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INELASTIC HADRONIC PROCESSES AT LARGE MOMENTUM TRANSFERS, AND DEEP INELASTIC ELECTROPRODUCTION

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A distinguishing feature of hadronic processes, both elastic (quasielastic) and inelastic, is the exponential decrease of the cross section with increasing transverse momenta of the secondary particles [1, 2].

It has therefore been generally accepted long ago that at large momentum transfers the electromagnetic interaction, with its power-law dependence on q^2 , can compete with the strong interaction.

For elastic scattering, however, say of protons in the region $s \gg -t = q^2 \gg m^2$ (m is the nucleon mass), proceeding via one-photon exchange, the cross section

$$\frac{d\sigma}{dq^2} \approx \frac{4\pi\alpha^2}{q^4} G_M^4(q^2)$$

(G_M is the magnetic form factor of the proton) becomes comparable with the hadronic one when the cross section is already outside the limits of present-day experimental capabilities.

At the same time, there exists an electromagnetic process characterized by a rather weak dependence on q^2 (corresponding to the "bare" hadron), namely the deeply-inelastic electroproduction of hadrons.

We wish to call attention to the fact that at large momentum transfers the electromagnetic mechanism will make an appreciable and perhaps the decisive contribution to inelastic collisions of hadrons of a definite kinematic configuration.

Let us examine pp collisions with production of two hadron beams X_1 and X_2 with masses M_1 and M_2 in a kinematic configuration

$$s = (p_1 + p_2)^2 \gg M_1^2, M_2^2, \quad q^2 = -(p_1 - p_{x_1})^2 = -(p_2 - p_{x_2})^2 \gg m^2,$$

that makes it possible to separate the beams from each other.

In the one-photon approximation, the differential cross section of this process can be easily expressed in terms of the well-known deeply-inelastic-electroproduction structure functions W_1 and W_2 :

$$\begin{aligned} \frac{d^3\sigma}{dq^2 d\omega_1 d\omega_2} = & \frac{4\pi\alpha^2}{q^4} \left[\frac{1}{\omega_1 \omega_2} \left(1 - \omega_1 \omega_2 \frac{q^2}{2s} \right)^2 F_2^{(1)} F_2^{(2)} + \right. \\ & \left. + \frac{q^4}{s^2} \left[3F_1^{(1)} F_1^{(2)} - \frac{1}{2} F_1^{(1)} F_2^{(2)} \left(\omega_2 + \frac{4m^2}{\omega_2 q^2} \right) - \frac{1}{2} F_1^{(2)} F_2^{(1)} \left(\omega_1 + \frac{4m^2}{\omega_1 q^2} \right) \right] \right] \end{aligned} \quad (1)$$

Here

$$\begin{aligned} \omega_i &= 1 + \frac{M_i^2 - m^2}{q^2}; \quad F_1^{(i)} \equiv m W_1^{(i)}(\omega_i, q^2); \\ F_2^{(i)} &\equiv \frac{\omega_i q^2}{2m} W_2^{(i)}(\omega_i, q^2) \quad (i = 1, 2). \end{aligned}$$

Under our kinematic conditions (and when $M_1 > 2 \text{ GeV}$ and $q^2 > 1 \text{ GeV}^2$), inasmuch as $F_{1,2}^{(i)}$ depends only on ω_1 (cf. [3]), we can write

$$\frac{d^3\sigma}{dq^2 d\omega_1 d\omega_2} \approx \frac{4\pi\alpha^2}{q^4} \frac{F_2(\omega_1) F_2(\omega_2)}{\omega_1 \omega_2} \quad (2)$$

$$F_2^{(i)}(\omega_i) \approx 0.3 \quad (\omega_i \lesssim 20).$$

Hence, apart from a factor on the order of unity, it follows that

$$\frac{d\sigma}{dq^2} \approx \frac{4\pi\alpha^2}{q^4}. \quad (3)$$

At $q^2 = 5 \text{ GeV}^2$, we get from (3) the value $10^{-32} \text{ cm}^2/\text{GeV}^2$.

At the present time, unfortunately, there are no direct experimental data on inelastic collisions of hadrons in the configuration under consideration. If we start from the experimental fact that at small $q^2 \lesssim m^2$ the cross sections of inclusive processes at high energies do not greatly exceed the corresponding elastic-scattering cross section, then we can use for comparison with (3) at large q^2 the Orear formula for elastic pp scattering [1], which yields $10^{-35} \text{ cm}^2/\text{GeV}^2$ at $q^2 = 5 \text{ GeV}^2$ and $s = 1000 \text{ GeV}^2$. With increasing q^2 , the difference becomes, naturally, much larger.

On the basis of the foregoing considerations one can hardly expect the production of the beams ($m^2 \ll M^2 \ll s$) to be able to compensate for the factor $10^3 - 10^4$ obtained for $q^2 = 5 \text{ GeV}^2$.

We can thus conclude that at high energies and at large momentum transfers ($q^2 > 5 \text{ GeV}^2$) the electromagnetic mechanism of production of two hadronic beams should play an important role, and may in all probability even turn out to be dominating.

This means that the characteristics of the secondary particles in such configurations (multiplicity, spectrum, etc.) should be similar to the analogous characteristics in the deeply-inelastic electroproduction. In particular,

it is of interest to obtain information on the dependence of the multiplicity on q^2 , which in the case of the purely hadronic mechanism should be proportional to $\sqrt{q^2}$. At large q^2 one should observe in such configurations a transition to a much slower decrease of $d\sigma/dq^2$ as a function of q^2 .

The mechanism in question might provide in the future unique information concerning deeply inelastic photoproduction from unstable particles.

It should be borne in mind that all the foregoing ceases to hold if for some reason there is no longer an exponential dependence on q^2 in strong interactions at high energies.

This will occur, for example, in the model of [4], where the strong interaction has at high energies the character of a local interaction of two currents (see also [5]). Then (3) must be considered as a lower limit of the differential cross sections for hadron interactions at large momentum transfers.

In conclusion, we present an expression for $d\sigma/dq^2$, analogous to (3), in the case of a process with one beam X ($p + p \rightarrow p + x$):

$$\frac{d\sigma}{dq^2} \approx \frac{4\pi a^2}{q^4} G_M^2(q^2). \quad (4)$$

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CONCERNING THE ROTATION OF THE PLANE OF LINEAR POLARIZATION OF γ QUANTA IN A MAGNETIZED FERROMAGNET

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In a recent paper in this journal [1], Lobashov et al. reported the results of an experimental investigation of the rotation of the plane of linear polarization of 230- and 290-keV γ quanta in magnetized iron. Analogous experiments at 230 and 330 keV are described in a paper by Bock and Luksch [2]²⁾. The effect of rotation of the γ -quantum polarization plane in a polarized electron target, observed by the authors of [1] and [2], was considered theoretically a few years ago by Baryshevskii and Lyuboshitz [3, 4]. It was shown in these papers that the rotation of the polarization plane of γ quanta with energies from several hundred keV to several MeV is determined completely by the contribution of radiative corrections of order α^2 to the real spin-dependent part of the "forward" Compton scattering amplitude. The method of dispersion relation was used in the calculation of the radiative corrections. The order of magnitude of the rotation angles, indicated in [3, 4], agreed with the data of [1, 2].

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