scale) for the available experimental data for proton and α-particles. The values of R for the Ilford C2 emulsion in "dry conditions" were taken as follows: α-particles from Picciotto,[1] Green and Gibson[2] and Lattes, *et al.*;[3] for protons from Lattes, *et al.*[3] and Bradner, *et al.*[4]. The ranges in air for α-particles were taken from Feather;[3,5] for protons, from Smith.[6] The full line was obtained by the least square method and corresponds to the values $A=2760$ and $k=0.157$. It agrees with the experimental points within 2 percent. As pointed out by Bradner, *et al.*,[4] the moisture content has a special importance in the stopping power of the emulsions; it seems to us that this results mainly from its effect on the density of emulsion. Small deviation of the experimental points from the straight line may be attributed to this effect. It is therefore necessary to standardize the figures on the basis of dry atmosphere or vacuum conditions.

We also plotted the points for fission fragments,[7,8] the one which falls closer to the line corresponding to the lightest fragment.

Comparison with experimental data for electrons is rendered difficult by the fact that the only available data for range-energy relations in emulsions are the ones in NT4 plates.[9] However, the calculations on the basis of the chemical composition[10] using Webb-Cüer's[11] method shows that in the range of β from 0.3 to 0.8 the stopping power of C2 and NT4 agrees within 2 percent. In the upper part of Fig. 1, "s" (and the corresponding standard deviation) is plotted against β, for the experimental data of Ross and Zajac,[9] the ranges in air being taken from Tsiang *et al.*,[12] up to 100 kev and from M. Curie[13] for higher energies (in this region Curie's curve is practically an extrapolation of Tsiang's). The full line is the one previously determined. Although the discrepancy of the points with the curve goes up to 8 percent, we cannot exclude the possibility of a good agreement as the standard deviations are of the order of 20 percent.

One expects that better experimental results may decide on the general validity of relation (1) regardless of the nature of the particles up to values of β 0.8 or larger, except for very heavy particles at low velocities.

We are indebted to Mr. J. Tiomno for helpful discussions.

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A Metastable State of Half-Life 13×10^{-8} Sec. in $_{71}Lu^{177}$ *

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October 14, 1949

Using sources of Yb^{177} (1.8 hr.) and an experimental arrangement similar to that described in a previous letter,[1] delayed coincidences well above the random coincidence rate were detected. In Fig. 1 the number of delayed coincidences after subtraction of random coincidences is plotted as a function of delay time. It appears from this curve that the disintegration of Yb^{177} leads to a metastable state Lu^{177*} which in turn decays to the ground state with a half-life of $(13\pm2)\times10^{-8}$ sec.

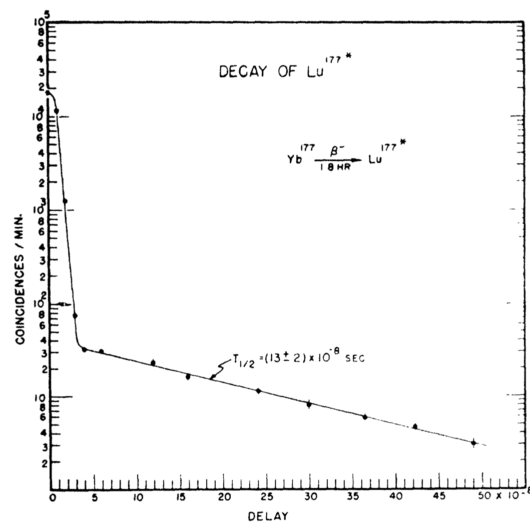

FIG. 1. Delayed coincidences as a function of delay time.

In order to reduce the variable delay introduced by a pulse height selector operating on signals of different amplitude with a finite rise time, the amplifiers were replaced by video amplifier sections with a rise time of approximately 10^{-8} sec. and maximum gain of 240. The pulses may be delayed in discontinuous steps after the first stage of amplification by inserting terminated coaxial cables (RG 7/U; characteristic impedance 100 ohms) which introduce a delay of 10^{-8} sec. per 9 feet. Pulse discrimination is performed after the coincidence stage at the input to the scalar. The resolving time of the coincidence circuit is 2.5×10^{-8} sec. The stilbene crystals and 1P21 multiplier tubes are cooled to dry-ice temperature and operated at 80 volts per stage.

