cathode ring. Since the electron velocity during the injection pulse falls as the electron enters the injector, goes through a minimum as it passes through the cathode ring, and rises to its initial value as the electron leaves the gun, it is necessary to supply a compensating magnetic field in the neighborhood of the injector during the injection pulse.

An injector of this type has been designed at the Naval Research Laboratory and is under development.

The Beta-Ray Spectrum of C^{14}[1]

PAUL W. LEVY
Clinton Laboratories, Oak Ridge, Tennessee
June 9, 1947

A 180° beta-ray spectrometer of 10-cm radius, using a Geiger-Mueller tube as the detecting device, has been used to investigate the continuous beta-ray spectrum of the 4700-year C^{14} activity. It was necessary to use a very thick source because of the long half-life and low concentration of C^{14} in the available material. The spectrum obtained with this source appears simple, that is, it has only one component and has a maximum energy of 0.154 Mev. As is to be expected from the fact that no gamma-rays have been detected accompanying the decay of C^{14}, no conversion electron lines appear.

The maximum energy of the beta-ray spectrum was determined from the Kurie plot, Fig. 1, which was constructed from that part of the spectrum high enough in energy so that absorption in the window of the detecting G. M. tube is negligible. One cannot say, however, that this part of the spectrum is entirely free from the effects of self-absorption and back scattering due to the thickness of the source. These effects might possibly combine in a way that introduces an undetermined error in the 0.154-Mev end point and, therefore, one cannot claim the 2 percent inherent accuracy of the spectrometer at this energy. Yet it is surprising that the Kurie plot is straight, and, if it were not for the unusual thickness of the source, one would interpret this as evidence that the spectrum was free from large disturbing effects.

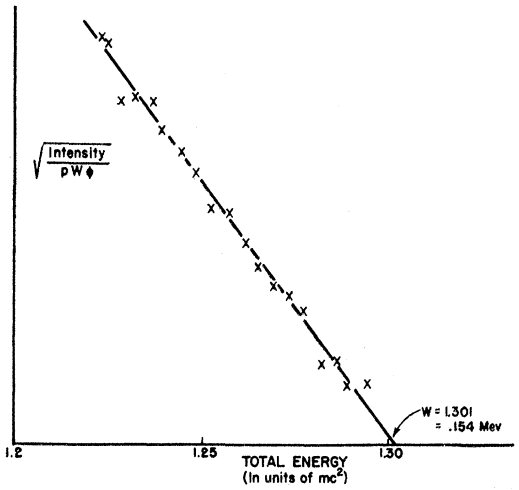

FIG. 1. Kurie plot of C^{14} beta-ray spectrum.

The author wishes to express his thanks to L. D. Norris for preparing the C^{14} source.

This work was done under the auspices of Manhattan District Contract W 7405-eng. 39.

[1] A detailed description of this work and the spectrometer used is contained in Plutonium Project Report CP-3702 which is to be published as a contribution to the Plutonium Project Record volume on nuclear physics.

On the Change of the Mean Life of Negative Mesotrons

HAROLD K. TICHO AND MARCEL SCHEIN
Department of Physics, University of Chicago, Chicago, Illinois
June 23, 1947

RECENT experiments[1,2] have demonstrated that negative mesotrons, stopping in solid materials of low atomic number, do disintegrate; this result is in contradiction with the calculations of Tomonaga and Araki[3] who predicted that mesotrons carrying a negative charge should be captured by the nuclei of solid absorbers, whatever their atomic number. Subsequently, Fermi, Teller, and Weisskopf,[4] and also Wheeler[5] investigated the energy loss of mesotrons after they have stopped ionizing and concluded that negative mesotrons should fall into the (mesotron) K-shell within 10^{-12} second. From the K-orbit, mesotrons can either be captured by the atomic nucleus or disintegrate spontaneously. Their decay constant should therefore be $\lambda+\Lambda$, where $1/\lambda=\tau_0$ is the mean life for disintegration and Λ the probability per second for capture. The fact that the disintegration of negative mesotrons is observed in light absorbers indicates that Λ is not much larger than λ; hence, $\Lambda\sim 5\times 10^5$ sec.$^{-1}$, which is in strong disagreement with meson theories which yield $\Lambda\sim 10^{18}$ sec.$^{-1}$. According to Wheeler[5] Λ should increase roughly as Z^4.

If it is true that the capture probability is considerably smaller than that calculated on the basis of meson theories of nuclear forces, then the disintegration electrons arising from the decay of negative mesotrons should also follow a disintegration curve with the modified decay constant $\lambda+\Lambda$. The number of negative mesotrons dN_d^-, *disintegrating* in the time interval dt, is equal to the original number of negative mesotrons N_0^- times the probability that they have neither disintegrated nor been captured before t, $\exp(-\lambda t-\Lambda t)$, times λdt. The integration of this expression yields

$$N_d^-=N_0^-[\lambda/(\lambda+\Lambda)]\exp[-(\lambda+\Lambda)t].$$

The capture constant Λ could, therefore, be measured by determining the mean life $1/(\lambda+\Lambda)$ of negative mesotrons alone. In such a determination one should use $\tau_0=2.15\times 10^{-6}$ second for $1/\lambda$. This value of τ_0 was obtained by Nereson and Rossi[6] chiefly in lead, where negative mesotrons do not disintegrate.

