The Mean Life of Mesotrons at an Altitude of 11,500 Ft.

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IN 1943 Nereson and Rossi[1] described an experiment for determining the mean life of cosmic-ray mesotrons at sea-level in various solid absorbers. The purpose of this letter is to report on a measurement of the mean life which was carried out at Climax, Colorado (11,500 ft. above sea-level) to determine whether the mean life is altitude-dependent. The method consisted of a direct comparison of the lifetime of each individual mesotron, stopping in a 10-cm Al absorber with the period of vibration of an accurately calibrated quartz crystal.[2] Figure 1 shows the counter-tube assembly, and the integral-decay curve obtained by this method. The upper set of points between 0.05 and 0.5 μsec. represents the total number of delays observed with the Al absorber in its place, whereas the lower set was obtained by subtracting all delays occuring with the Al absorber removed. When delays of this kind (produced by natural delays in the counters accompanying a simultaneous event) are subtracted, the curve remains a true exponential to time delays as small as 0.05 μsec. This fact indicates that if any contribution to the decay curve of delays arising from the disintegration of of short-life ($\tau_0 < 10^{-8}$ sec.) mesotrons should exist, it must be quite negligible for time intervals larger than 0.05 μsec.

The data in Fig. 1 were analyzed according to the statistical method of Peierls[3] which permits an evaluation of the mean life and its standard deviation from a set of individual lifetime determinations. The value obtained by this method for the mean life of mesotrons at rest is $\tau_0 = 1.78 \pm 0.10$ μsec. For the calculation of the standard deviation the points between 0.05 and 0.5 μsec. were omitted because of the natural delays which occur occasionally in the G. M. counters in that interval. Assuming that the mean range of the disintegration electrons, having an energy of 50 Mev, is 7 cm in Al, the ratio of disintegration electrons to mesotrons stopped in the absorber is calculated to be 0.50 ± 0.06.

The value for the mean life determined at Climax is not in complete agreement with that obtained by Nereson and Rossi[1] at sea-level. These authors compiled their best value

