analyzed into a 30-minute short-lived activity (square points) superimposed on a 4.8-hour background.

Figure 1 is the decay of a sample collected at a frequency corresponding to $I=9/2$. The curve is analyzed by the least-squares method into a short-lived component with a measured half-life of 30 minutes and a long-lived background component with a measured half-life of 4.8 hours. For comparison, Fig. 2 is the decay curve of the sample corresponding to $I=11/2$. The short-life component has been clearly depressed. Figure 3 is the corresponding decay curve of the "full beam" sample. This sample is obtained with all magnetic fields off and all stops removed. When the full-beam curve is compared with Fig. 1, the relatively higher amount of the short-lived component in Fig. 1 is ap-

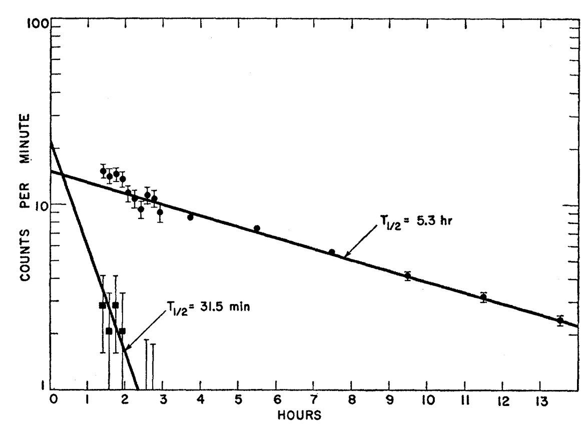

Fig. 2. Spin-11/2 decay. The known half-life of Rb^{81m} (31.5 minutes) is used to extrapolate the short-lived activity (square points) to time $t=0$.

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[1] S. Millman and M. Fox, Phys. Rev. **50**, 220 (1936); S. Millman and P. Kusch, Phys. Rev. **58**, 438 (1940).
[2] E. H. Bellamy and K. F. Smith, Phil. Mag. **44**, 33 (1953).
[3] Hobson, Hubbs, Nierenberg, and Silsbee, Phys. Rev. **96**, 1450 (1954).
[4] Hobson, Hubbs, Nierenberg, Silsbee, and Sunderland, Phys. Rev. **104**, 101 (1956).
[5] W. O. Doggett, University of California Radiation Laboratory Report UCRL-3438, June, 1956 (unpublished).
[6] A. Flammersfeld, Z. Naturforsch. **5a**, 687 (1950); R. S. Caird and A. C. G. Mitchell, Phys. Rev. **89**, 573, 903(A) (1953).

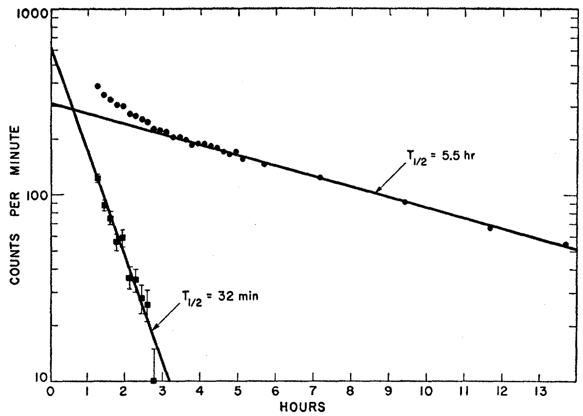

FIG. 3. Decay of full-beam sample. The full-beam sample, taken with all fields off and stops removed, gives an estimate of the constituents of the material leaving the oven.

parent. Since the statistics of one run did not seem to make the assignment sufficiently definite, two other runs were undertaken, with essentially similar conclusions. Some of the results appear in Table I.

Table I shows the enrichment of the 31.5-minute Rb^{81m} for the $I=9/2$ samples. In each case, the background half-life is slightly less for the $I=9/2$ sample—presumably because of the relative enrichment of Rb^{81} over Rb^{82} as a result of the decay of the additional Rb^{81m}. Several even-spin-value settings were made in search for the 23-minute Rb^{84m}, with negative results.

TABLE I. Summary of decay data. (Each button received a 5-min exposure in the apparatus.)

Run	Button spin	Counter	Short activity counts/min ($t=0$)	Short activity $\tau_{\frac{1}{2}}$ (min)	Background counts/min ($t=0$)	Background $\tau_{\frac{1}{2}}$ (hr)	Ratio: short activity to background
5	9/2	1	140	27[a]	19.0	5.0[a]	7.4
	5	3	16	(b)	36.0	6.4	Rb^{82} res.
	7/2	2	30	(b)	12.3	5.2	2.5
8	9/2	4	107	30[a]	22.0	4.8[a]	4.9
	11/2	3	22	(b)	15.0	5.3	1.5
	7/2	1	49	(b)	17.5	5.5[a]	2.8
10	Full beam	3	620	32	310	5.5	2.0
	9/2	1	110	30	11.6	4.6	9.5
	7/2	2	30	(b)	11.4	5.8	2.4

[a] Least-squares analysis.
[b] $\tau_{\frac{1}{2}}$ assumed 31.5 min for extrapolation to $t=0$.

CONCLUSIONS

The spin of Rb^{81m} is 9/2, in agreement with the value from the decay scheme postulated by Doggett.[5] The hyperfine structure is not likely to be measured without some improvement in technique. It is noteworthy that the number of atoms of Rb^{81m} prepared in any run is about 10^{10} to 10^{11}.

The search for the 23-minute Rb^{84m} level did not succeed, presumably because it does not decay by K capture. As a result the counting rate dropped to the point where the experiment could not be done with the available number of atoms.