Nuclear Spin and Magnetic Moment of 3.1 hr Cs^{134m}

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THE atomic beam magnetic resonance method has been used to measure the spin, hyperfine structure constant, and magnetic moment of the radioactive nucleus 3.1-hr Cs^{134m}. The apparatus constructed for this purpose incorporated the magnet design of Nagle,[1] but contained a movable compartment for rapid insertion and pumpdown of sources, and a detector compartment, removable through vacuum locks, making possible the collection of the radioactive atoms on disks at liquid nitrogen temperatures. The beam intensity of the active species was determined by counting, in a windowless flow counter, the 100-kev conversion electrons of Cs^{134m} from the deposit formed during constant exposure time.

The "flop-in" method of Zacharias[2] was employed to detect the low-field $[F=I+\frac{1}{2},\ m_F=-F\leftrightarrow F=I+\frac{1}{2},\ m_F=-(F-1)]$ transitions in both the active nuclide and inactive Cs^{133} in the beam. Collected in Table I are

Table I. Observed low-field resonance frequencies in Cs^{134m} and Cs^{133}.

ν_{133} (Mc/sec)	ν_{134m} (Mc/sec)
9.365	4.480
17.220	8.295
43.940	21.934
90.937	48.403
164.105	97.140

the resonances in Cs^{134m} found in magnetic fields determined by observing resonances of the same transition in Cs^{133} ($I=7/2$, $\Delta\nu=9193$ Mc/sec). In general, each frequency value is an average of the results of two experiments. A typical curve of a resonance in Cs^{134m} appears in Fig. 1.

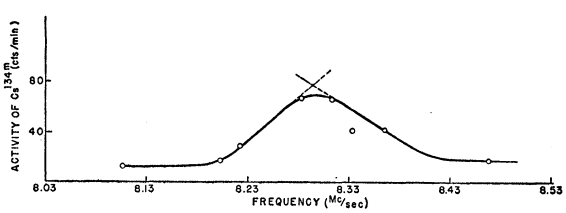

Fig. 1. A typical curve of a resonance in Cs^{134m}.

In sufficiently low magnetic fields the frequency at which the $F=I+\frac{1}{2}$, $m_F=-F\leftarrow m_F=-(F-1)$ transition is observed is given to a high degree of approximation by[3]

$$\nu=1.400\frac{H}{I+\frac{1}{2}}+\left(1.400\frac{H}{I+\frac{1}{2}}\right)^2\frac{2I}{\Delta\nu},$$

where ν is the low-field transition defined above (in Mc/sec), H is the magnetic field (in gauss), I is the nuclear spin (in units of $\hbar$), and $\Delta\nu$ is the hyperfine structure constant (in Mc/sec). Solution of this equation using the first two pairs of data of Table I gives unambiguously a spin of 8 and $\Delta\nu\approx 3600$ Mc/sec. From the Fermi relation,[4]

$$\Delta\nu_{134m}/\Delta\nu_{133}=\frac{(2I_{134m}+1)\mu_{134m}}{I_{134m}}\cdot\frac{I_{133}}{(2I_{133}+1)\mu_{133}},$$

the magnetic moment, μ_{134m}, was then calculated to be 1.1 nm ($\mu_{133}=+2.58$ nm). At higher magnetic fields the approximate low-field equation is no longer valid, and the complete Breit-Rabi relation[5] is used to arrive at a more precise value of the hfs constant. Our best estimate at present is $\Delta\nu_{134m}=3662$ Mc/sec, based on the highest pair of frequencies listed in Table I and assuming that μ_I is positive in sign. The magnetic moment is then more precisely calculated to be 1.10 nm. Further experiments at higher frequencies are being conducted to establish the algebraic sign of the moment.

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Decay of Cs^{134m} (3.1 hr)

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THE discovery reported in the two preceding letters,[1,2] that Cs^{134m} (3.1 hr), has a spin of 8 units ($\hbar$), reopens the question of its correct decay scheme. It was previously shown that this isomer decays by a 128-kev transition, identified as an $E3$ transition from its K conversion coefficient.[3] As the ground state of Cs^{134} has a measured spin of 4 units,[4] and as no β rays are observed from Cs^{134m}, it was considered likely that the metastable state has a spin of 7 units.[5] Because of the discrepancy between this value and the now directly measured value of 8 units for the