normal phase. In order to explain the proportionality of the heat flow with the cube root of the temperature gradient[9] the force of mutual friction M per unit of volume has to be taken as

$$M = A\rho_s\rho_n(v_s - v_n)^3 + \cdots, \quad (2)$$

where A is about 50 cm sec./gram and decreases with decreasing temperature. Approximately the same value of A is found from the analysis of heat transport and fountain effects in the slits of 5, 10, and 15 microns.

There are very few data on the flow of matter at known values of grad$p$ and grad T. In narrow slits this flow should also be conditioned by the mutual friction and the order of magnitude of the flow agrees satisfactorily with (2).

A detailed comparison with the experimental data will be published in Physica in cooperation with Dr. J. H. Mellink.

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Interaction Energy in Quantum Field Theory

ALEX E. S. GREEN
Department of Physics, University of Cincinnati, Cincinnati, Ohio
September 29, 1948

IN Focks treatment of quantum electrodynamics[1] the auxiliary conditions are eliminated by means of a transformation which when followed by the single time formulation results in the explicit appearance of the Coulomb interaction energy.[2] The purpose of this note is to point out that an extension of this mathematical method will also give the dynamic interaction energy. Thus the solution $\psi = (\exp\chi)\Omega$ where

$$\chi = 1/c\hbar \int d\mathbf{k}[2k_iA_i^*\phi + \Sigma_v(\phi f^{v*}/k - k_iA_i^*f^v/k^2 - \Sigma_w f^w f^{v*}/4k^3 + \alpha_i^v A_i^* f^v/k - \alpha_i^v k_i k_j A_j^* f^v/k^3)],$$

and

$$f^v = (1/2\pi)^{\frac{3}{2}} e^v \exp[i(ckt^v - k_i x_i^v)]$$

leads to a transformed wave equation which does not contain any photon creation operators. Summing the set of wave equations for the various particles, applying the single time formulation, and evaluating the integrals yields Breit's formula,[3] which is good for first-order processes. As is well known it is necessary in the electrodynamic case to discard the infinite self-energies and to evaluate the integrals with care. The first four terms above are equivalent to those used by Fock. The last two replace the perturbation method used to find the dynamic interaction.

The present method is relatively simple, it points out clearly the nature of the approximations, and it avoids the objectionable resolution of the vector potential into longitudinal and transverse components. An analogous procedure may be used to obtain the total interaction energy in vector meson theory, in generalized electrodynamics, and in generalized meson theory.[4]

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On the Range of Decay Electrons from Mesons*

M. H. SHAMOS AND A. RUSSEK
Physics Department, New York University, New York, New York
September 23, 1948

THE slow meson detector described earlier[1] has been used to obtain information regarding the range of decay electrons in carbon. The wide range of energies reported to date[2-8] lends considerable doubt to the hypothesis of a unique decay energy. Moreover, two of the experiments described recently[9,10] showed evidence for a continuous distribution in the range of the decay particles. One of these,[9] in fact, seemed to indicate a continuous distribution superimposed upon a unique range.

The counter telescope is shown in Fig. 1 for reference. The method employed consists in comparing the observed yield (number of electrons detected by "D" per stopped meson) from the cylindrical carbon absorber with the yield calculated on the basis of an assumed range. It was necessary to evaluate the yield numerically, taking into account the distribution of stopped mesons in the absorber. Runs were taken with six absorbers, ranging in radius from ~ 2 to ~ 13 g/cm², and with ~ 32 cm of Pb above the telescope. Background runs were taken without absorber and the data corrected accordingly. Only those electrons which were delayed more than 0.95μsec. were recorded, and these numbers were than extrapolated to zero time on the basis of a 2.15-μsec. mean life. In determining the number of mesons stopped in each case, the decay electrons which passed through the anticoincidence set "E" were recorded

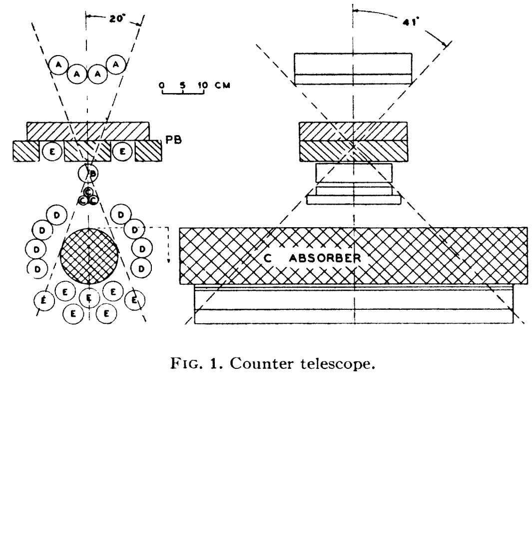

FIG. 1. Counter telescope.

by a separate delay discriminator. This also served to establish the fact that the distribution of decay electrons about the absorber was isotropic.

