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DIFFRACTION DISSOCIATION OF HADRONS AND PHOTONS ON HYDROGEN

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+ Photon Dissociation: T. Chapin, R.L. Cool, K. Goulianos, K. Jenkins, J. Silverman, G. Snow, H. Sticker and S.N. White - The Rockefeller University, New York, New York 10021, USA; and Yue-Hua Chou, Institute of High Energy Physics, Beijing, The People's Republic of China.

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We report results on the inclusive diffraction dissociation of hadrons and photons on hydrogen, $h + p \rightarrow X + p$ ($h=\pi^\pm, K^\pm, p^\pm$) and $\gamma + p \rightarrow X + p$, in the kinematic region $0.02 \leq |t| < 0.1$ (GeV/c)² and $M_X^2/s \leq 0.1$. Both reactions were studied at Fermilab using the recoil proton technique. The t -value was determined from the kinetic energy of the recoil proton, $|t| = 2 M_p T$, while the excitation mass was obtained from the kinetic energy and polar angle of the proton and from the beam momentum, p_0 , using the formula $M_X^2 = 2 p_0 \sqrt{2 M_p T} (\cos \theta - \sqrt{T/2 M_p})$. The energy of the protons was determined from the pulse height resulting by stopping them in scintillation counters. Their polar angle was measured either with drift chambers (hadron dissociation, experiment E-396) or with a high pressure hydrogen time projection chamber (TPC) which served both as target and detector (photon dissociation, experiment E-612). A tagged photon beam was used to provide the necessary measurement of the momentum of the incident photon. Scintillation counters placed immediately after the recoil apparatus measured the charged particle multiplicity of the diffractively produced states.

Typically, the resolution in t was $\Delta t = \pm 0.0025$ (GeV/c)², the resolution in θ was $\Delta \theta = \pm 0.005$ rad (limited by multiple scattering of the recoil proton in the material along its path) and the resolution in beam momentum was $\Delta p_0 = \pm 1\%$ for the hadron beam and $\pm 2\%$ for the tagged photon beam. With these values, the resolution in the excitation mass in the region $0.05 < M_X^2/s < 0.1$ is calculated to be $\Delta M_X^2/M_X^2 \approx 0.03$ or $\Delta M_X/M_X \approx 0.015$.

The results on hadron dissociation have already been published^(1,2). We found, at 100 and 200 GeV/c, the cross sections $d^2\sigma/dt dx$ are exponential in t , vary as $1/M_X^2$ and scale to the corresponding total cross sections, as required by triple pomeron dominance and factorization (see Figure 1).

FIG. 1. Diffractive to total cross section ratios vs σ_T for $K^\pm$, $\pi^\pm$, and $p^\pm$ at 100 GeV/c. (From Ref. 1).

The triple pomeron coupling constant was measured to be $G_{ppp}(t) = 0.364 \pm 0.025 \text{ mb}^{1/2}$, independent of t . The charged multiplicity distributions of the diffractive π^+ , K^+ and p^+ states were found to be described well by a Gaussian function that depends only on the available mass $M = M_X - M_h$, has a maximum at $n_0 \approx 2M^2$, and a peak-to-width ratio $n_0/D \approx 2$. The uncovering of this simplicity and universality of diffractive charged multiplicities prompted an analysis of all hadronic charged multiplicities. We have shown that^(3,4) the charged multiplicity distributions of the non-diffractive components of hadronic interactions, as well as those of hadronic states produced in a variety of other reactions, such as $e^+e^- \rightarrow \text{hadrons}$, follow the same Gaussian function as the diffractive multiplicities. This function is therefore universal, describing all hadronic multiplicity distributions in terms of only one parameter -- the available hadronic mass. Figure 2 shows the success of this analysis in the case of $pp \rightarrow \text{anything}$.

FIG. 2. The product of the probability for n charged particles times $\langle n \rangle$, plotted versus $n/\langle n \rangle$ for $pp \rightarrow \text{anything}$. The curve was calculated using the same Gaussian distribution function, at the appropriate available mass, for both the diffractive and the non-diffractive components of the inelastic cross section (From Ref. 3)

Photon dissociation was studied at energies $80 < p_Y < 140 \text{ GeV/c}$. The high-pressure hydrogen TPC⁽⁵⁾ was discussed in the instrumentation session of this Conference. In order to compare directly photon with pion dissociation, data were also obtained with a pion beam of 100 GeV/c , which is the mean momentum of the photon beam. Preliminary results, based on $\sim 1/4$ of the data, show that the photon dissociation cross section, $d^2\sigma/dtdM_X^2$, is exponential in t and, for $M_X^2 > 4 \text{ GeV}^2$, varies as $1/M_X^2$ (see Fig. 3). In comparing photon with pion data, we find that the diffractive cross sections scale to the corresponding total cross sections (see Fig. 4). These results, which are identical to those obtained in hadron dissociation, establish in yet another reactions the well known hadronic character of the photon.

A review of "Diffractive Interactions of Hadrons at High Energies" containing the hadron results discussed here was submitted to this Conference (K. Goulianos, Rockefeller University Report No. RU 81/A-23).

FIG. 3. The inclusive photon dissociation cross section, $d\sigma/dM_x^2$, multiplied by M_x^2 for $0.02 < |t| < 0.1$ $(\text{GeV}/c)^2$. The $1/M_x^2$ behavior for $M_x^2 \geq 4 \text{ GeV}^2$ is clearly established.

FIG. 4. Inclusive M_x^2 spectra for $\gamma p \rightarrow Xp$ and $\pi^- p \rightarrow Xp$, normalized respectively to the γp and $\pi^- p$ total cross sections.

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