[7] F. Seitz and D. Turnbull, Solid State Physics **2**, (1956).
[8] Rol, Fluit, and Kistemaker, Physica **26**, 1009 (1960).

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LARGE-ANGLE SCATTERING OF HIGH-ENERGY PIONS

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RECENTLY there has been discussed in the literature[1,2] the possibility of scattering of high-energy pions at c.m.s. angles close to 180°, in reactions of exchange scattering

$$\pi^- + p \to \pi^0 + n \quad (1)$$

and elastic scattering

$$\pi^+ + p \to \pi^+ + p \quad (2)$$

The presence or absence of such scattering indicates the presence or absence of a contribution of Feynman diagrams with virtual nucleons and is connected with the nature of the dependence of the nuclear forces on the distance at high energies. Complete cancellation of the backward scattering signifies, in particular, that the impact parameters involved in the scattering can be made as large as desired, but the amplitudes of the partial waves are very small.

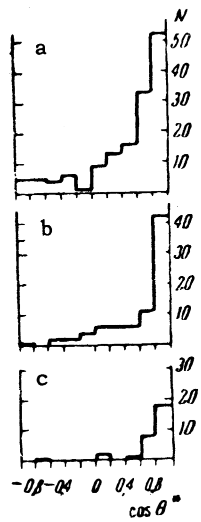
We have previously[3,4] investigated in detail the reaction

$$\pi^- + n \to \pi^- + n, \quad (3)$$

which is isotopically symmetrical to reaction (2), for an incoming meson with momentum 2.8 Bev/c. It was shown that the cross section for scattering at c.m.s. angles greater than 90° is less than 0.006 mb/sr, and that the probability that the elastic-scattering angles exceed the angle corresponding to the first diffraction minimum is small and decreases sharply with increasing momentum of the incoming pion. Data on exchange scattering at large angles in the energy region above 1 Bev are lacking at the present time.

The total cross section of reaction (1) at 2.8 Bev/c was estimated in a paper by one of the authors and Shebanov[5] using a bubble chamber filled with a propane-xenon mixture; we studied prongless stars accompanied by electron-positron pairs of conversion γ-quanta from the decay of π^0 mesons. In the present note we give the results of a different reduction of the data obtained in the same investigation.

The figure shows the angular distribution of the γ quanta in the πN c.m.s. without account of the chamber γ-quantum counting efficiency. Plot a in this figure corresponds to the case when there are 3 to 6 electron-positron pairs in the direction towards the point of disappearance of the π^- meson,



plot b corresponds to two pairs, and plot c to one conversion pair. The high average efficiency for the registration of γ quanta ($\sim$ 0.52) enables us to distinguish between process (1) and a reaction in which several π^0 mesons are produced. It is seen from this figure that elastic charge exchange with emission of a π^- meson backward is not observed in practice: one case in the figure (plot b) is connected either with the creation of one more π^0 meson or with the escape of the π^0 meson from the reaction (1) at an angle greater than 1 sr (relative to 180°). The corresponding estimate of the upper limit of the cross section is $\sigma < 0.01$ mb/sr.

The data enable us to estimate the cross section of elastic charge exchange with emission of a π^0 meson at a c.m.s. angle greater than 90°, found to be $\lesssim 0.002$ mb/sr. Similar data are obtained if the bubble chamber is filled with freon.

From the point of view considered here, it is interesting to estimate the cross section of backward scattering of π^- mesons by protons in the process

$$\pi^- + p \rightarrow \pi^- + p, \qquad (4)$$

inasmuch as diagrams similar to those responsible for the cancellation of the backward scattering in reactions (1) and (2) may occur in this scattering. Such an estimate was made for a π^--meson momentum 2.8 Mev/c by a method completely similar to that described in our previous paper.[3] We merely selected the quasi-elastic π^--p scattering cases, by using additional criteria based on the kinematics of the quasi-elastic process, namely the approximate complanarity (accurate to 15°) and the correspondence between the angles of emission of the charged particles. The cross section of the reaction (4) for l.s. angles greater than 90° (for an interval approximately 1 sr in the c.m.s.) was found to be less than 0.03 mb. This estimate is obtained without subtracting the possible contribution from the background due to creation of π^0 mesons. The cross section for elastic backward scattering, $\sigma < 0.03$ mb, compared with the cross sections for elastic π^--p scattering given by Wood et al,[6] confirms that the character of the scattering varies with increasing energy.

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1 V. N. Gribov and I. Ya. Pomeranchuk, Preprint 61-15, Inst. Exptl. Theoret. Phys., 1961.

2 M. Gell-Mann and F. Zachariasen, Preprint, (1961).

3 Bayukov, Leksin, Suchkov, Shalamov, and Shebanov, JETP 41, 52 (1961), Soviet Phys. JETP 14, 40 (1962).

4 Bayukov, Leksin, and Shalamov, JETP 41, 1025 (1961), Soviet Phys. JETP 14, 729 (1962).

5 Ya. Ya. Shalamov and V. A. Shebanov, JETP 39, 1232 (1960), Soviet Phys. JETP 12, 859 (1961).

6 Wood, Devlin, Helland, Longo, Moyer, and Perez-Mendez, Phys. Rev. Lett. 6, 481 (1961).

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MOLECULAR PHOTODISSOCIATION AS A MEANS OF OBTAINING A MEDIUM WITH A NEGATIVE ABSORPTION COEFFICIENT

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POPULATION inversion in various systems (atoms, molecules, crystals etc.) can be used, as is well known, to obtain a negative absorption coefficient and can be produced by means of optical excitation.[1-7] A new method of obtaining population inversion is discussed below.

We are concerned here with the production of excited atoms as a result of photodissociation of molecules. For simplicity we consider a diatomic molecule XY. In the figure we show a number of typical potential energy curves corresponding to the electron ground and excited states in a molecule (the atomic levels of the X atom are shown in the right side of the figure). Two kinds of curves are possible (these are shown by solid lines and dashed lines in the figure); the following discussion applies to both kinds. The absorption of a photon characterized by a frequency $\omega \gtrsim \omega_0$ causes dissociation of the molecule; as a result one of the atoms (for example, X) can be left in an excited state. Under certain conditions (cf. [1]) an inverted distribution between levels 3 and 2 is obtained in the X atoms, that is to say, the inequality $N_3/g_3 > N_2/g_2$ is satisfied, where N and g are the populations and statistical weights of the corresponding levels shown in the right side of the figure.* This population inversion can be used for