On the Magnetic Moments of Xe^{129}, Bi^{209}, Sc^{45}, Sb^{121}, and Sb^{123}*

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THE nuclear magnetic resonances of Xe^{129}, Bi^{209}, Sc^{45}, Sb^{121}, and Sb^{123} have been observed by use of the nuclear induction spectrometer described earlier.[1] The magnetic moments listed in column two of Table I have been computed directly from our measured frequency ratios and the value of the magnetic moment of the nucleus used as a standard. Diamagnetic corrections were not applied; they are listed separately in column three, and have been determined by linear interpolation from the values for specific atoms given by Lamb, using Hartree fields.[2] These corrections are to be applied in a direction such as to increase the magnitude of the listed magnetic moments.

As a monatomic gas, Xe presented certain difficulty with regard to a suitable mechanism for establishing thermal equilibrium. An admixture of O_2 could be used as paramagnetic catalyst,[3,4] but it would require rather excessive pressures to obtain the full signal magnitude. Instead, we followed a suggestion by Professor Bloch, filling a test tube packed with powdered Fe_2O_3 to a pressure of about 12 atmos. of xenon for a sample. The kinetic motion of the Xe atoms about the paramagnetic Fe_2O_3 particles successfully shortened the longitudinal relaxation time by providing time-varying magnetic fields at the Xe nuclei. Samples made without paramagnetic powders present, and samples using $CuCl_2$ or $K_3Fe(CN)_6$, gave no signals. The resonance was located near 7.7 Mc, using a magnetic field of 6600 gauss. Comparing this frequency with that from Na^{23}, we found

$$\nu(Xe^{129})/\nu(Na^{23}) = 1.0456 \pm 0.0001$$

leading to the magnetic moment listed in Table I. This is in good agreement with the spectroscopic[5] value, $\mu(Xe^{129}) = -0.9\mu_N$. The negative sign has been confirmed.

Using an aqueous solution of 0.69M $Bi(NO_3)_3$, the resonance of Bi^{209} was found in the neighborhood of 7.0 Mc, with a magnetic field near 10,000 gauss. Comparing the resonance frequency with that from D^2, we found

$$\nu(Bi^{209})/\nu(D^2) = 1.0468 \pm 0.0001.$$

The magnetic moment was found to be positive and it is in good agreement with the h.f.s. value[6] of $3.45\mu_N$.

The Sc^{45} resonance was observed with a magnetic field of 7400 gauss, near 7.6 Mc, using a sample of Sc_2O_3 in HNO_3. We found

$$\nu(Sc^{45})/\nu(Na^{23}) = 0.9183 \pm 0.0001$$

which leads to a value in excellent agreement with the h.f.s.[7] value $\mu(Sc^{45}) = 4.8\mu_N$. The positive sign was verified.

The antimony resonances were observed using a sample of $NaSbF_6$ in weak HF. The absorption lines of both the Sb^{121} and the Sb^{123} resonances manifested a structure inasmuch as they were each composed of five lines, approximately 2 gauss apart. The structure can be understood qualitatively, and will be reported upon in detail elsewhere. It appears most likely that it is due to the additional field, acting on the Sb nucleus, which originates from the magnetic moments of the six surrounding fluorine nuclei in the $(SbF_6)^-$ ion; the analysis shows that the central line suffers no displacement from this cause. Measurements then gave

$$\nu(Sb^{121})/\nu(Na^{23}) = 0.9048 \pm 0.0001,$$

$$\nu(Sb^{123})/\nu(D^2) = 0.8442 \pm 0.0001.$$

These frequency ratios lead to values of the magnetic moments which are in good agreement with the spectroscopic values $\mu(Sb^{121}) = 3.7\mu_N$, $\mu(Sb^{123}) = 2.8\mu_N$, and their ratio,[8] $\mu(Sb^{121})/\mu(Sb^{123}) = 1.32$.

