scattering as well as the absorption is a many-body process. This probably naive picture of the nuclear scatterings is, to some extent, supported by some particular cases which are especially difficult to reconcile with a single pi-nucleon encounter. One of these cases is shown in Fig. 3(a). A meson of $E_1=82\pm5$ Mev (track length 2400μ) is scattered through 157°. The scattered meson (track length 8400μ) energy $E_2=33\pm3$ Mev. At the vertex, the three heavy prongs all end in the emulsion and have ranges, $R_1=21\mu$, $R_2=138\mu$, $R_3=145\mu$. If these are assumed to be 3 α-particles, the reaction would be $\pi_1^-+{}_6C^{12}\rightarrow3\alpha+\pi_2^-$. The α's are practically coplanar. The energy balance is

$$Q=(82-33)-(6+18.5+19)=5.5\pm6 \text{ Mev},$$

and the Q of the process ${}_6C^{12}\rightarrow3\alpha$ is 7.2 Mev. Figure 3(b) illustrates the consistency of the momentum balance. In another case, the meson has $E_1=73\pm10$ Mev, and the scattered meson, $E_2=2.2\pm0.2$ Mev. At the vertex, a proton track is found to have an energy $E_p=80\pm10$ Mev. No correlation of momenta is observed. These and other similar cases give us the impression that it will be difficult to explain the scattering of mesons and its energy dependence with any simple model based on the known properties of nuclei and conventional meson-nucleon interactions.

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The Mean Square Angle of Emission of Nucleons in High Energy Nucleon-Nucleus Collisions

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In previous work[1,2] we consider the problem of finding the mean square angle of emission of nucleons in high energy nucleon-nucleon collisions. In the present case we are concerned with obtaining the mean square angle of emission of nucleons resulting from a collision of a high energy nucleon with a nucleus using the results obtained in references 1 and 2.

Let $n(U, C, z)dUdC$ be the probability of finding a nucleon at a depth z in homogeneous nuclear matter with energy in the interval U, $U+dU$ and making an angle with the downward vertical whose cosine lies in the interval C, $C+dC$. Further, let $W(U, c)dUdc$ be the probability of finding a nucleon with energy in the interval U, $U+dU$ and scattered at an angle whose cosine lies in the interval c, $c+dc$. Denote by ω the angle between the plane containing the vertical and the direction of motion of a scattered nucleon and the plane passing through the directions of motion of both the incident and scattered nucleons.

The fundamental equation for $n(U, C, z)$ is

$$C[\partial n(U, C, z)/\partial z]+n(U, C, z)$$
$$=2\int_U^\infty\int_{c0}^1\int_0^{2\pi} n(U', Cc+Ss\cos\omega, z) \times W(U, U', c)dU'dcd\omega/2\pi, \quad (1)$$

where

$$S=(1-C^2)^{\frac{1}{2}} \quad\text{and}\quad s=(1-c^2)^{\frac{1}{2}}.$$

The mean square angle of scatter of nucleons at a depth z in homogeneous nuclear matter is given by

$$\langle\theta^2(U_0, U, z)\rangle=\left\{\int_{-1}^1 n(U, \cos\theta, z)\sin^2\theta d(\cos\theta)\right\} \times\left\{\int_{-1}^1 n(U, \cos\theta, z)d(\cos\theta)\right\}^{-1}. \quad (2)$$

Using the solution we have found for Eq. (1) and assuming that the nuclei are spherical in shape, we can show that the mean square angle of emission of nucleons with energies greater than U, resulting from a nucleon-nucleus collision is equal to

$$\langle\theta^2(U_0, U)\rangle=I_1/I_2, \quad (3)$$

where

$$I_1=\frac{1}{2\pi i}\frac{1}{2U}\int_{s_0-i\infty}^{s_0+i\infty}\left(\frac{U}{U_0}\right)^{-s}\left\{\frac{2-\alpha(s)-\alpha(s+1)}{\alpha(s)}\right\}f[D_A\alpha(s)]\frac{ds}{s+1} \quad (4)$$

and

$$I_2=\frac{1}{2\pi i}\int_{s_0-i\infty}^{s_0+i\infty}\left(\frac{U}{U_0}\right)^{-s}\frac{1-f[D_A\alpha(s)]}{s}ds. \quad (5)$$

Both the primary energy U_0 and the secondary energy U are measured in proton mass units. In the above expressions

$$f(x)=1-2[1-(1+x)e^{-x}]/x^2, \quad (6)$$
$$\alpha(s)=1-240\{(s+2)(s+3)(s+4)(s+5)\}^{-1}, \quad (7)$$

and D_A is the average number of collisions suffered by a primary nucleon in making a diametrical passage through a nucleus whose atomic weight is A.

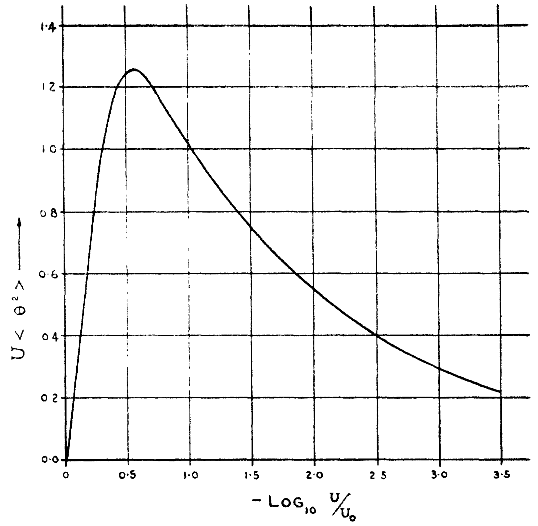

FIG. 1. A plot of $U\langle\theta^2(U_0, U)\rangle$ against the logarithm of the ratio of the energy U above which particles are emitted from a nucleus, to the primary energy U_0. The energies are measured in proton mass units. $\langle\theta^2(U_0, U)\rangle$ gives the mean square angle of emission in radians squared of nucleons resulting from a nucleon-nucleus collision. The curve is valid for nitrogen and oxygen nuclei.

The result of a calculation for light nuclei using Eq. (3) (D_A was taken equal to 3·7 and hence should be valid for nitrogen and oxygen nuclei) is given in Fig. 1. The apparent approach to zero in the limit $U\rightarrow U_0$ may be fallacious, since the method for evaluating the integrals becomes precarious for $U/U_0>\frac{1}{3}$, i.e., to the left of the maximum. However, this region has little physical significance.

These results ought to enable us to estimate the energy of the primary nucleon from a statistic of the angles of secondary nucleons in high energy photographic plate stars.

We shall present the details of the above work and a comparison with experiments in a subsequent publication. Results will also be presented for the heavy nuclei, silver and bromine.

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