the quantity $l/2\delta$, where l = electron mean free path and δ = skin depth. This function is shown in Fig. 1.

The calculation of $\sigma_{\text{r-f}}/\sigma_{\text{d.c.}}$ for any given l (i.e., for a $\sigma_{\text{d.c.}}$) must be carried out self-consistently since δ depends on $\sigma_{\text{r-f}}$. The theoretical curve of $\sigma_{\text{r-f}}$ at 10^4 megacycle/sec. *versus* $\sigma_{\text{d.c.}}$ for the metal silver is shown in Fig. 2. It is to be noted that $\sigma_{\text{r-f}}/\sigma_{\text{d.c.}}$ decreases rapidly with increasing $\sigma_{\text{d.c.}}$. $\sigma_{\text{d.c.}}$ may be increased by decreasing the temperature.

The above results are in qualitative agreement with recent experiments performed on lead[2,3] at M.I.T.

At infra-red frequencies, the effect of skin depth is again small and one obtains the usual expression[4] for the r-f conductivity.

The author wishes to thank Dr. H. C. Torrey for suggesting this problem to him.

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* This work was supported in part by funds provided by the Research Corporation, F. G. Cottrell Grant, and by the Rutgers University Research Fund.

[1] A. H. Wilson, *The Theory of Metals* (Cambridge University Press, 1936), pp. 3, 158.

[2] J. C. Slater, private communication.

[3] J. G. Daunt has recently informed the author that A. B. Pippard of the Royal Society Mond Laboratory, England, has several papers in press in the Proc. Roy. Soc. on both the experimental and theoretical aspects of this subject.

[4] See reference 1, p. 123ff.

Abnormality in Cosmic-Ray Absorption in Lead in Low Latitudes*

W. F. G. Swann and P. A. Morris
Bartol Research Foundation of the Franklin Institute, Swarthmore, Pennsylvania
October 27, 1947

THE apparatus used comprised two cosmic-ray telescopes in parallel, each supplied with five counter trays. Lead could be placed between trays 3 and 4 and between trays 4 and 5. Triple coincidences were observed between trays 3, 4, and 5.[1] Six centimeters of lead were placed above the apparatus to shield out electrons and a shield was also placed around the top tray.

In taking the aforementioned observations, and in order to allow for possible variations of the cosmic-ray intensity throughout those observations which extended over about ten days, the plan was not to complete the observations for any one lead thickness, a, and then pass on to another thickness, b, but to take a few observations for all thicknesses ranging from the smallest to the largest, then another few observations with thicknesses ranging from the largest to the smallest, then another set ranging from the smallest to the largest, and so on. In this manner, each thickness of lead was tested with rays which, on the average, were of exactly the same kind. Also the procedure was to make observations without lead, with 1 cm of lead between trays 3 and 4 and another between trays 4 and 5, then with two 1-cm slabs between trays 3 and 4 and two between trays 4 and 5, proceeding in this way until a totality of 20 cm of lead had been reached. Observations were made with each of the two telescopic units, and the results were combined.

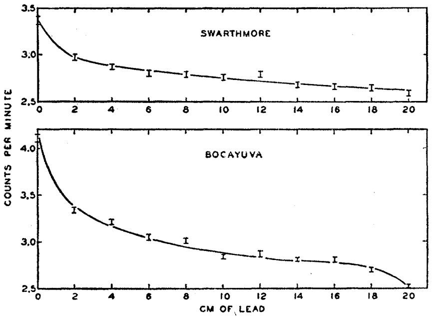

FIG. 1. Coincidence rate *vs.* lead-absorber thickness.

