Letters to the Editor

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Remarks on H. W. Lewis' Paper "On the Reactive Terms in Quantum Electrodynamics"[1]

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IN connection with the results of Lewis, it should be noted that once one knows the differential cross section, $\varphi\sigma$, to the first non-vanishing order in $\alpha(=e^2/\hbar c)$ for a process in which a free particle interacts with an electromagnetic field, there is an almost trivial method for determining the correction of order α which has to be applied to this result because one has used the experimental, not the mechanical rest mass of the particle in computing it. This correction, combined with the usual radiative corrections of order α, may be expected to yield a finite result.

To find the correction we remark that the effect of a change in the particle's rest mass (that is, the difference between experimental and mechanical rest masses) on the plane waves, density of states, incident flux, and other quantities entering into the calculation of a cross section is to change the value of M, the parameter representing the mass, and through this the value of the energy defined by $E^2=C^2P^2+M^2C^4$, where P is the particle momentum. P is, of course, unchanged. Hence the first-order correction in $\varphi\sigma$, due to the mass difference δM, is

$$\delta(\varphi\sigma)=\frac{\delta(\varphi\sigma)}{\delta M}\cdot\delta M,$$

where, before differentiation, $\varphi\sigma$ has been expressed as a function only of the mass and of the momenta, and where for δM we substitute the electromagnetic rest mass of the free particle to order α, however, with a minus sign because the experimental mass is greater than the mechanical mass.

Lewis has mentioned my application of this simple method to the problem of radiative corrections to electron scattering; we will consider here the corrections to the scattering of a Pauli-Weisskopf particle by a central field. Two cases will be discussed: (I) the potential is an electrostatic potential and (II) the potential is a world scalar $V(\Lambda)\Psi\Psi^*$, Ψ, being the particle wave function.

We have, keeping just the relevant terms,

$$\varphi\sigma_I\alpha P^2+M^2C^2,$$

$$\varphi\sigma_{II}\alpha\frac{P^2+M^2C^2}{P^2+M^2C^2},$$

$$\delta M=-\frac{\alpha}{\pi M}\int K\varphi K+\cdots,$$

where the dots represent both infinite and finite terms.[2] Therefore, for small momenta

$$\frac{\delta(\varphi\sigma_I)}{\varphi\sigma_I}=-\frac{2\alpha}{\pi M^2}\left(1-\frac{P^2}{M^2C^2}\right)\left(\int K\varphi K+\cdots\right),$$

$$\frac{\delta(\varphi\sigma_{II})}{\varphi\sigma_{II}}=-\frac{2\alpha}{\pi M^2}\left(1-\frac{P^2}{M^2C^2}\right)\left(\int K\varphi K+\cdots\right)+\frac{2\alpha}{\pi M^2}\left(1-\frac{P^2}{M^2C^2}\right)\left(\int K\varphi K+\cdots\right).$$

Dancoff[3] has studied the radiative corrections to this problem. Since in I the part of $\varphi\sigma_I$ which contributes is just the product of the density of states and the incident flux, he found only finite corrections, and did not find the negative of the mass correction because, as Lewis has discussed, he used an inconsistent perturbation method. For the same reason he did not find the negative of the first term in II. However, he does find the nagative of the second term (when the electrostatic terms found by Lewis are included) plus finite terms. Thus, we see that by considering all the corrections we get a finite result in both cases, removing the anomaly found by Dancoff.

Clearly this same procedure will be helpful in determining the mass corrections in Compton scattering, bremsstrahlung, and other processes.

I would like to thank H. W. Lewis and Professor J. R. Oppenheimer for many stimulating discussions.

[1] H. W. Lewis, Phys. Rev. **73**, 173 (1948).
[2] V. Weisskopf, Phys. Rev. **56**, 72 (1939).
[3] S. M. Dancoff, Phys. Rev. **55**, 959 (1939).

On the Mean Life of Negative Mesons

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THE cloud-chamber apparatus, previously described by one of us,[1] has been reconstructed in such a way as to allow measurement of the decay times of individual positive or negative mesons which stop in the specimen block S (compare Fig. 1, reference 1). The time-measuring apparatus is in principle similar to that described by Rossi and Nereson.[2,3]

The decay time is registered by a ballistic meter which is photographed on the same picture as is the cloud chamber.

With this apparatus we have observed that slow mesons of both signs decay in a specimen of type 61-S Duralumin (98 percent Al, 1 percent Mg) and have succeeded in accumulating sufficient data to make rough determinations of the mean lives of the positive and negative mesons.

Our results are shown in Fig. 1 in the form of integral decay distributions. When analyzed by the method of Peierls[4] the mean lifetime is, for the positive mesons 2.19 ± 0.24 microseconds, and for the negative mesons 0.74 ± 0.17 microsecond.