FINE STRUCTURE OF THE DIFFRACTION PEAK

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Recent measurements revealed rich structure of the differential cross section and polarization of the elastic hadron-hadron scattering. It is characterized by sequence of breaks, dips and bumps with typical intervals $\Delta t_\ell \gtrsim 1$ (GeV/c)^2 /1/. This ("large-scale") structure is usually assumed to be a manifestation of coherent effects originating from "hadron size" region $\lesssim 1$ Fermi.

The possibility of a small-scale structure with period Δt_s of order of 0.1 (GeV/c)^2 was also discussed theoretically/2,3/. Some experimental indication to this structure is perhaps present (?)/2/ in the ISR data/4/. New data presented at this Conference seem to give quite a clearcut evidence for such structure.

To begin with we show in Fig. 1 elastic proton-proton differential cross section measured at p=60 GeV/c at Serpukhov/5/. Experimental points are plotted with respect to commonly used smooth curve $(d\sigma/dt)_{AV} = A\,exp(\ell t + ct^2)$ ("peak with break") and display distinct oscillations with period $\Delta t \sim 0{,}4$ (GeV/c)^2.

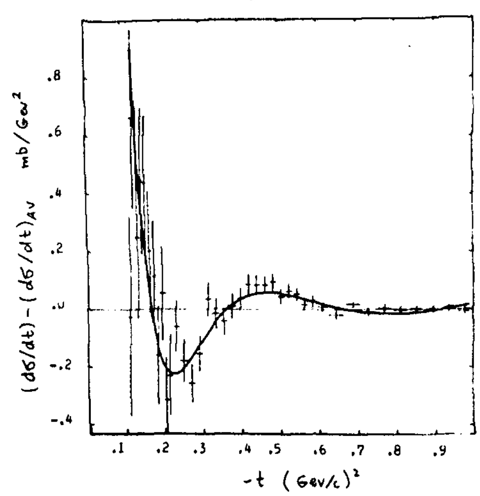

Fig. 1

The questions arise: What is the mechanism responsible for the small-scale oscillations (SSO)? Do they mean the existance of a new hadronic scale $\gg 1$ Fermi? We believe there is no need in any exotic dimensions. In fact SSO-phenomenon has been anticipated/2,3/ on the basis of ordinary scales ($t \sim 4\mu^2$ or $\ell \sim 1$ Fermi). It may arise simply due to edge effect caused by peripheral processes occurring mainly at impact parameters $\rho \sim 1$ Fermi.

It is instructive to consider an explicit model, but qualitative effect is not very sensitive to details and is model independent.

The main contribution to peripheral part $\Delta T(t)$ of elastic amplitude $T(t)$ is suggested in/3/ as coming from inelastic diffraction which is believed to have peripheral impact parameter profile/6/ (although there may be, of course, another contributions). Deck model with absorption/7/ was used to calculate the profile of diffractive dissociation contribution $\Delta G(\rho)$ into inelastic overlap function $G(\rho)$. Normalizing to diffractive cross section σ_D $(\simeq 6 mb)$ the normalization parameter C has been fixed. The resulting profile (Fig. 2) is a "ring" with radius $R \sim \left\{ 2\ell \ln \frac{\sigma(B+B_1+\ell)}{4\pi \ell^2} \right\}^{1/2} \sim 0.9$ Fermi (Here $B \simeq \ell \simeq B_1 \simeq 10$ (GeV/c)$^{-2}$ are slopes of πN, NN scattering cross sections and π-meson vertex and propagator; $\sigma \equiv \sigma_{tot}(NN)$),

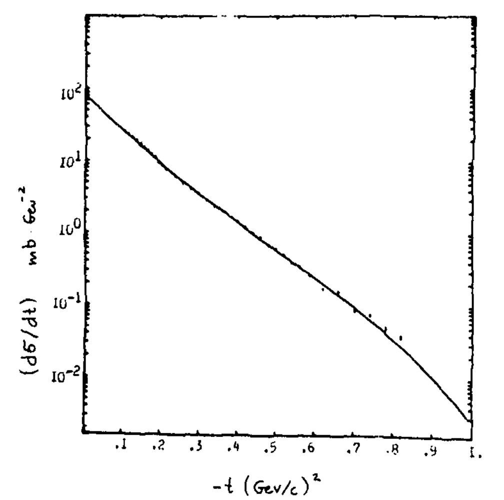

Fig. 2

Neglecting spin-flip and $\mathrm{Re}\, T$ contributions the s-channel unitarity gives $T(\rho) = 2i(1-\sqrt{1-G(\rho)})$, where $G = G_c + \Delta G$. G_c is a "central" term. Using the fact that $\Delta G(\rho)$ contributes mainly near $\rho \sim 1$ Fermi, where $G(\rho) \ll 1$, one can approximate elastic amplitude as $T(t) \simeq T_c(t) + \Delta T(t)$. $\Delta T(t)$ is the Fourier transform of $\Delta G(\rho)$ and exhibits expected Bessel - like behaviour*)

$$\Delta T(t) \sim i C \exp(at)\, J_c(R\sqrt{-t}).$$

Inelastic diffraction is believed itself to give rise to absorption resulting in alternation of the ΔT sign. In other words the "central term" T_0 may be expected to have a simple form if one takes $T = T_c - \Delta T$. Here $T_c(t)$ has a meaning of unabsorbed overlap fuction of true inelastic processes. So, we can consider both versions:

$$\frac{d\sigma}{dt} = \left\{ |T_c(t)|^2 \pm 2\, T_c^*(t)\, \Delta T(t) \right\} + |\Delta T(t)|^2. \quad (1)$$