Figure 1 shows the data obtained at Bocayuva (magnetic latitude 7°S) and at Swarthmore (magnetic latitude 51.5°N). The Bocayuva curve shows an approximately 10 percent drop at a total lead thickness of 22 cm. Experiments performed by S. V. Chandrashekhar Aiya at Bangalore show a 5 percent drop at 21 cm of lead. On the other hand, the Swarthmore curve shows no appreciable drop. These facts seem to invite the belief that the phenomenon resulting from a component of the radiation which is present in low latitudes is absent in high latitudes. This aspect is being developed in detail by one of us elsewhere.

One element rather difficult to reconcile is the fact that the altitude at Bocayuva is 2300 feet while that at Bangalore is 3100 feet. The difference in lead absorption is the equivalent of about 7 cm of lead. It is rather surprising, therefore, that the phenomenon seems to take place at approximately the same lead thickness at Bocayuva as at Bangalore, suggesting that it is concerned purely with something happening in the lead as distinct from something depending upon the energy of the rays.

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* Supported by funds from Navy Contract N6ori-144 and from the National Geographic Society, also by airplane services from the U. S. Army Air Force.

[1] The other trays were for another purpose.

Microwave Spectra: Methyl Cyanide and Methyl Isocyanide*

Harold Ring,** Howard Edwards, Myer Kessler,** and Walter Gordy
Department of Physics, Duke University, Durham, North Carolina
November 7, 1947

THE first and second rotational transitions of CH_3CN and of CH_3NC have been studied in the microwave region.

Nuclear Effects. The spectrum of CH_3CN shows a definite hyperfine structure which can be attributed to the quadrupole moment effects of the nitrogen nucleus. Figure 1 shows the $J=0$ to $J=1$ transition, which is split into only three components by the nuclear effects. Accurate measurement of the separation of the components was made by a method evolved in this laboratory.[1] The bars give the theoretically predicted hyperfine structure. The magnitude of the coupling coefficient, $eQ(\partial^2 V/\partial z^2)$, thus deter-

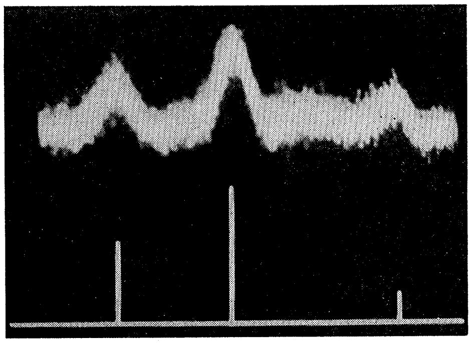

FIG. 1. Theoretical and observed hyperfine structure in the $J=0$ to $J=1$ rotational transition of CH_3CN occurring at 18,400 Mc. Observed spacing of lines are 1.40 Mc/sec. and 2.10 Mc/sec. from central line.

mined is 4.67±0.10 Mc. This differs somewhat from that given by Townes and his co-workers[2] for the nitrogen coupling in ClCN, 3.66±0.15 Mc. This difference is significantly greater than that allowed by the probable experimental errors and must be attributed to differences in the electronic structures of the molecules. An even greater difference is shown for CH_3NC, for which the hyperfine structure could not be resolved. This indicates that the absolute value of the coupling factor $eQ(\partial^2V/\partial z^2)$ must be less than about one megacycle and implies a rather symmetric distribution of electronic charge about the nitrogen nucleus.

In calculating the hyperfine structure, the formula,

$$T_F=\left(eQ\frac{\partial^2V}{\partial z^2}\right)\left(\frac{3K^2}{J(J+1)}-1\right)\frac{\frac{3}{4}C(C+1)-I(I+1)J(J+1)}{2I(2I-1)(2J-1)(2J+3)},$$

where

$$C=F(F+1)-I(I+1)-J(J+1)$$

was used. This formula differs slightly from that given by Coles and Good[3] and that used in previous papers[4] from this laboratory. Though both formulas give correct positions of the lines, they yield different coupling coefficients except when $I=\frac{3}{2}$. The different formulas apparently arise from different definitions of quadrupole coupling existing in the literature. The above formula is used so that the coupling coefficient may be compared with the results of Townes and his associates.

