a proton configuration $(f_{7/2})^5$. In the extreme single-particle model, a spin $I=7/2$ and a magnetic moment given by the Schmidt limit $\mu=+5.79$ nm would be expected. Although we have not determined the sign of the magnetic moment in our experiment, the fairly good agreement in magnitude between the Schmidt limit value and our measured value, Eq. (6), indicates that it is positive. Other nuclei with 25 odd nucleons, ${}_{25}Mn_{30}{}^{55}$ and ${}_{22}Ti_{25}{}^{47}$ and, presumably, ${}_{10}Ne_{11}{}^{21}$, represent some of the few cases where the single-particle model clearly breaks down, as was pointed out by Mayer.[20] In these cases the assumption of a simple jj coupling of all the odd particles in the unfilled shell to a resultant spin $j-1$ gives approximate agreement with the empirical magnetic moment and spin. In the present case it is possible to check this assumption more closely for Mn^{55} by noting that identical nucleons in jj coupling yield a resultant g factor which is the same as that of the single nucleon.[21] The empirical value of the proton g factor from our measurements on Mn^{53}, $g_p=\mu/I=1.443$, corresponds rather well with the corresponding empirical value $g_p=1.385$ for Mn^{55}.

[20] M. G. Mayer, Phys. Rev. **78**, 16 (1950).
[21] See, for example, A. de-Shalit, Phys. Rev. **90**, 83 (1953).

A long-lived manganese radioactivity attributed to Mn^{53} has recently been established by Wilkinson and Sheline,[7] who bombarded enriched Cr^{53} with 9.5-Mev protons: $Cr^{53}(p,n)Mn^{53}$. From the measured activity and an estimated cross section for this reaction, they estimate the half-life to be ~140 years. There is good evidence that the decay is by electron capture to the $p_{3/2}$ ground state of Cr^{53} and that there is no gamma radiation. For a disintegration energy of 0.6 Mev obtained from $Cr^{53}(p,n)Mn^{53}$ threshold measurements,[22] this leads to a logft value of about 8.5. On this basis they suggested that the ground state of Mn^{53} is $f_{5/2}$, as is that of Mn^{55}. Our measurements show that the Mn^{53} ground state is $f_{7/2}$, so that a rather high logft value (~12) for the $f_{7/2}\rightarrow p_{3/2}$ transition would be normally expected. This would seem to indicate that the Mn^{53} half-life is longer than 140 years.

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[22] P. H. Stelson and W. M. Preston, Phys. Rev. **86**, 807 (1952).

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Spins of Cesium-127, Cesium-129, and Cesium-130*

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The spins of three neutron-deficient radioactive isotopes of cesium have been measured by atomic beam methods. The results are: for 6-hour Cs^{127}, $I=1/2$; for 31-hour Cs^{129}, $I=1/2$; for 30-minute Cs^{130}, $I=1$.

EXPERIMENTAL METHOD

The isotopes Cs^{127} (6 hour),[1,2] Cs^{129} (31 hour),[1] and Cs^{130} (30 minutes)[2,3,4] were produced in the Berkeley 60-inch cyclotron by (α,kn) reactions on iodine. About 5 mg of CsI carrier was added to a solution of the BaI_2 target material; then the barium was eliminated by precipitation of its carbonate, and the excess iodine was sublimed off as NH_4I. The resulting CsI was transferred to an atomic-beam oven and reduced by heating with calcium to form a beam of atomic cesium. The beam could be obtained in a little more than an hour after the end of the bombardment.

The $I^{127}(\alpha,n)Cs^{130}$ reaction could be relatively enhanced by using short bombardments and placing aluminum foils in front of the target material to cut the α-beam energy to a point where the $I^{127}(\alpha,2n)Cs^{129}$ cross section would be low but the Cs^{130} yield would be reasonably high.

Table I. Counting rates for Cs^{130}, integral spin values.

Spin value	0	1	2	3	4
Counting rate (arbitrary units)	−14±7	100±13	7±5	14±6	9±3

Table II. Counting rates for Cs^{127} and Cs^{129}, half-integral spin values.

Spin value	1/2	3/2	5/2	7/2	9/2
Counting rate (arbitrary units)	100±1.3	1.4±0.2	1.9±0.2	1.8±0.2	1.4±0.2

* Research supported jointly by the U. S. Atomic Energy Commission and the Office of Naval Research.
[1] Fink, Reynolds, and Templeton, Phys. Rev. **77**, 614 (1950).
[2] H. B. Mathur and E. K. Hyde, Phys. Rev. **95**, 708 (1954).
[3] J. R. Risser and R. N. Smith, private communication from Lark-Horowitz cited by Hollander, Perlman, and Seaborg, Revs. Modern Phys. **25**, 469 (1953).
[4] Smith, Mitchell, and Caird, Phys. Rev. **87**, 454 (1952).