If the experiment is carried out in the usual way, i.e., without differentiating between positive and negative mesotrons, a small change of the disintegration constant

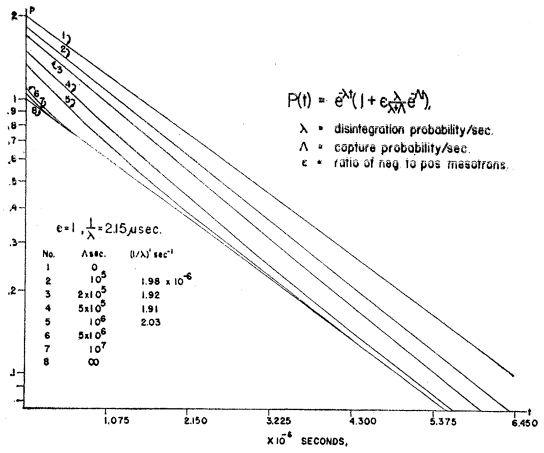

FIG. 1. The integral-disintegration curves which should be obtained if negative mesotrons both disintegrate and get captured. The values $(1/\lambda)'$ are the "mean-life" value calculated from the average slope of these curves.

should still be observable in materials of suitable atomic number. This change of the disintegration constant is due to the fact that the experimental data obtained really represent a superposition of two decay curves, one produced by positive mesotrons with a mean life $1/\lambda$ and one produced by negative mesotrons with a mean life $1/(\lambda+\Lambda)$. Hence, the total disintegration curve is represented by the following expression:

$$N_d = N_0^+ \exp(-\lambda t) + N_0^-[\lambda/(\lambda+\Lambda)] \exp[-(\lambda+\Lambda)t].$$

Disintegration curves of this kind for values of Λ between 0 and ∞, and assuming an equal number of positive and negative mesotrons, are shown in Fig. 1. The quantities $(1/\lambda)'$ are the "changed" values of the mean life obtained by determining the average slope of the curves for a time interval from 1×10^{-6} to 4.5×10^{-6} sec. This "change" may be as large as 11 percent. From the curves, however, it is clear that in such an investigation particular attention must be paid to very short decay times, especially if the capture constant is large. This consideration applies also to experiments where the ratio of disintegration electrons to stopped mesotrons is measured.

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[2] T. Sigurgeirsson and A. Yamakawa, Phys. Rev. **71**, 319 (1947).
[3] S. Tomonaga and G. Araki, Phys. Rev. **58**, 90 (1940).
[4] E. Fermi, E. Teller, and V. Weisskopf, Phys. Rev. **71**, 314 (1947).
[5] John A. Wheeler, Phys. Rev. **71**, 320 (1947).
[6] N. Nereson and B. Rossi, Phys. Rev. **64**, 199 (1943).

Analysis of the Hyperfine Structure in the Microwave Spectrum of the Symmetric Top Molecule CH_3I*

WALTER GORDY, A. G. SMITH, AND JAMES W. SIMMONS
Department of Physics, Duke University, Durham, North Carolina
June 7, 1947

THE preliminary measurements[1] of the $J=1$ to $J=2$ rotational transition of CH_3I have been repeated at a lower temperature, $-70°C$. As a result of the increased absorption at the lower temperature, additional lines have been observed and a more accurate estimate of relative intensities has been made.[1] The measurements at low temperature revealed that none of the observed lines arises from molecules in excited vibrational states.

A complete analysis of the hyperfine structure resulting from the nuclear quadrupole moment of iodine has now been made. In Fig. 1 the theoretically predicted structure is compared with that experimentally observed.[2] The particular formula used to calculate the positions of the CH_3I lines is that used by Coles and Good[3] to calculate the quadrupole effects in NH_3:

$$T_F = [eQ\partial^2 V/\partial z^2]\cdot[3K^2/2J(J+1)-\tfrac{1}{2}] \cdot[3C(C+1)-4J(J+1)I(I+1)/(2J-1)(2J+3)(2I-1)(2I+3)], \quad (1)$$

where

T_F represents the hyperfine splitting of the rotational energy levels,
$C=F(F+1)-I(I+1)-J(J+1)$,
$F=J+I, J+I-1, \cdots J-I$ (or to $I-J$ when $I\geqq J$),
$I=5/2$, the nuclear spin of iodine, and
$eQ(\partial^2 V/\partial z^2)$ represents the quadrupole coupling coefficient, Q being the quadrupole moment of iodine, V, the molecular potential at the iodine nucleus, and z, the coordinate axis along the C—I bond.

Because of the nuclear effects the K-levels, associated with a given J-level, which otherwise would be degenerate for low J-values, are well separated. This allows two hyperfine patterns for the $J=1$ to $J=2$ transition corresponding to the transitions $0\rightarrow0$ and $1\rightarrow1$ for K. The relative intensities of the lines of a given K-transition can be determined from the intensity rules for atomic fine structure. To determine the relative intensities of the two

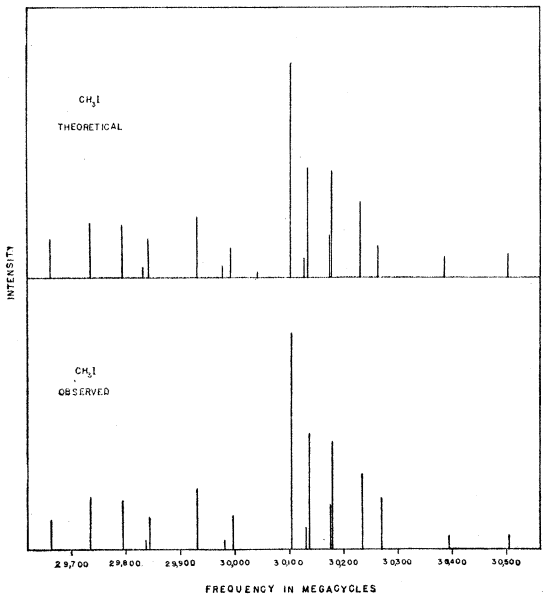

FIG. 1. Theoretical and observed hyperfine structure of the CH_3I spectrum for the rotational transition $J=1$ to $J=2$.