# *ANGULAR ASYMMETRY IN* ($\pi$N) *COLLISIONS AND* ($\pi\pi$) *INTERACTION*

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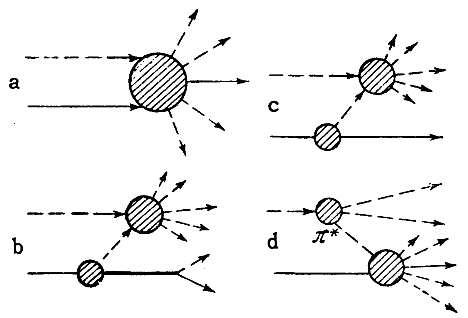
A model of "central" and "peripheral" collisions was proposed[1,2] to interpret experiments with inelastic (NN) collisions at energies E > 1 Bev.

This model can also be used to explain the angular distributions of particles generated in inelastic ($\pi$N) collisions. The figure shows the diagram of a central ($\pi$N) collision (a), and also possible variants of peripheral collisions (b, c, and d). In one of these the nucleus, losing the peripheral pion, goes into an excited state, which then decays (model with isobar). In the calculations we have assumed values of $^3/_2$ for the spin and the isotopic spin of the isobar. The peripheral collisions are due to ($\pi\pi$) interactions.




Numerical calculations have been made for ($\pi^-$p) collisions at E = 5 Bev. The results can be compared with the experimental data of reference 3. The central collisions for this energy have been considered in reference 4. We used the statistical theory of multiple production to calculate the inelastic ($\pi$p) and ($\pi\pi$) collisions.

The table lists the average numbers of particles created in peripheral collisions of type b and c and emitted, in the c.m.s. of the colliding negative pion and proton, into the forward ($\vec{n}^p$) or rear ($\overleftarrow{n}^p$) hemisphere relative to the velocity vector of the primary negative pion. As can be seen, the particles produce here a considerable angular asymmetry, $A = \vec{n}/\overleftarrow{n} \neq 1$.*

A calculation of the type-d collisions is less unambiguous, since little is known at present concerning the structure of the meson. From a comparison of various assumptions with experiment it is possible to obtain, in principle, information

| Generated particles | Model with isobar | | Model without isobar | |
|---|---|---|---|---|
| | $\vec{n}^p$ | $\overleftarrow{n}^p$ | $\vec{n}^p$ | $\overleftarrow{n}^p$ |
| $p$ | 0 | 0.78 | 0 | 0.33 |
| $n$ | 0 | 0.22 | 0 | 0.67 |
| $\pi^+$ | 1.15 | 0.79 | 1.0 | 0.34 |
| $\pi^-$ | 1.0 | 0.39 | 1.0 | 0.34 |
| $\pi^0$ | 0.95 | 0.59 | 0.86 | 0.34 |

on the structure of the pion.† However, if collisions with small momentum transfer are considered, the results of the table do not change qualitatively and change very little quantitatively within the framework of sensible assumptions concerning the peripheral meson.

Taking central ($\pi^-$p) collisions into account, the angular asymmetry of the particles generated in ($\pi^-$p) collisions is of the form

$$A = \vec{n}/\overleftarrow{n} = \left(\vec{n}^c + \vec{n}^p \frac{\xi}{1+\xi}\right) \Big/ \left(\overleftarrow{n}^c + \overleftarrow{n}^p \frac{\xi}{1+\xi}\right),$$

where $\xi = \sigma^p_{\pi N}/\sigma^{in}_{\pi N}$, $\vec{n}^c \simeq \overleftarrow{n}^c \simeq n^c/2$ is the number of particles of a given kind, produced in the central collisions: $n^c_p \simeq 0.4$, $n^c_n \simeq 0.6$, $n^c_{\pi^+} \simeq n^c_{\pi^-} \simeq n^c_{\pi^0} \simeq 1.2$.

Qualitatively, both models (with and without the isobar) explain the experimental values of the angular asymmetry, but the model with the isobar is in better agreement with the experiment. In this case the experimental data for protons and pions can be reconciled with the theory if $\xi \gtrsim 0.2$. To reconcile the angular asymmetry of the neutrons with experiment we must have $\xi \gtrsim 0.5$, but the experimental data obtained in reference 3 for neutral particles are less reliable than those for charged ones.

If the cross section $\sigma_{\pi\pi}$ of the ($\pi\pi$) interactions, like the cross sections $\sigma_{\pi N}$ and $\sigma_{NN}$, changes little with energy at E > 1 Bev, then the cross section for the peripheral ($\pi$N) and (NN) interactions is

$$\sigma^p_{NN} \equiv \eta\sigma^{in}_{NN} = 2\int \sigma_{\pi N}(\varepsilon)\, q_N(\varepsilon)\, d\varepsilon \simeq 2\sigma_{\pi N}\, n_N,$$

$$\sigma^p_{\pi N} \equiv \xi\sigma^{in}_{\pi N}$$

$$= \int \sigma_{\pi\pi}(\varepsilon)\, q_N(\varepsilon)\, d\varepsilon + \int \sigma_{\pi N}(\varepsilon)\, q_\pi(\varepsilon)\, d\varepsilon \simeq \sigma_{\pi\pi}\, n_N + \sigma_{\pi N}\, n_\pi,$$

where $\sigma_{\pi N}$ and $\sigma_{\pi\pi}$ are the total interaction cross sections, $q_N$ and $q_\pi$ are the spectra of the peripheral mesons, and $n_N$ and $n_\pi$ are their number ($\sim$0.05 to 0.1, cf. reference 2).

