For molecules $Y^{(M)}X_4{}^{(M)}$ and $Y^{(M)}X_3{}^{(m)}X^{(m+\Delta m)}$, we have different relationships, naturally. For the inactive frequencies:

$$\omega_1'/\omega_1=\omega_2'/\omega_2=(1+\Delta m/4m)^{-\frac{1}{2}}. \qquad (2)$$

The triple frequencies ω_3 and ω_4 of $YX_4{}^{(m)}$ are now replaced by two double frequencies, say ω_3' and ω_4' and two single frequencies, say ω_5' and ω_6', each depending on the force constants (this is the result essentially different from Langseth's), but related by

$$\omega_3'\omega_4'/\omega_3\omega_4=1-(\Delta m/8m)(\mu+\tfrac{1}{2}) \qquad (3)$$

and

$$\omega_5'\omega_6'/\omega_3\omega_4=1-(\Delta m/8m)(\mu+2). \qquad (4)$$

The degeneracy of the active vibrations is, as Langseth pointed out, completely destroyed in the molecule $Y^{(M)}X_2{}^{(m)}X_2{}^{(m+\Delta m)}$, but again we find that the frequency shift of each active vibration is not calculable from the masses alone, only shifts of certain pairs of frequencies being thus simply determined. This different result is, of course important in the use of the isotope effects for the assignment of the spectroscopic frequencies to the proper normal vibrations.

We are greatly indebted to Dr. Louis S. Kassel of the United States Bureau of Mines for pointing out to us that the relative concentrations of the different isotopic species, as stated on page 433,[2] are in error and should read

$$1 : 2a/b : (a/b)^2 \quad \text{and} \quad 1 : 3a/b : 3(a/b)^2 : (a/b)^3.$$

The relative abundances of the C Cl_4 molecules with different proportions of isotopes of Cl were noted by Langseth. In general, if the relative concentration of $X^{(m)}$ to $X^{(m+\Delta m)}$ is b/a, then the molecules are present in the following proportions:

$$YX_4{}^{(m)} : YX_3{}^{(m)}X^{(m+\Delta m)} : YX_2{}^{(m)}X_2{}^{(m+\Delta m)} : YX^{(m)}X_3{}^{(m+\Delta m)} : YX_4{}^{(m+\Delta m)}=1 : 4a/b : 6(a/b)^2 : 4(a/b)^3 : (a/b)^4.$$

Physics Department,
New York University,
March 8, 1933.

E. O. SALANT
JENNY E. ROSENTHAL

The Nuclear Spin of Sodium

We have made a direct measurement of the nuclear spin of sodium by means of the magnetic deflection of a beam of neutral sodium atoms.[1] Sufficient resolution is attained by the use of a magnetic velocity selector consisting essentially of an inhomogeneous magnetic field which spread the beam into a velocity spectrum, the field being of sufficient strength to cause a complete decoupling of the nuclear and electronic spins. By means of a movable selector slit we select a portion of this beam homogeneous in velocity to about 10 percent and corresponding to about half the velocity of the Maxwell distribution.[2]

This beam is then permitted to pass through a weak inhomogeneous field of the Stern-Gerlach type. This field is so chosen that there is still strong coupling between the nuclear and electron spins. Each magnetic level is thus under the influence of a different deflecting force and the beam splits up into a number of components. The beam is then further allowed to traverse a strong inhomogeneous field of the same type, supplied by a third magnet, so arranged as to bring the whole deflection pattern into the neighborhood of the original position of the undeflected beam. This serves as a focussing device to sharpen up the lines. The length of path of the beam is 61 cm. The method of detection is the Langmuir-Taylor surface ionization detector used ballistically.[2]

The beam splits up into four distinct components as shown in Fig. 1 which represents the experimental points of one particular run directly. We have checked this result under varied conditions. The peak marked A does not belong to the deflection pattern for the selected atoms. It is due to fast atoms from the small tails of the original beam. This we have proved abundantly.

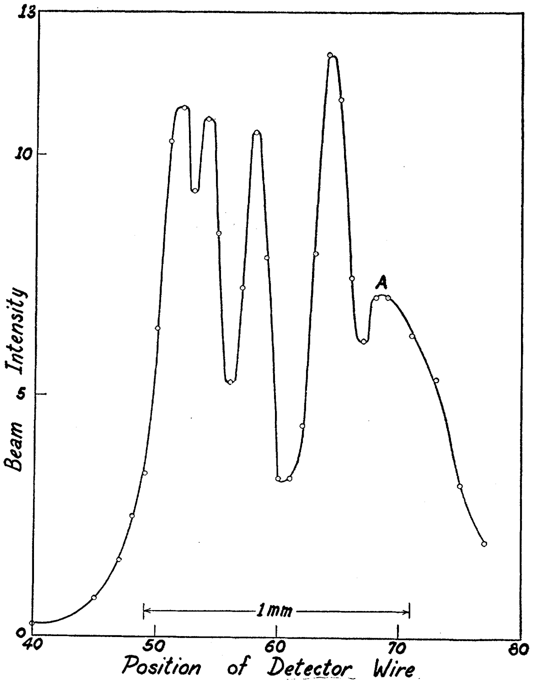

FIG. 1.