No attempt was made to check spin values for the above nuclei, and the spectroscopically determined values have been used in computing the magnetic moments listed[9] in Table I. In view of the observed dependence of nuclear magnetic resonance frequencies on chemical compound,[10,11] we wish to emphasize that the moments listed in Table I are without corrections of any kind. At the time of this writing none of the nuclei reported upon here has been observed in compounds other than those given.

TABLE I. Magnetic moments and diamagnetic corrections.

Nucleus	Nuclear moment in nuclear magnetons	Diamagnetic correction in percent
Xe^{129}	-0.7726 ± 0.0001	0.56
Bi^{209}	$+4.0400 \pm 0.0005$	1.04
Sc^{45}	$+4.7497 \pm 0.0008$	0.15
Sb^{121}	$+3.3427 \pm 0.0005$	0.52
Sb^{123}	$+2.5341 \pm 0.0003$	0.52

The magnetic moment of Na^{23} has been computed by taking

$$\mu(H^1) = (2.7935 \pm 0.0003)\mu_N;^{12}$$

and

$$\nu(Na^{23})/\nu(H^1) = 0.26450 \pm 0.00003;^{13}$$

the magnetic moment of D^2 was similarly computed using $\mu(D^2)/\mu(H^1) = 0.307013$.[14]

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[1] W. G. Proctor, Phys. Rev. **75**, 522 (1949).
[2] W. E. Lamb, Jr., Phys. Rev. **60**, 817 (1941).
[3] F. Bloch, Phys. Rev. **70**, 460 (1946).
[4] H. L. Anderson, Phys. Rev. **76**, 1460 (1949).
[5] H. Kopfermann and E. Rindal, Zeits. f. Physik **87**, 460 (1934).
[6] H. Wittke, Zeits. f. Physik **116**, 547 (1940).
[7] H. Kopfermann and H. Wittke, Zeits. f. Physik **105**, 16 (1937).
[8] M. F. Crawford and S. Bateson, Can. J. Research **10**, 693 (1934).
[9] See "Properties of Atomic Nuclei," Publication BNL 26 (T-10), Brookhaven National Laboratory, Upton, New York (October 1, 1949).
[10] W. G. Proctor and F. C. Yu, Phys. Rev. **77**, 717 (1950).
[11] W. C. Dickinson, Phys. Rev. **77**, 736 (1950).
[12] H. Taub and P. Kusch, Phys. Rev. **75**, 1481 (1949).
[13] F. Bitter, Phys. Rev. **75**, 1326 (1949).
[14] This figure is that given by Bloch, Levinthal, and Packard, Phys. Rev. **72**, 1125 (1947), rounded to six places.

Magnetic Suspension Balance*

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MAGNETIC suspension balances, in which the material to be weighed is freely suspended, have been designed and operated successfully by Holmes[1] and by Clark,[2] but these balances lacked the sensitivity and stability necessary for some types of measurement. In a recent paper[3] a magnetic suspension for high speed rotors was described which also proved to be an excellent magnetic suspension balance. This magnetic balance has now been modified and improved to a point where its sensitivity is limited only by the natural fluctuations or "Brownian motion" of the system.

The material to be weighed is attached to a cylindrical ferromagnetic body (iron, steel, or Permalloy) which is supported freely by the vertical axial magnetic field of a solenoid. The ferromagnetic body is positioned in the edge of a horizontal light beam so that it scatters or reflects light into a photo-electron multiplier cell. The signal from the cell actuates an electronic circuit which in turn regulates the current in the solenoid in such a way as to maintain the suspended ferromagnetic body at the desired height. By proper adjustment of the circuits and of the vertical gradient of the light intensity, where the suspended body is positioned in the light beam, the apparatus can be made very sensitive to slight changes in vertical force on the suspended body. If the dimensions of the suspended ferromagnetic cylinder are small in comparison to its distance below the solenoid, the upward force F on the rotor is approximately MdH/dX where H is the magnetic field, X is a