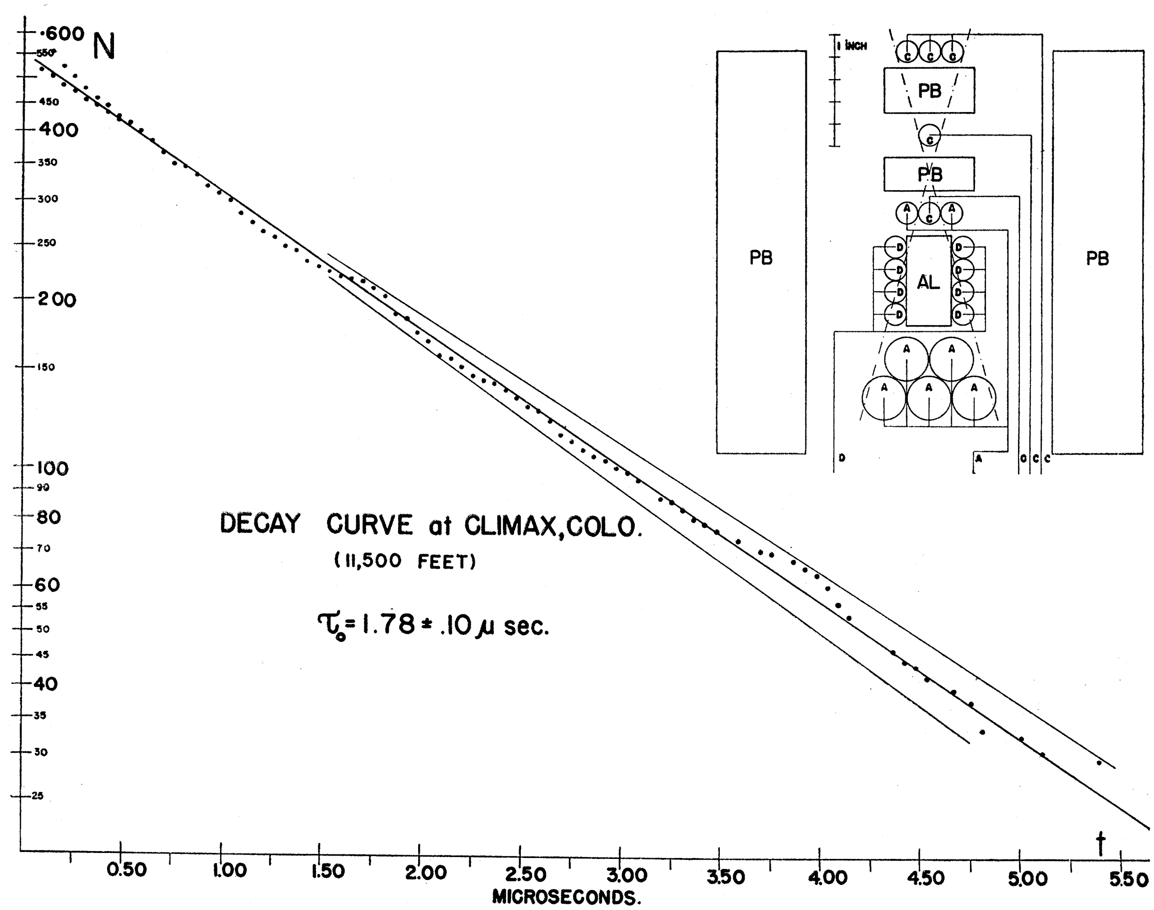

FIG. 1. The counter-tube assembly and the integral-disintegration curve obtained at Climax, Colorado. The upper set of points in the time interval from 0.05 to 0.5 μsec. is due to counter-pulse delays accompanying simultaneous events.

for the mean life $\tau_0=2.15\pm0.07$ μsec. by adding all their data collected in various materials. It seems difficult to explain the difference between the two values by a systematic error in the experimental method since the disintegration curve appears linear, and hence the error would have to increase *linearly* with the time interval which has actually been recorded. A shortening of the mean life, however, may be due to a contribution by negative mesotrons decaying in the absorber. The following letter explains why such a contribution might result in an apparent change of the mean life.

The author wishes to express his gratitude to Dr. Walter O. Roberts of the Fremont Pass Station of the Harvard College Observatory at Climax, and to the Climax Molybdenum Company for making available the facilities required for carrying out this investigation.

[1] N. Nereson and B. Rossi, Phys. Rev. **64**, 199 (1943).
[2] H. Ticho, Rev. Sci. Inst. **18**, 271 (1947).
[3] R. Peierls, Proc. Roy. Soc. **149**, 467 (1935).

Errata: The Double Focusing Beta-Ray Spectrometer

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DR. EDWIN M. McMILLAN has kindly pointed out an error in our article which he discovered by comparing our equations with the results of some earlier unpublished calculations of his own. The error has its origin in the expression for H_z given on page 682. The last term in this equation should read $[-(\beta-\alpha/2)z^2H_0/a^2]$. The subsequent calculations are, we believe, all correct, but this correction introduces changes in certain of the coefficients in the equations. The final result, the expression for r^* given in Eq. (25), must be modified as follows. The coefficient of $(\delta z)^2$ should be $[(4\beta-3)/3a]$ rather than $[(4\beta-2)/3a]$. The coefficient of ϕ_z^2 should be $[(16\beta/3-2)a]$ rather than $[(16\beta/3-2/3)a]$. The remaining terms, as well as Eq. (26), are correct as they stand.

The new expression for r^* is less favorable, since the ϕ_r defocusing may be eliminated for $\beta=\frac{1}{8}$ but not the ϕ_z defocusing. To eliminate the latter, β must equal $\frac{3}{8}$. The correct choice of β will depend upon the baffle system to be employed. It may often be more convenient to allow a wider variation in ϕ_r than in ϕ_z in which case β should be $\frac{1}{8}$. Although the focused image will not be as perfect as that shown in Fig. 1, the conclusion still stands that, with the double focusing spectrometer, the image may be made both more intense and also sharper than with the usual semicircular spectrometer.

