and Mr. J. B. Bulkley of the Radioactivity Center at the Massachusetts Institute of Technology for his cooperation in arranging the necessary cyclotron bombardments.

† Assisted by the joint program of the Office of Naval Research and the U. S. Atomic Energy Commission.

[1] Bergström, Hill, and de Pasquali, Phys. Rev. **92**, 918 (1953).
[2] G. Scharff-Goldhaber, Phys. Rev. **90**, 487 (1953); P. Preiswerk and P. Stähelin, Helv. Phys. Acta **24**, 623 (1952).
[3] *Handbook of Chemistry and Physics* (1952/53) (Chemical Rubber Publishing Company, Cleveland, 1952), p. 1990.
[4] We thank Professor R. G. Wilkinson of Indiana University for his advice concerning the plating process.
[5] F. R. Metzger and W. B. Todd, Phys. Rev. **95**, 853 (1954).

Self-Energy Effects on Meson-Nucleon Scattering According to the Tamm-Dancoff Method

J. C. Taylor
Peterhouse, Cambridge, England
(Received January 24, 1955)

In a paper with the foregoing title, Visscher[1] has shown that the self-energy effects in the Tamm-Dancoff method (as modified by Dyson) give rise to an unphysical pole in the meson-nucleon wave function. We show here that a simple and natural modification of the usual way of eliminating the negative frequency components removes this difficulty.

We use Visscher's notation. Define

$$X(\mathbf{p})=[X^+(\mathbf{p})u+X^-(\mathbf{p})w](M/E_{\mathbf{p}})^{\frac{1}{2}}$$
$$=[(\Psi_0{}^*(0)b_{\mathbf{p}u}a_{-\mathbf{p}\alpha}\Psi(0))u+(\Psi_0{}^*(0)b_{\mathbf{p}w}{}^*a_{-\mathbf{p}\alpha}\Psi(0))w](M/E_{\mathbf{p}})^{\frac{1}{2}},$$

where w is a negative-energy solution of the Dirac equation; and

$$-i\gamma_4(p\cdot\gamma-iM)N(p)=\tfrac{3}{4}iG^2\Omega_R(p\cdot\gamma),$$

where Ω_R is the finite self-energy function defined by Visscher. We suppose the meson negative-frequency components eliminated, since they are not our concern; and we leave out the meson self-energy term for simplicity. Then the second-order equation has the form

$$(\epsilon-H_{\mathbf{p}}-\omega_{\mathbf{p}})[1-\gamma_4N(p)]X(\mathbf{p})=\int\gamma_4K(\mathbf{p},\mathbf{k})X(\mathbf{k})d\mathbf{k},\quad(1)$$

where $p=(\mathbf{p},\,\epsilon-\omega_{\mathbf{p}})$ and K represents the interaction terms. Visscher drops negative energy components from (1), to give the approximate equation

$$(\epsilon-E_{\mathbf{p}}-\omega_{\mathbf{p}})[1-(\bar{u}(\mathbf{p})N(p)u(\mathbf{p}))M/E_{\mathbf{p}}]X^+(\mathbf{p})=\int(M/E_{\mathbf{p}})^{\frac{1}{2}}(\bar{u}(\mathbf{p})K(\mathbf{p},\mathbf{k})v(\mathbf{k}))(M/E_{\mathbf{k}})^{\frac{1}{2}}X^+(\mathbf{k})d\mathbf{k},\ (2)$$

and a zero of the factor in the square bracket causes the unwanted pole in $X^+(\mathbf{p})$.

We propose the following alternative prescription. First transfer the square bracket in (1) to the right-hand side, then separate and drop the negative frequency components, to give

$$(\epsilon-E_{\mathbf{p}}-\omega_{\mathbf{p}})X^+(\mathbf{p})=\int(M/E_{\mathbf{p}})^{\frac{1}{2}}(\bar{u}(\mathbf{p})\{[1-\gamma_4N(p)]^{-1}\times K(\mathbf{p},\mathbf{k})\}v(\mathbf{k}))(M/E_{\mathbf{k}})^{\frac{1}{2}}X^+(\mathbf{k})d\mathbf{k}.\quad(3)$$

A natural further approximation gives

$$(\epsilon-E_{\mathbf{p}}-\omega_{\mathbf{p}})X^+(\mathbf{p})=(\bar{u}(\mathbf{p})[\gamma_4-N(p)]^{-1}u(\mathbf{p}))M/E_{\mathbf{p}}\times\int(M/E_{\mathbf{p}})^{\frac{1}{2}}(\bar{u}(\mathbf{p})K(\mathbf{p},\mathbf{k})v(\mathbf{k}))(M/E_{\mathbf{k}})^{\frac{1}{2}}X^+(\mathbf{k})d\mathbf{k}\quad(4)$$

as our alternative to Eq. (2).

The factor in front of the integral in (4) can be written

$$[L(u^2)]^{-1}[1-(\bar{u}(\mathbf{p})N(-p)u(\mathbf{p}))M/E_{\mathbf{p}}],\qquad(5)$$

where $u=\gamma\cdot p/(iM)$, and $L(u^2)$ is a function defined by Feldman.[2] This is verified by noting that N is connected with Feldman's function $f(u)$ by the equation

$$-\tfrac{1}{3}\gamma_4N(p)=cf(u).$$

Feldman has found the zeros of $L(u^2)$ (when $\mu=0$), and none of them is real. Therefore, Eq. (4) does not have the difficulty of Eq. (2).

[1] W. M. Visscher, Phys. Rev. **96**, 788 (1954).
[2] G. Feldman, Proc. Roy. Soc. (London) **223A**, 112 (1954).

Photoproduction of π^+ Mesons from Hydrogen Near Threshold*

J. E. Leiss,† C. S. Robinson, and S. Penner
Department of Physics, University of Illinois, Urbana, Illinois
(Received January 27, 1955)

The total cross section for photoproduction of π^+ mesons very close to threshold has been investigated, following the method of a preliminary experiment.[1] π^+ mesons and their μ^+ decay mesons were stopped in a carbon absorber surrounding the target. Since the positrons from the decay of the stopped μ^+ mesons are emitted with an energy spectrum peaked around 36 Mev,[2] a large fraction will escape with considerable energy and can be counted. Since the decay of the stopped μ^+ mesons is isotropic, the positrons leaving the absorber will be essentially isotropic, regardless of the angular distribution of the emitted π^+ mesons. Except for small corrections due to geometry