and a thickness of d_1 = 18.8 gms/cm^2 ; the pulverized graphite absorber had a density d = 1.0 – 1.0 gms/cm^3 ; d_1 = 16.0 gms/cm^2). The mean free path and inelastic scattering cross section for proton–proton interaction came out to be

$$L_p^{\mathrm{H}} = 47^{+37}_{-15} g/\mathrm{cm}^2\,;\ \sigma_p^{\mathrm{H}} = 35 \pm 16 \text{ mb}.$$

In getting this value of the cross–section we did not know sufficiently accurately the contribution of δ-showers produced in the hydrogen. However, on the basis of experimental data available, it can be said that the values of the cross–section will not change more than ± 10% after correcting for these δ-showers. At the present time we are carrying out measurements at sea level to determine the formation of delta showers in graphite and paraffin.

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On the Theory of Scattering of Particles by Nuclei

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In the study of the scattering of nucleons by nuclei, a model[1,2] has often been used which considers the nucleus as a Fermi gas of nucleons at a temperature T = 0. It seems reasonable to use this same model to study the nuclear scattering of particles having masses different from that of a nucleon. Such a study would allow one to start evaluating the effect of the Pauli principle in the scattering of π and K-mesons.

Let a particle 1 with mass m_1 and momentum p_1 impinge on a Fermi gas of particles 2 of mass m_2 and momenta p_2 $(0 \leq p_2 \leq p_F)$, at a temperature T = 0. Let the differential scattering cross section for the free particles 1 and 2 be isotropic, independent of energy, and equal to $\sigma_0 / 4\pi$. We will calculate the total cross section $\sigma = \sigma_0 F$ for the collision of particle 1 with one of the particles of the gas. It is obvious that the factor F must be less than 1 since, because of the Pauli principle, not all of the final states for particle 2 are allowed, but only those with $p_2' > p_F$. In order to calculate F let us consider the collision of two particles (Fig. 1). We will let p_1' and p_2' be the momenta of particles 1 and 2 in the laboratory system of coordinates after the collision; p and p′ will be the momenta of particle 1 in the center of mass before and after the collision, respectively. Then

$$p_2' = |-\mathrm{p}' + m_2(\mathrm{p}_1 + \mathrm{p}_2)/(m_1 + m_2)| > p_F.$$

Keeping in mind that

$$p' = p = |m_2 \mathrm{p}_1 - m_1 \mathrm{p}_2| / (m_1 + m_2)$$

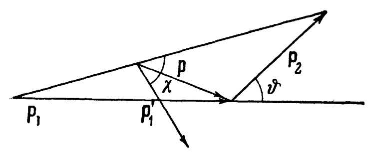

Fig. 1

and introducing the variables

$$\alpha = m_1 / m_2,\ u = p_2 / p_1,$$
$$w = p_F / p_1,\ x = \cos\vartheta,\ y = \cos\chi,$$

we obtain the equation for the surface S in the space u, y, x that determines the allowed region of the variables u, y, x:

$$S(\alpha, w; u, y, x) = (1 + \alpha^2u^2 - 2\alpha ux) + (1 + u^2 + 2ux) - 2\left[(1 + \alpha^2u^2 - 2\alpha ux)(1 + u^2 + 2ux)\right]^{1/2} y - w^2(1+\alpha)^2 = 0.$$

This surface depends on α and w parametrically. Schematically, the allowed region is presented in Fig. 2. It is bounded by the surface S and the planes $y = -1$, $x = +1$, $x = -1$, $u = 0$, $u = w$.

Calculating the number of collisions suffered by particle 1 in unit time, we obtain for the factor F the following expression:

$$F = (3/4w^3)\int\int\int u^2 \sqrt{1 + \alpha^2u^2 - 2\alpha ux}\, du\, dx\, dy.$$

Here the integration has to be carried out over the allowed region described above. Different

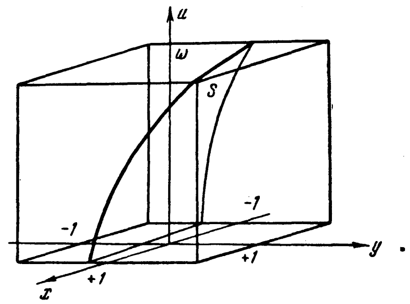

FIG. 2

values of F result from different values of the parameters α and w. In the general case ($0 \leq \alpha \leq 1$) we get:

$$0 < w < 1 \quad : \quad F = 1 - w^2(1 + 2\alpha)/5,$$

$$1 < w < 1/\alpha : \quad F = [\alpha^2 - 2 + 10w^2 - 20\alpha w^3 + 15\alpha^2 w^4 - 4\alpha^3 w^5] / 10w^3(1-\alpha)^2,$$

$$1/\alpha < w < \infty : \quad F = (1+\alpha)^2 / 10\alpha^2 w^3.$$

As is easily seen these formulae simplify considerably in the limiting situations $\alpha = 0$ and $\alpha = 1$.

We express our sincere gratitude to Prof. I. Ia. Pomeranchuk and L. A. Ter–Martirosian for interesting and productive discussions.

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The Spatial Distribution of the Penetrating Component of Wide Atmospheric Showers

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STUDIES have been carried out on the spatial distribution of the penetrating component of wide atmospheric showers at an altitude of 400 meters above sea level in a tunnel underneath 26.6 meters of earth (65.5 meters of water equivalent, m. w. e).

The measurements of the density of penetrating particles were carried out at distances of 0, 10, 20, 30, 45, and 60 meters from a vertical axis passing through the center of the detecting system. The shower detection was carried out using two core selectors similar to those used in previous work.[1] In addition, the apparatus contained correlating hodoscopic systems which served to determine the total number of particles and the point of passage of the core of the wide atmospheric shower. There was also an underground apparatus registering the particles in the penetrating component. The showers were recorded with the help of a movie camera. This set–up was most efficient for showers containing between 10^5 and 5×10^5 particles. During 2156 hours of running data were obtained on the spatial distribution of the penetrating component of showers with this number of particles and these are presented in the Table.

Distance from the axis of detecting system	Time of observation, hours	No. of showers registered	Rate of counting, Days^{-1}	Calculated density of penetrating particles, *Particles/m²*
0	276,0	72	6,25	0,55±0.065
10	250,0	61	5.9	0.51±0.078
20	244.0	58	5.7	0,49±0.064
30	246,0	48	4,7	0,39±0.056
45	395.0	38	2.3	0,17±0.027
60	745.0	31	1.0	0.07±0.013

The experimental data obtained are represented satisfactorily, within statistical error, by a Gaussian of the form:

$$\rho(r) = 0{,}61 \exp[-0{,}00059 r^2]. \qquad (1)$$

We note, however, that in carrying out the measurements we did not take into consideration the angular distribution of the cores of the wide atmospheric showers and the inaccuracy in determining the position of passage of this core. Consideration of the two distributions shows that the axes