The results are shown in Fig. 2. Here are plotted the

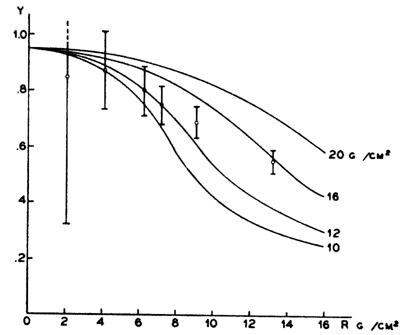

FIG. 2. The yield Y as a function of the absorber radius with range as the parameter.

yield Y as a function of the absorber radius R, with range as the parameter. The indicated deviations are standard statistical errors, and the solid curves show the results to be expected for ***unique*** ranges of 10, 12, 16, and 20 g/cm^2. It is assumed that the electrons escape through the surface of the absorber with sufficient energy to penetrate the counter walls, which are 0.7 mm of brass or equivalent to $\sim$0.5 g/cm^2 of carbon. This correction is taken into account later in translating range into energy.

In computing the theoretical yield curves, it was necessary to know the fraction of mesons which decay in carbon. Assuming Wheeler's[11] fourth-power relation to hold, only 89 percent of the negative mesons should decay in carbon (for $Z_0 \approx 10$), or 95 percent of the total (for a 20 percent positive excess). The fact that the experimental points do not tend toward unit yield as R decreases was taken to indicate some capture of negative mesons. Consequently, the yield curves have been adjusted to a maximum yield of 0.95.

It will be observed that the data are not consistent with a unique range. Instead, the *mean* range tends to increase with increased radius of absorber. For absorber radii up to $\sim$8 g/cm^2, the apparent range is $\sim$12 g/cm^2, increasing to $\sim$16 g/cm^2 for an absorber radius of 13 g/cm^2. The increase in mean range with absorber radius is a consequence of the non-linear dependence of the yield upon the range for the particular geometry employed here; were this dependence linear, a constant mean range should be found regardless of absorber size, and the effect of a distribution in range, if any, would be masked. The energies corresponding to the ranges 12 and 16 g/cm^2 are about 25 and 33 Mev, respectively, taking into account both the ionization and average radiation losses, but neglecting scattering. Here the ionization losses have been computed on the basis of the Halpern-Hall[12] calculation. These values would be increased some 20 percent if the losses were calculated on the Bethe-Bloch theory. In computing the energy, an allowance of 2 Mev was made for the counter walls. This was considered a reasonable average for the oblique paths since the minimum path through the walls corresponds to an energy loss of $\sim$1 Mev. The decrease in range due to scattering was calculated in a manner similar to that employed by Koenig[13] for mesons. The effect was found to be small, requiring that the above energies be increased by $\sim$2 Mev. In addition, a rough calculation was made of the spread in range to be expected as a result of fluctuations in the radiation loss,[14] assuming a unique decay energy of 40 Mev. The results indicated that this effect could not account for the observed yields, although the fluctuations are not negligible. The same conclusions apply to the assumption of a lower unique energy.

The experimental results are in agreement with those reported by Steinberger[9] and by Hincks and Pontecorvo[10] insofar as they indicate an apparent distribution of electron energies. Unfortunately, it is not possible to draw accurate conclusions regarding the mean range or the form of the distribution, due primarily to the uncertainty in the fraction of negative mesons which are captured in carbon. For example, if only 90 percent of the total mesons decay in carbon, the mean range indicated would correspond to about 40 Mev at the largest radius. It is interesting to note that the results would be consistent as well with a spectrum consisting of two discrete energies, one of the order of 20 Mev and the other about 45 Mev.

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A Boundary Value Condition for Proton-Proton Scattering

G. BREIT AND W. G. BOURICIUS
Yale University, New Haven, Connecticut*
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IT has been found that the values of the phase shift for the ^1S state of two protons, derivable from experiments[1] on the scattering of protons by protons in the energy range $0.2-14$ Mev, can be interpreted by means of a boundary condition requirement with about the same accuracy as by means of a potential energy curve description. The requirement is that of keeping the logarithmic derivative $d(rR)/Rdr = Y$ constant at a value of the interparticle distance $r \sim 0.47\ e^2/mc^2$. Here R is the radial wave function in