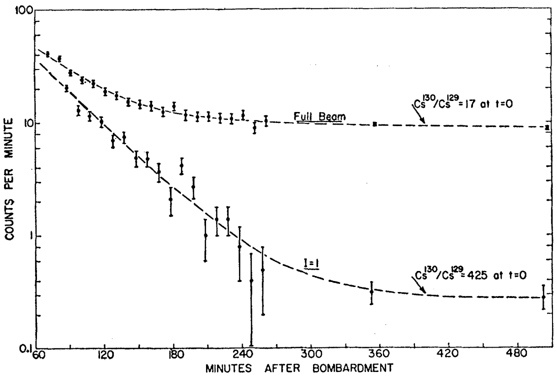

FIG. 1. Decay of $I=1$ sample (Cs^{130}).

Similarly the $I^{127}(\alpha,4n)Cs^{127}$ production could be favored by using a target so thin that the α beam left the back of the material before the $I^{127}(\alpha,2n)Cs^{129}$ cross section became high. This was important, because Cs^{127} does not undergo K capture with high probability,[1] and hence the x-ray counters are relatively inefficient for the isotope.

The spins of the three isotopes were investigated in an atomic-beam resonance apparatus by techniques previously described.[5]

CESIUM-130 RESULTS

Table I compares the counting rates obtained at conditions appropriate to several integral spin values. The rates have been corrected for counter background, extrapolated to a common time, and normalized for variations in beam intensity (as indicated by the resonance height observed for the carrier isotope).

There is a clear indication that $I=1$. This was confirmed by a repetition of the experiment.

Figure 1 compares the decay of the $I=1$ sample with that of a sample of the full beam (obtained by turning off the deflecting fields and removing the stop). The full-beam sample shows the 30-minute Cs^{130} component superimposed on a 31-hour Cs^{129} background. The $I=1$ sample shows a marked enrichment of the 30-minute activity, indicating that Cs^{130} is responsible for the $I=1$ signal.

CESIUM-127 AND CESIUM-129 RESULTS

Table II gives the results of a search at half-integral spin values. A significant signal appears only for $I=1/2$.

In Fig. 2 the decay of the $I=1/2$ sample is compared with that of the full beam. It is clear that both the 6-hour Cs^{127} and the 31-hour Cs^{129} are present in both samples and in the same ratio. The same result has been obtained in other runs in which the relative amounts of the two isotopes were appreciably different. The conclusion is that both Cs^{127} and Cs^{129} have $I=1/2$.

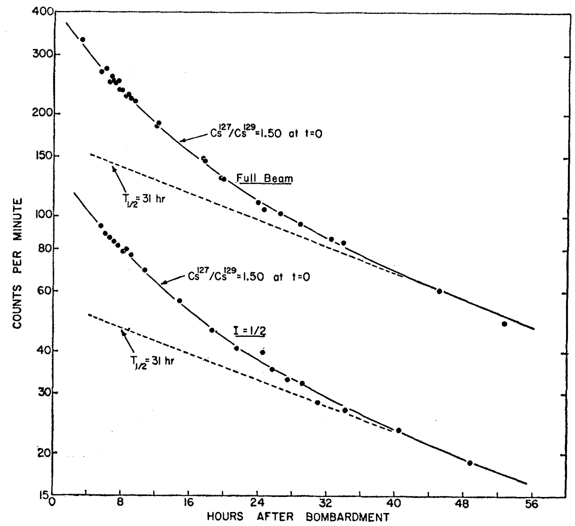

FIG. 2. Decay of $I=1/2$ sample (Cs^{127} and Cs^{129}).

REMARKS

The measured spin, $I=1$, for Cs^{130} agrees with the prediction by Smith, Mitchell, and Caird[4] deduced from the decay scheme, and—as they point out—it is consistent with a shell-model picture of an unpaired $(d_{5/2})$ proton coupled with a $(d_{3/2})$ neutron.

A ground-state spin of 1/2 for either Cs^{127} or Cs^{129} is hard to fit into the shell picture. If the spin is due to a single proton it must occupy an $(s_{1/2})$ state, which is presumed to lie at the top of the shell,[6] while the $(g_{7/2})$ and $(d_{5/2})$ levels at the bottom of the shell are available. Furthermore, no coupling scheme with the five protons outside the closed shell at $Z=50$, all in the $(g_{7/2})$ level or all in the $(d_{5/2})$ level, can give $I=1/2$; nor can three protons in one of these levels and a canceling pair in the other give $I=1/2$. Five protons in the $(h_{11/2})$ level can produce $I=1/2$, but coupling to such a low spin value seems unlikely. It is conceivable but improbable that the neutrons contribute to the spin.

A measurement of the hyperfine structure may throw light on the problem. Preliminary results indicate that the hyperfine splitting for both isotopes is in the neighborhood of 8000 to 10 000 Mc/sec.

If protons give a ground-state spin of 1/2 for Cs^{127} and Cs^{129}, then the observed spin of 1 for Cs^{130} may be due to these protons coupled to an $(s_{1/2})$ neutron. Again a measurement of the hyperfine structure would be useful.

[5] J. P. Hobson *et al.*, Phys. Rev. **104**, 101 (1956).

[6] M. G. Mayer and J. H. D. Jensen, *Elementary Theory of Nuclear Shell Structure* (John Wiley and Sons, Inc., New York, 1955), pp. 74–81.