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July 5, 1956

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## ABSTRACT

The nuclear spin of 31.5-min $Rb^{81m}$ has been measured by the atomic beam resonance method. The result is $I = 9/2$.

+ Work supported jointly by the Office of Naval Research and the Atomic Energy Commission.

# THE SPIN OF RUBIDIUM-81 m+

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## INTRODUCTION

The spins of rubidium isotopes 81 through 87 have been measured.[1,2,3,4] 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 Ref. 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.

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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 apparent. 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.

## 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 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.

Table I

Summary of decay data
(each button received a 5-min exposure in the apparatus)

| Run | Button spin | Counter | Short Activity cpm (t=0) | Short Activity $\tau_{1/2}$ (min) | Background cpm (t=0) | Background $\tau_{1/2}$ (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] $\tau_{1/2}$ assumed 31.5 min for extrapolation to t = 0.

## REFERENCES

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. (to be added).
5. W. O. Doggett, Radioactivity of Neutron-Deficient Rubidium Isotopes (thesis) UCRL-3438, June 1956.
6. A. Flammersfeld, Z. Naturf. 5a, 687 (1950); R. S. Caird and A. C. G. Mitchell, Phys. Rev. 89, 573, 903A (1953).

## FIGURE CAPTIONS

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.

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 $t = 0$.

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.

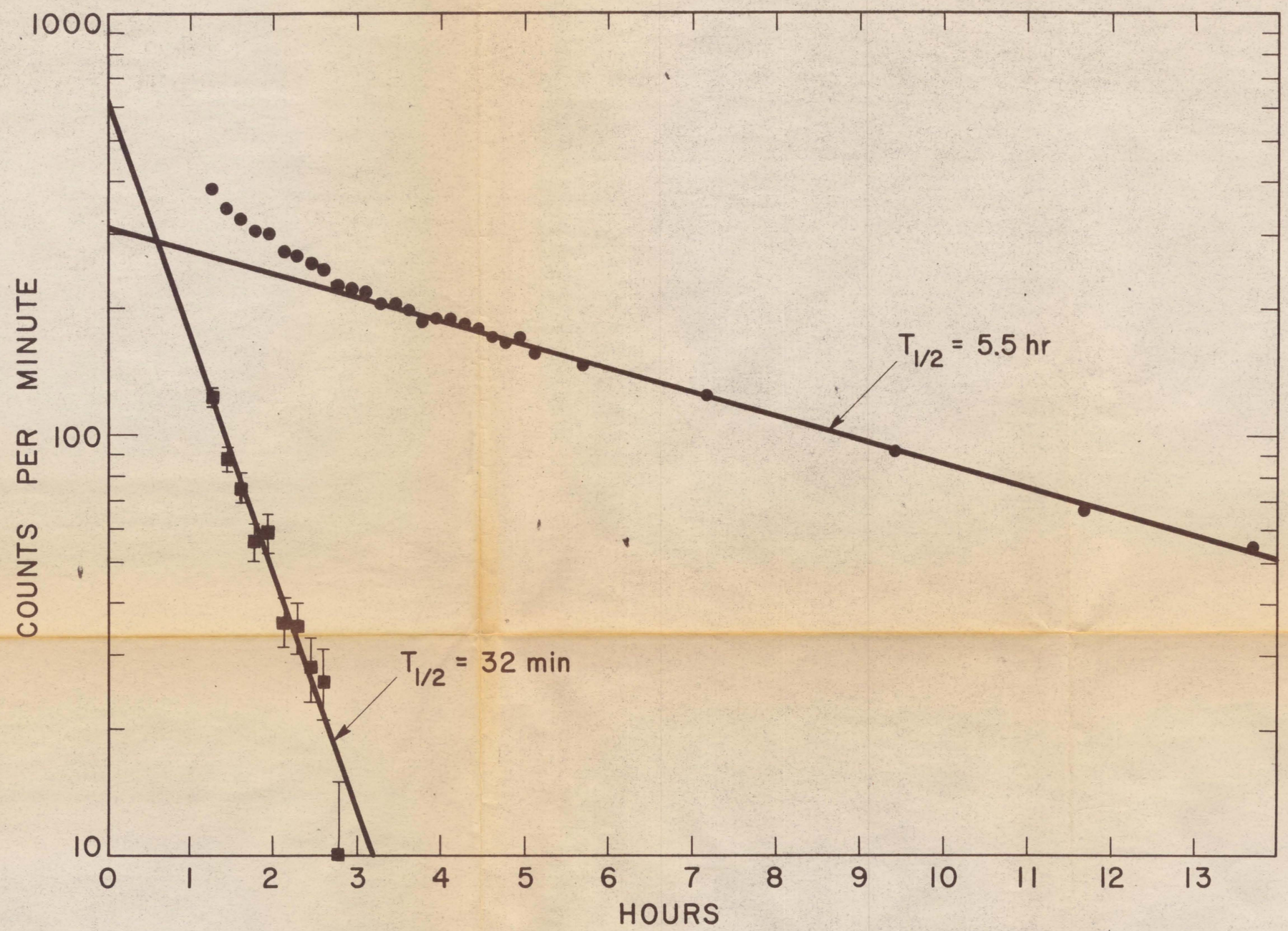
1000
100
10
COUNTS PER MINUTE
0
1
2
3
4
5
6
7
8
9
10
11
12
13
HOURS
$T_{1/2}$ = 5.5 hr
$T_{1/2}$ = 32 min