Another advantage pointed out to us by Dr. McMillan is that the dispersion ($p\delta r/r\delta p$ where p is the electron momentum) is twice as great as in the semicircular case.

Since submitting our paper we have received a reprint from Dr. N. Svartholm[1] in which the image formed by a point source is discussed. His results are in agreement with our corrected equations.

[1] N. Svartholm, Ark. f. Mat. Astron. och Fys. **33A** [24] (1946).

On the Magnetic Exchange Moment for H³ and He³

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RECENT experiments of Bloch and others[1] on the magnetic moment of H^3 gave the value 1.0666 for the ratio of the magnetic moments of H^3 and proton. Assuming a value of 2.789 n.m. for $\mu(p)$, we find $\mu(H^3)=2.975=\mu(p)+0.186$ n.m. This result seemed to be in contradiction to the results of theoretical investigations of Sachs and Schwinger,[2] which require $\mu(H^3)\leqslant\mu(p)$, unless very artificial assumptions on the ^2P and ^4P admixtures to the S-component of the ground-state eigenfunction are made.[3]

However, Schwinger's ansatz[4] for the nuclear Hamiltonian does not allow for taking into account the charge-exchange phenomena connected with the interaction of nucleons. On the other hand, it is well known that these phenomena give rise to exchange moments.[5] Whereas the magnetic exchange dipole moment vanishes in the case of the deuteron (on account of the symmetry properties of the de-eigenfunction), this is not the case for H^3 and He^3, provided that the quantum number T of the total isotopic spin is $\frac{1}{2}$. (It vanishes for $T=\frac{3}{2}$.)

A calculation has been carried out on the basis of the symmetrical pseudoscalar meson theory. According to this theory, the H^3 and He^3 ground states are doublet states both with respect to spin and isotopic spin ($S=T=\frac{1}{2}$) and symmetrical with respect to permutations of the space coordinates of the particles, if we neglect the influence of the tensor force. The latter is responsible for small admixtures of higher states, the influence of which may be neglected here, since there is a non-vanishing expectation value of the exchange moment in the above described S state.

The exchange moment operator is given by $M=M^{(1)}+M^{(2)}$:

$$M^{(1)}=-\frac{ef^2}{2}\mu\sum_{A<B}(\tau^A\times\tau^B)_3\left\{z^{AB}(z^{AB}\cdot\sigma^A\times\sigma^B)\Big/ r_{AB}^2\cdot\left(1+\frac{1}{\mu r_{AB}}\right)-(\sigma^A\times\sigma^B)\right\}e^{-\mu r_{AB}},$$

$$M^{(2)}=+\frac{ef^2}{2}\mu^2\sum_{A<B}(\tau^A\times\tau^B)_3\cdot(z^A\times z^B)\cdot V(AB),$$

where $V(AB)$ is the interaction energy of the nucleon pair AB in the pseudoscalar theory:

$$V(AB)=\left\{\tfrac{1}{3}(\sigma^A\sigma^B)+(3(\sigma^Az^{AB})(\sigma^Bz^{AB})/r_{AB}^2-(\sigma^A\sigma^B))\times\left(\frac{1}{3}+\frac{1}{\mu r_{AB}}+\frac{1}{(\mu r_{AB})^2}\right)\right\}\frac{e^{-\mu r_{AB}}}{r_{AB}}.$$

On account of its symmetry properties, the expectation value of $M^{(2)}$ vanishes, whereas $M^{(1)}$ gives, in units of nuclear magnetons

$$M^{(1)}=(8/3)\gamma(f\mu)^2\cdot T_3\int dv\varphi^2\left(\frac{1}{\mu r_{AB}}-2\right)e^{-\mu r_{AB}}.$$

(γ is the ratio of the masses of proton and meson: $\gamma\cong10$,