A delayed coincidence scintillation spectrometer was used to investigate the radiation spectrum resulting from the isomeric transition of Lu^{177*}. For this purpose anthracene crystals and Type 5819 multiplier tubes operated at room temperature were used with the delayed coincidence unit described in the previous letter.[1] A differential pulse height selector was used in the channel

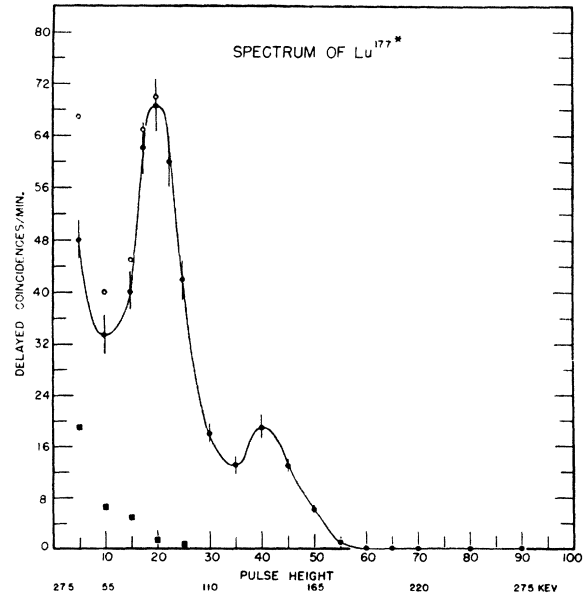

FIG. 2. Delayed coincidence counting rate as a function of pulse height.

for detection of delayed radiation. By counting delayed coincidences in a small height interval against pulse height, a measurement of the spectrum of the delayed radiation is obtained. Figure 2 shows the result of such a measurement.

The scale of the pulse height dial *B*as calibrated in energy units by using the *K* and *L* internal conversion lines of the 132-kev transition from the decay of the 22μsec. metastable state in Ta^{181*} and the *K* internal conversion line of the 247-kev transition from the decay of the 8×10^{-8} sec. metastable state in Cd^{111*}.[2] The latter isomeric state was detected using sources of Cd^{111*} (48 min.) produced by (n,γ) reaction on a sample of enriched Cd^{110}.

The solid curve is the conversion electron spectrum obtained after subtraction of the Compton electron distribution produced by the γ-rays and x-rays. The *K* and *L* conversion lines at 87 and 140 kev correspond to a (150 ± 10) kev transition. From the energy and half-life of this isomeric state the transition is probably electric octupole radiation or a combination of electric octupole and magnetic quadrupole radiation. It appears from this curve that no other γ-rays follow in cascade with the decay of Lu^{177*}.

The half-life of Yb^{177} as listed in the table of isotopes[3] ranges from 1.9 to 3.5 hr. A conventional half-life determination is complicated by the presence of the daughter activity Lu^{177} (6.9 day) and the Yb^{175} (100 hr.) present in the sources. By counting delayed coincidences at a fixed delay as a function of time, the coincidence rate decreases according to the decay of Yb^{177}. The decay was observed for 6 hr. and the half-life of Yb^{177} appears to be (1.8 ± 0.1) hr.

* This document is based on work performed under Contract No. W-7405, eng. 26 for the Atomic Energy Project at Oak Ridge National Laboratory, Oak Ridge, Tennessee.

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Remarks on Non-local Spinor Field

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IN a recent letter to the editor,[1] it was shown that quantized non local fields could be so constructed as to represent assemblies of particles with the definite mass and radius. In a paper, which will appear very soon,[2] detailed account is given together with the elucidation of most of the points, on which the author was not very sure when he wrote the above letter.[1] However, there is still one point, which seems to the author to be unsatisfactory. Namely, in the case of non-local spinor field, we assumed the commutation relation

$$\beta_\mu[x^\mu, \psi]+\lambda\psi=0 \tag{1}$$

between the space-time operators x^μ and the non-local spinor operator ψ, in addition to the commutation relation

$$\gamma^\mu[p_\mu, \psi]+mc\psi=0 \tag{2}$$

between ψ and the space-time displacement operators p_μ. Further, we assumed that γ^μ, β_μ, which were matrices with four rows and columns, were defined by

$$\left.\begin{matrix} \gamma^1=i\rho_2\sigma_1, & \gamma^2=i\rho_2\sigma_2, & \gamma^3=i\rho_2\sigma_3, & \gamma^4=\rho_3 \\ \beta_1=\rho_3\sigma_1, & \beta_2=\rho_3\sigma_2, & \beta_3=\rho_3\sigma_3, & \beta_4=-i\rho_2 \end{matrix}\right\}. \tag{3}$$