Fig. 3

23554-3

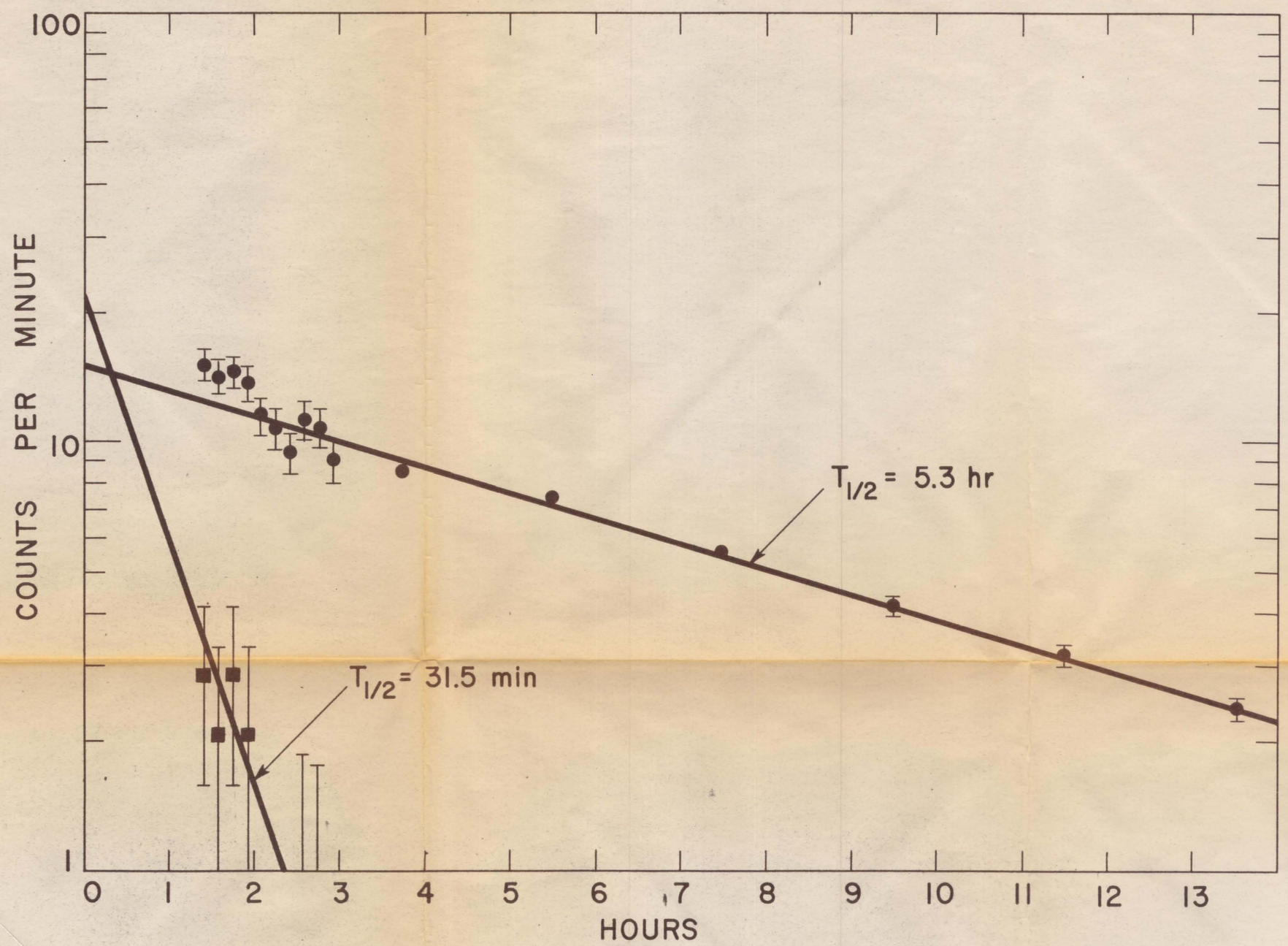
100
10
1
COUNTS PER MINUTE
0
1
2
3
4
5
6
7
8
9
10
11
12
13
HOURS
$T_{1/2}$ = 5.3 hr
$T_{1/2}$ = 31.5 min

