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44

BEHAVIOR OF THE TOTAL CROSS SECTION FOR THE PHOTOPRODUCTION OF π MESONS AT HIGH ENERGIES

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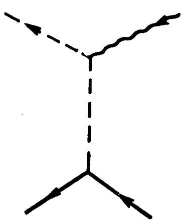
WE shall consider the process of collision of a photon with a nucleon for very high incident photon energies $\omega \gg m$, where ω is the photon energy in the c.m. system and m is the mass of the nucleon. At such energies, processes involving the production of two or more π mesons, as well as processes involving the production of heavier mesons, etc., are already possible.

In order to obtain some information on the behavior of the total cross section for the photoproduction of π mesons at high energies, we shall estimate the contribution to this cross section from peripheral interactions. The condition for a collision to be peripheral is $l \gg \omega/\mu$,[1] where μ is the mass of the π meson, and l is the orbital angular momentum. For such large l the basic contribution to the amplitude is made by terms corresponding to a diagram with one virtual meson (see figure). Making use of the results of reference 2 [see formula (6)], we obtain the following expression for the amplitude of the photoproduction of π mesons with an orbital angular momentum l and parity $(-1)^{l+1}$:



$$|a^{(1)}_{l\pm\frac{1}{2},l,M}| = (eg\pi\mu^2/2\omega^3)\sqrt{\omega/2\mu}\exp(-\mu l/\omega). \quad (1)$$

Here $g^2 = 0.08(2m/\mu)^2$; $e^2 = 1/137$; $M = \pm 3/2$ and $\pm 1/2$ are the projections of the total angular momentum on the z axis (the z axis is chosen in the direction of the incident photon momentum).

The total cross section of the process can be written in the form $\sigma = \sigma_0 + \sigma_1$. Here σ_0 contains the contribution from the nonperipheral part of the π-meson photoproduction process, σ_1 is the peripheral part of the cross section. Only one-meson amplitudes with orbital angular momenta $l > \omega/\mu$ contribute to it.

The cross section σ_1 is written in the following way:

$$\sigma_1 = \sum_j \sum_{l=\omega/\mu}^{\infty} \sum_{M=-3/2}^{3/2} |a^{(1)}_{jlM}|^2. \quad (2)$$

Performing the summation, we obtain

$$\sigma_1 = e^2 g^2 \pi^2 \mu^2 / 15\omega^4.$$

This expression corresponds to small scattering angles $\theta \lesssim \mu/\omega$. Since $\sigma_0 > 0$, then

$$\sigma > e^2 g^2 \pi^2 \mu^2 / 15\omega^4. \quad (3)$$

Hence the total cross section for the π meson photoproduction process at high energies cannot drop more rapidly than ω_{lab}^{-2}, where ω_{lab} is the photon energy in the laboratory system. This conclusion is evidently not in agreement with the results obtained from the statistical-hydrodynamical theory of multiple production of particles,[3,4] which predicts that the total cross section of the process at high energies should drop exponentially with an increase in energy: $\sigma \sim \exp(-kE^{1/4})$.

In conclusion, I wish to express my graitude to I. Ya. Pomeranchuk for suggesting the problem and for helpful comments.

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45