The total number of magnetic levels of the atom is $(2I+1)(2J+1)$ where I is the nuclear spin, in units of $h/2\pi$ and J is the angular momentum of the external electron configuration. For sodium $J=\frac{1}{2}$, and the number

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[1] Breit and Rabi, Phys. Rev. **38**, 2082 (1931).

[2] Rabi and Cohen, Phys. Rev. **43**, 377 (1933).

of levels is $4I+2$. Our method of velocity selection in a strong field involves the use of only one-half the total number of levels. We therefore obtain $2I+1$ components in the deflection pattern. Since we have four components we accordingly find the spin of the sodium nucleus to be $3h/4\pi$.

A complete description of the method and results will be published in this journal.

I. I. Rabi
V. W. Cohen

Columbia University,
March 11, 1933.

Angular Distribution of Low Energy Cosmic Radiation and Interpretation of Angular Distribution Curves

One of us has made an experimental determination of the angular distribution of the cosmic radiation at two different elevations,[1] but an interpretation of the data on the assumption of straight line paths through the atmosphere was not advocated since it was uncertain to what extent the distribution might have been affected by divergences between the paths of primary and secondary rays and by scattering in their passage through the atmosphere. Since it is known that the soft rays suffer the greater deviations[2] we have measured the angular distribution of the radiation which is stopped by 3.8 cm of lead in order to determine the extent to which such scattering affects the angular distribution. At every 15 degree interval between the vertical and horizontal measurements of the coincidence counting rates of three G.M. counters[3] were made alternately with and without a block of lead inserted just above the lower counter.

Each counting rate was the average of fifteen or more independent data, an analysis of which showed that the fluctuations agreed with those to be expected statistically and for which the standard deviation is the quotient of the square root of the total number of counts by the total time. Two such complete runs taken several weeks apart were in good agreement. The differences in counting rates with their probable errors as calculated by combining both sets of data are shown by the experimental points in Fig. 1.

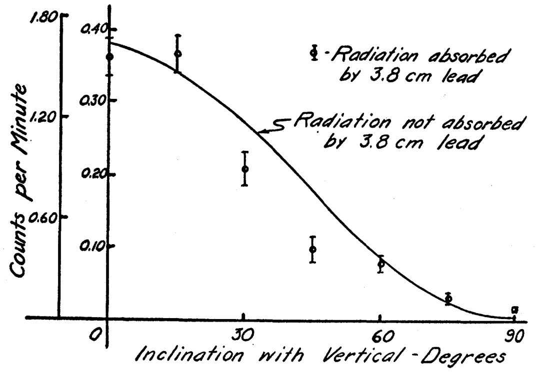

Fig. 1.

For comparison the continuous line represents the distribution of the rays which penetrated the lead plotted to a reduced scale. Although there is an indication that a small fraction of the soft rays, equal to about fifty percent of the horizontal rays, has been scattered through large angles, the majority are fully as concentrated about the vertical as are the penetrating rays, and we may conclude that the distribution of the total radiation is not appreciably broadened by scattering. We may, therefore, interpret the angular distribution of the total radiation on the basis of straight line paths through the atmosphere.

Assuming a simple exponential law the theoretical distribution is:

$$j(\theta)=j_0e^{-\mu h\sec\theta}$$

In Fig. 2 are plotted three sets of experimental data showing the distributions on Mt. Washington, New Hampshire, at a base station near Mt. Washington, and on the roof of the Bartol Laboratory. The theoretical distributions for sea level and the top of Mt. Washington for $\mu=0.18$ per meter of water are represented by the continuous curves. The agreement between the observed and calculated dis-

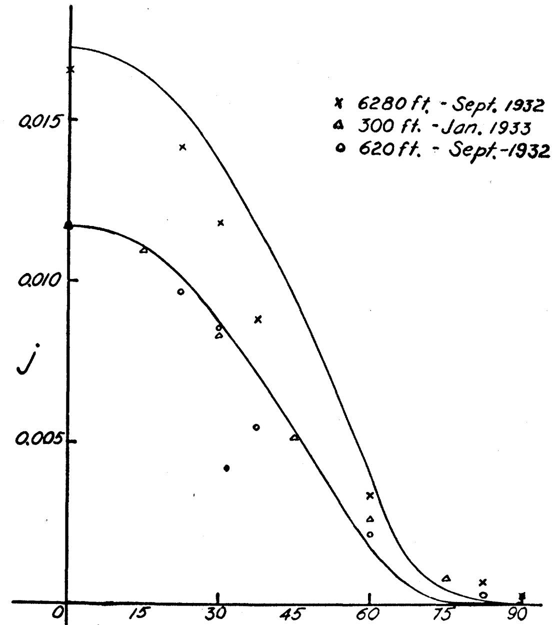

Fig. 2. Distribution of total radiation. Points are experimental; solid curves are computed for $\mu=0.18$ per meter of water for elevations sea level and 6280 ft.

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[1] T. H. Johnson, Phys. Rev. **43**, 307 (1933).

[2] C. D. Anderson, Phys. Rev. **43**, 381 (1933).

[3] T. H. Johnson and J. C. Street, J. Frank. Inst. **215**, 239 (1933).