Fig. 2

23553-3

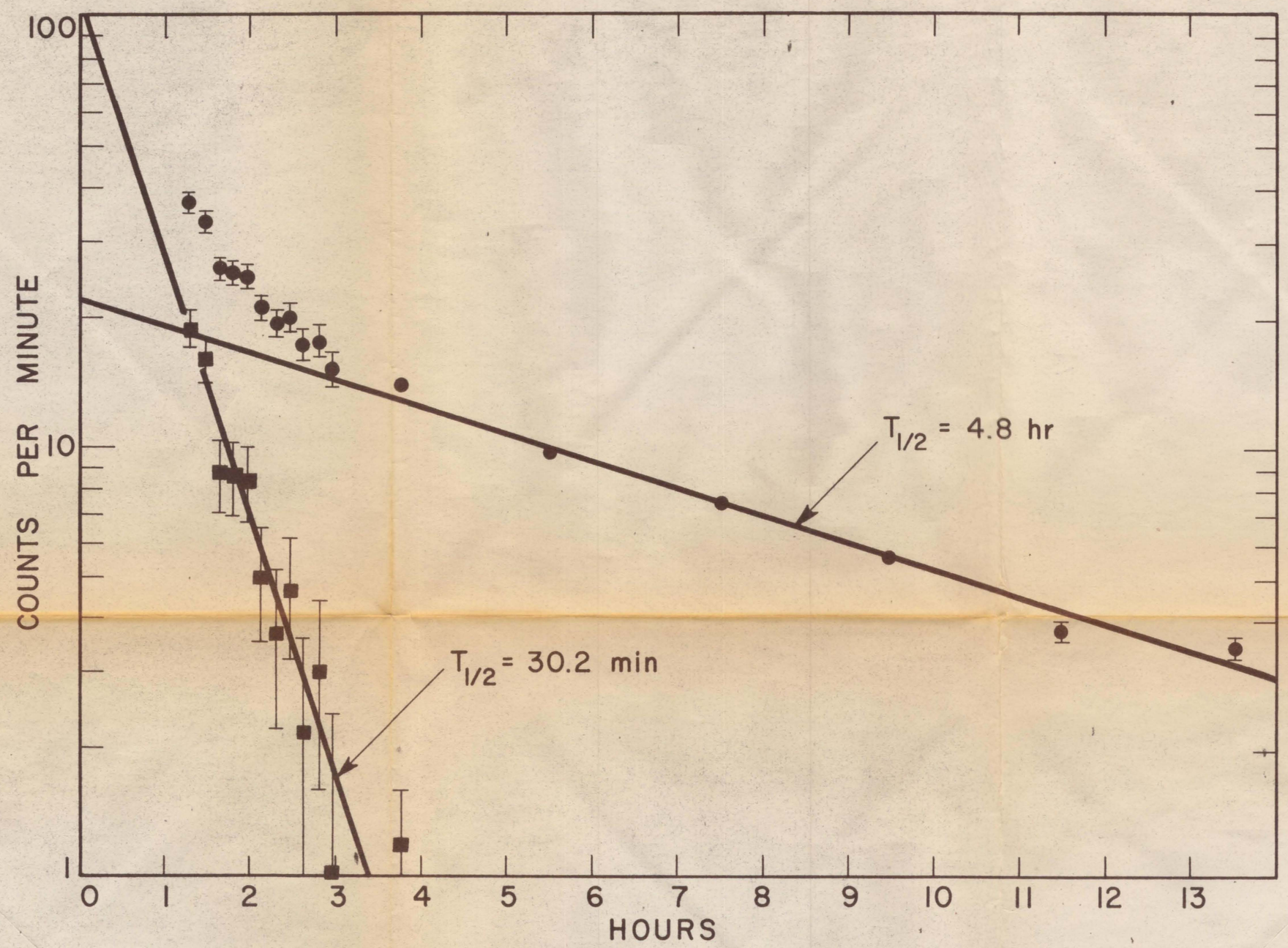
100
10
1
COUNTS PER MINUTE
0
1
2
3
4
5
6
7
8
9
10
11
12
13
HOURS
$T_{1/2}$ = 4.8 hr
$T_{1/2}$ = 30.2 min

Fig. 1

23552-3