Since $\sigma^{in}_{\pi N} \sim \sigma^{in}_{NN}$ and $\eta \gtrsim 0.2$ (see reference 2), we have

$$\sigma_{\pi\pi} = 2\sigma_{\pi N}\left(\xi - n_\pi\, \sigma_{\pi N} / \sigma^{in}_{\pi N}\right) / \eta \sim \sigma_{\pi N}.$$

This estimate is confirmed also by an optical analysis of the experimental angular distributions of elastic $(\pi^- p)$ interactions at $E > 1$ Bev.‡

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*It was assumed here that, in the case of $(\pi N)$ and (NN) collisions at $E > 1$ Bev, the cross section of diffraction $(\pi\pi)$ scattering $\sigma^d_{\pi\pi} \simeq 1/3\sigma^{in}_{\pi\pi}$, where $\sigma^{in}_{\pi\pi}$ is the cross section of all inelastic $(\pi\pi)$ interactions. Calculations have shown that the numbers in the table vary little with $\sigma^d_{\pi\pi}$.

†This question will be considered in detail in another paper.

‡Approximately half of the $(\pi^- p)$ collisions occurs at impact parameters $\rho \gtrless (0.5$ to $0.6) \times 10^{-13}$ cm, which can be explained only by assuming $r_\pi \sim r_N \sim 0.5 \times 10^{-13}$ cm, i.e. $\sigma_{\pi\pi} \sim 4\pi r^2_\pi \sim \sigma_{\pi N}$ (see reference 5).

[1] I. E. Tamm, Nucl. Phys., in press.

[2] Barashenkov, Maltsev, and Mihul, Nucl. Phys., in press.

[3] Maenchen, Fowler, Powell, and Wright, Phys. Rev. **108**, 850 (1957).

[4] V. S. Barashenkov and V. M. Maltsev, Acta Phys. Polonica **17**, 177 (1958); JETP **37**, 884 (1959), Soviet Phys. JETP **10**, 630 (1960).

[5] Barashenkov, Belyakov, Wang, Glagolev, Dolhadzov, Kirillova, Lebedev, Maltsev, Markov, Tolstov, Tsyganov, Shafranova, and Jao, Nucl. Phys., in press.

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## *DETECTION OF* $Eu^{++}$ *IONIZATION IN THE* SrS-Eu, Sm *PHOSPHOR BY THE PARAMAGNETIC ABSORPTION METHOD*

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IN the phosphor SrS-Eu, Sm (without flux) we discovered a decrease in the paramagnetic absorption of $Eu^{++}$ upon excitation of this phosphor with light in the absorption band of $Eu^{++}$ ($\lambda \sim 440$ m$\mu$). This decrease was found to be dependent on the degree of the phosphor stimulation. At the moment of excitation the decrease of paramagnetic absorption is $\sim 15\%$, and $\sim 10$ minutes after cessation of excitation this decrease amounts to $\sim 8\%$. This agrees with the decrease in the self-absorption coefficient of $Eu^{++}$ in phosphor during excitation. Measurements made some 10 — 20 minutes after cessation of excitation showed that the coefficient of activator absorption in the excited phosphor was less by $\sim 11\%$. At the same time, measurements of the total number of quanta emitted by the excited phosphor were made starting 10 — 20 minutes after cessation of excitation. The measurements yielded $6.5 \times 10^{15}$ quanta, proving that not less than 4% of the $Eu^{++}$ became ionized. Assuming that the quantum yield of the radiation at recombination is $\sim 1/2$ and that the full amount of the activator was used for the formation of luminescence centers $(Eu^{++})$ we can state that about 8% of the $Eu^{++}$ ions became ionized.

Thus, three independent methods gave compatible results. This allows us to state that ionization of the activator $(Eu^{++} \rightarrow Eu^{+++})$ takes place upon excitation of the phosphor SrS-Eu, Sm.

The cause of the non-detection of ionization in the previous[1] work remains unclear. It is probably connected with the lower stability of the radiation spectroscope or with stray excitation of the luminophore in the resonator.

[1] Manenkov, Prokhorov, Trapeznikova, and Fock, Оптика и спектроскопия (Optics and Spectroscopy) **2**, 470 (1957).

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## *SCATTERING OF A LOW-ENERGY ELECTRON BY A SHORT-RANGE POTENTIAL IN A STRONG MAGNETIC FIELD*

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WE study the question of the scattering of an electron with energy E by a potential $V(\mathbf{r})$ in a homogeneous magnetic field $\mathbf{H}$, assuming that the radius of action of the scattering potential