Now the difficulty was that, in contrast to (2), the relation (1) was not invariant with respect to the improper Lorentz transformation with the determinant -1, but was to change itself into the form

$$\beta_\mu[x^\mu, \psi]-\lambda\psi=0. \tag{4}$$

In the paper mentioned above,[2] a way of removing this difficulty was indicated, but was very unsatisfactory in that the number of components of the spinor ψ was to be increased from 4 to 8 without any immediate physical interpretation for the extra degree of freedom. It came to the author's notice very recently that the following alternative way was far more acceptable in that no extra components of the spinor were introduced. Namely, we take advantage of the antisymmetric tensor of the fourth rank with the components $\epsilon_{\kappa\lambda\mu\nu}$ which are $+1$ or -1 according as $(\kappa, \lambda, \mu, \nu)$ are even or odd permutations of (1, 2, 3, 4) and 0 otherwise.[3] Further we take into account the relations

$$i\beta_\nu=\gamma^\kappa\gamma^\lambda\gamma^\mu, \tag{5}$$

where $(\kappa, \lambda, \mu, \nu)$ are even permutations of (1, 2, 3, 4). Then (1) can be written in the form

$$\tfrac{1}{6}\sum_{\kappa\lambda\mu\nu} \epsilon_{\kappa\lambda\mu\nu}\gamma^\kappa\gamma^\lambda\gamma^\mu[x^\nu, \psi]+i\lambda\psi=0, \tag{6}$$

which is obviously invariant with respect to the whole group of Lorentz transformations. However, the invariance of (6) can be proved more explicitly by transforming ψ, while the matrices γ^μ are assumed to retain their prescribed forms as defined by (3) independent of the coordinate system. Namely, we can associate a linear transformation

$$\psi'=S\psi \tag{7}$$

with each of the Lorentz transformation

$$x_\mu'=a_{\mu\nu}x_\nu, \tag{8}$$

where S is a matrix with four rows and columns satisfying the relations

$$S\gamma^\mu S^{-1}=a_{\nu\mu}\gamma^\nu. \tag{9}$$

If we insert (7), (8) and (9) in (6) and take advantage of the fact that $\epsilon_{\kappa\lambda\mu\nu}$ are components of a tensor of the fourth rank, we obtain the commutation relation

$$\tfrac{1}{6}\sum_{\kappa\lambda\mu\nu} \epsilon'_{\kappa\lambda\mu\nu}\gamma^\kappa\gamma^\lambda\gamma^\mu[x'^\nu, \psi']+i\lambda\psi'=0, \tag{10}$$

which has the same form as (6).

It should be noticed, however, that the relation (6) is to be regarded as a unification of (1) and (4) rather than the mere reproduction of (1), because (6) must be identified with (4) in the coordinate system, which is connected with the original coordinate system by an improper Lorentz transformation with the determinant -1.

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Detection of Radioactive Atoms in the Air with Nuclear Emulsions

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IT has been shown recently[1] that atoms of a radioactive deposit remaining in the air from the decay of radon can be collected together with the dust from the air on a very small surface area of a glass plate. This is done by allowing air saturated with water vapor to flow (e.g., in a Owens-Běhounek dust-counter[2]) with a considerable velocity through a small jet toward this glass. This was demonstrated by exposing the glass in contact with a nuclear emulsion and by finding many tracks of alpha-particles after development of the plate in the small region, corresponding to the position of the dust-spot on the glass. We explained this phenomenon by at least partial adsorption of atoms of active deposit on dust particles.

New experiments with low activities of the air revealed that this method of collection of radioactive atoms from the air can be