First of all, it is easy to see that $|\Delta T(t)|^2$ gives rise to SSO (about "averaged" t-dependence) which are nicely confirmed by the data (see curve in Fig.1, $C = 4\ mb^{1/2}\mathrm{GeV}^{-1}$, $\alpha = 2{,}5\ (\mathrm{GeV/c})^{-2}$, $R = 5{,}0\ \mathrm{GeV}^{-1}$). Further, it is the absorptive (minus) sign which was shown by carefull analysis giving proper description of the "peak with break" with "simple" form for $T_o(t)$. Fig. 2 is an illustration with

$$T_o(t) = i C_1 \exp(a_1 t)\, J_1(R_1\sqrt{-t})/R_1\sqrt{-t}$$

corresponding to scattering off a disk with rounded edge $(C_1 = 26\, mb^{1/2}\mathrm{GeV}^{-1},\ a_1 = 4.8\ \mathrm{GeV}^{-2},\ R_1 = 4.\mathrm{GeV}^{-1})$.

One can expect the "edge effect" to show up also at large $|t|$ leading to large - and small-scale structure due to $\Delta T(t)$ and $|\Delta T(t)|^2$. SSO have to manifest itself in other elastic reactions and at different energies. Indeed, one could probably find it in SLAC data/7/ at 10 GeV/c and some $\pi^\pm p$ data at 4-6 GeV/c/8/.

*) From t-channel point of view it can be described by complex singularities in j - plane /2,3/.

Another place to look for SSO is the high energy nuclear scattering. Here nuclear fragmentation plays the role of dissociation and characteristic scale is determined by nuclear radii. The verification of the SSO hypothesis/2,3/ with nuclei has been done at JINR/9/ in α -particle beam at p=17.9 GeV/c. The data are summarized in Fig.3 where difference of experimental and Glauber cross sections for $\alpha - C$, $\alpha - Al$ and $\alpha - Cu$ scattering is plotted. At small $|t|$ ($.007 < |t| < .1\ \mathrm{GeV}^2$) the data exhibit oscillatory structure (although it

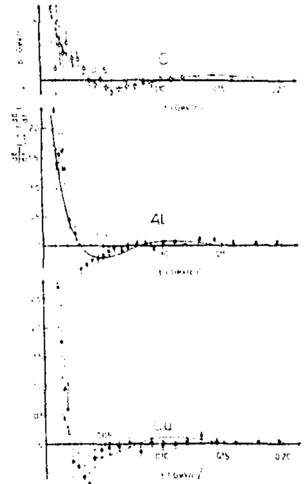

Fig. 3

is not excluded that the effect is introduced by inaccuratness of the Glauber description). Curves in Fig. 3 show the function

$$A_i\, J_0^2(R_i\sqrt{-t}) \exp(at) + c_i t + d_i .$$

The values of R_i found from the fit are of the order of radii of C, Al and Cu.

Detailed study of the nuclear fragmentation is of great interest in the light of present consideration.

We have discussed the model connecting the SSO with existence of peripheral inelastic diffraction. One can also try (especially for nuclei) to relate the SSO to fluctuations of the nuclear matter distribution ("shell effect"). However, as we know, the nuclear shell effects are expected to be shown up rather at large $|t|$ (small ρ) and have much larger period. Anyway one can hope to discriminate between these possibilities experimentally by comparing reactions with and without diffractive dissociating probe (for instance, hadron-hadron and electron-hadron scattering).

In conclusion we want to emphasize that the SSO phenomenon giving interesting information on s- and t-channel aspects of high energy scattering has to be investigated further in great detail. The energy dependence is of particular interest. If $\sigma_{tot} \sim (\ln s)^{\alpha}$ and elastic slope $B \sim (\ln s)^{\beta}$ we expect

$$\Delta t^{-1} \sim R^2 \sim (\ln s)^{\beta}[(\alpha-\beta)\ln\ln s + C].$$

The data available at present seem to confirm Δt decrease with s increasing.

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HIGH MASS DIFFRACTION EXCITATION OF PROTONS ON PROTONS AND DEUTRONS

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In this short talk I shall discuss some new results of four papers, submitted to the Conference, on the inclusive processes

$$p + p \longrightarrow X + p$$

and

$$p + d \longrightarrow X + d$$

in the kinematic range $5 \leqslant M_x^2 \leqslant 0.25$ (GeV)^2, $s > 120$ GeV^2 and $t < 0.3$ (GeV/c)^2.

Two of them present the data obtained at Fermilab with deuterium (USSR-USA collaboration)[1] and hydrogen (C-SB collaboration)[2] jet targets. In these experiments the recoil particles from the interactions of an internal beam were detected by the solid-state detector telescopes.

The authors took special care for background corrections which were < 8% for the pd case and $\leqslant$ 2% for pp.

The two others from CERN-ISR present the single-arm spectrometer data obtained with deuteron (CHM-collaboration)[3] and proton (CHLM-collaboration)[4] circulating beams.

The high mass region is the region where the triple Regge phenomenology is expected to apply. Using the generalized optical theorem[5], the inclusive reaction a + b ⟶ c + X can be related to three-body scattering amplitudes as shown in Fig. 1 and an invariant double differential cross section can be expressed as

$$s\frac{d^2\sigma}{dt\,dM_x^2}(s,t,M_x^2) = \frac{1}{s}\sum_{i,j,k} G_{i,j,k}(t)\left(\frac{s}{\nu}\right)^{\alpha_i(t)+\alpha_j(t)} \nu^{\alpha_k(0)},$$

where

$$\nu = M_x^2 - t - M_B^2 .$$

The term $G_{i,j,k}$ denotes the triple Regge coupling of three Reggeons i, j and k, where the Regge poles i and j with trajectories