Molecular Properties. The structure of the second rotational line of CH_3CN ($J=1$ to $J=2$ transition), observed at 36,800 Mc, reveals a purely symmetric top configuration for this molecule. The moment of inertia, I_B, determined from the present measurements is 90.9×10^{-40} g cm², compared with 92.8×10^{-40} g cm², computed from the dimensions determined by electron diffraction.[5] For the $J=0$ to $J=1$ transition of CH_3NC a single line was observed at 1.488-cm wave-length. However, in the region of the second rotational transition, about 7.45-mm wave-length, a group of eight lines was observed, dispersed over a region of 330 Mc. These are too widely spaced to represent hyperfine structure caused by the nitrogen nucleus. An attempt is being made to interpret the spectrum on the basis that the molecule is a very slightly asymmetric top, i.e., that the CNC group is not quite linear. Because the compound is rather unstable some of the lines may be due to impurities. We are attempting to determine whether this is true, or if any of the lines arise from molecules in excited vibrational states. Assuming the symmetric top configuration, the moment of inertia is 83.2×10^{-40} g cm², in satisfactory agreement with the most recent electron-diffraction data,[6] from which the moment of inertia, I_B, is determined as 84.8×10^{-40} g cm².

We wish to thank Dr. Walter M. Nielsen for his interest in the project.

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** Frederick Gardner Cottrell Fellow.

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Sea Level Latitude Effect of Cosmic Radiation*

PETER A. MORRIS, W. F. G. SWANN, AND H. C. TAYLOR
Bartol Research Foundation of the Franklin Institute, Swarthmore, Pennsylvania

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ON a recent voyage from Rio de Janeiro to Boston the vertical intensity of the total and hard components of the cosmic radiation were measured with a Geiger counter telescope apparatus. The hard component was measured both through 8 cm and 16 cm of lead.

The apparatus consisted of two identical units each with five trays of nine Geiger counters in parallel. The individual counting rates of the counters, their dead times, and the resolving time of the circuits were sufficiently small to preclude their contributing to any spurious effects on the coincident rates of the telescopes.

While the vertical intensity of the total and hard components of the radiation are measured directly, the intensity of the soft component must be arrived at by the difference between the other measured quantities. Such a method gives rise to considerably larger probable errors in the determination of the latitude effect, and the method has been criticized for this reason. Certain observers have made an effort to circumvent this difficulty by measuring the radiation underneath from 1 to 2 cm of lead to determine the latitude effect of the soft component. In any event,

TABLE I. Percentage diminution in the vertical intensity.

Telescope	Total radiation No lead	Hard component 8 cm	16 cm	Soft component 8-cm diff.	16-cm diff.
1 and 2	5.05±0.55	5.26±1.27	5.36±1.33	4.3±4.6	4.5±4.3
1	5.34±0.77	4.96±0.92	6.20±0.97	6.0±2.8	3.7±2.9
2	4.76±0.75	5.56±0.88	4.51±0.91	2.6±3.7	5.3±3.2
Combined		5.32±0.46		4.46±0.61	

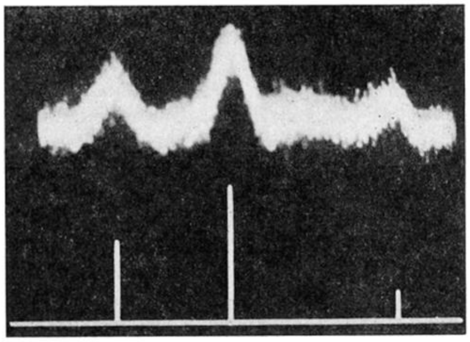

FIG. 1. Theoretical and observed hyperfine structure in the $J=0$ to $J=1$ rotational transition of CH_3CN occurring at 18,400 Mc. Observed spacing of lines are 1.40 Mc/sec. and 2.10 Mc/sec. from central line.