Non-Diffractive and Diffractive Mechanism in Multi-Particle Production Process

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A model for exclusive reactions is proposed in the viewpoint of a coexistence of non-diffractive and diffractive mechanism. Experimental data of partial cross sections and invariant mass distributions in π⁻p collision are analyzed in this model. It is shown that in the energy region from threshold to $P_L \leq 100 \text{ GeV}/c$, a gross structure of the reaction mechanism of exclusive reaction with a fixed multiplicity, say several, is characterized by the following three regions with energy:

Region (I): Non-diffractive mechanism dominates.
Region (II): Non-diffractive and diffractive mechanism are comparable to each other.
Region (III): Diffractive mechanism dominates.

These regions exhibit a band scheme on the multiplicity—the incident momentum plane.

§ 1. Introduction

Recently two representative models, the multi-peripheral model\(^1\) and the diffractive excitation model\(^2\) have been investigated extensively by many theorists for the reaction mechanism of multi-particle production processes. These models are so monistic that they explain only the partial features of experiments and are faced with difficulties in essential points.\(^3\)\(^4\)\(^5\)\(^6\)

On the other hand, models that both multi-peripheral and diffractive mechanisms coexist have been studied.\(^8\) After all the features of experiments seem to be successfully explained in these models.\(^9\) In previous papers we also proposed a model to account for the energy dependence of partial cross sections in exclusive reactions. Its standpoint is that the reaction mechanism in multi-particle production process is composed of the non-diffractive (ND) mechanism and the diffractive (D) mechanism. The D and ND are specified by whether the so-called Pomeron\(^*\) is exchanged somewhere in the multi-peripheral chain or not, respectively. In this paper we analyze systematically partial cross sections and invariant mass distributions of exclusive reactions in π⁻p collision from the above standpoint. We study the change of the reaction mechanism with energy and multiplicity, and the roles of the above two mechanisms. We clarify the gross structure of them, and the relative magnitude of the contribution of each mecha-

\(^*\) The Pomeron used in this paper is not necessarily equivalent to the one exchanged in the elastic channel.
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nism and its energy development. Especially, the following points are clarified:
When the final multiplicity is fixed, a dominant reaction mechanism of the production process switches over from ND to D mechanism with increasing energy. On the other hand, at a fixed incident energy the former (or the latter) is dominant in reactions with large (or small) multiplicity. It is shown that the various regions on a "multiplicity-the incident momentum plane" characterize the structure of the reaction mechanism concerned, as will be discussed in § 4.

We formulate the model of ND and D mechanism in § 2. Experimental data of partial cross sections and invariant mass distributions in π⁻p collision are analyzed by this model in § 3. In § 4 the role of two mechanisms in multiparticle production is clarified and the gross structure of the reactions is discussed. Concluding remarks are given in § 5.

§ 2. The structure of non-diffractive and diffractive mechanism

We consider the following reaction with multiplicity \( n \):

\[
a + b \rightarrow c_1 + c_2 + \cdots + c_n, \tag{2·1}
\]

where \( a \) and \( b \) are initial particles and the \( c_i \)'s are final particles.\(^*\) Here we neglect the spins and isospins of the particles for simplicity. We divide the amplitude for the reaction (2·1) into the non-diffractive and diffractive part. That is, the amplitude \( T_n \) is written as

\[
T_n = T_n^{\text{ND}} + T_n^{\text{D}}, \tag{2·2}
\]

where \( T_n^{\text{ND}} \) and \( T_n^{\text{D}} \) denote the amplitude of ND and D mechanism, respectively.\(^**\)

We construct the amplitudes \( T_n^{\text{ND}} \) and \( T_n^{\text{D}} \) in the following way:

(i) We assume the multi-peripheral diagrams for both mechanisms.

(ii) The exchange of the meson and the one of Pomeron in multi-peripheral chain are parametrized as follows:

(A) \( e^{at_1 \left( \frac{S_i}{s_0} \right)^{\alpha_M}} \) for meson, where \( a = 2(\text{GeV}/c)^{-2} \) and \( \alpha_M = 0 \),

(B) \( e^{bt_1 \left( \frac{S_i}{s_0} \right)^{\alpha_P}} \) for Pomeron, where \( b = 8(\text{GeV}/c)^{-2} \) and \( \alpha_P = 1.0 \),

where \( s_0 \) is scaling parameter and is taken to be 1(GeV/c)^2. These parametrization is assumed from the threshold to high energies. The above values

\(^*\) We denote the four momenta of the particles \( a, b \) and \( c_i \) in the reaction (2·1) as \( P_a, P_b \) and \( q_i \), respectively. The number \( i \) represents the order from the side of particle \( a \) in multi-peripheral chain as shown in Fig. 1(a), and the invariant variables are defined as follows:

\[
s = (P_a + P_b)^2, \quad t_i = (P_a - \sum_{j=1}^{i} q_j)^2, \quad s_j = (q_{j+1} + q_j)^2.
\]

\(^**\) All reactions have not necessarily the two mechanisms. For example, D mechanism is forbidden for the process \( K^-p \rightarrow \pi \pi \pi n \).
of parameters $a$ and $b$ are supported by the previous analysis. Also, the value of $\alpha_\pi$ is corresponding to the intercept of the effective meson trajectory with $S=0$, where $S$ denotes the strangeness number.

(iii) Though there are many multi-peripheral diagrams according to the permutation of the final particles in the multi-peripheral chain, we select only a few diagrams which are considered to give main roles for each reaction, and construct the amplitudes corresponding to them as the effective amplitudes. Also, in the following calculation, it is assumed that these amplitudes are added incoherently, since the structure of each reaction mechanism is different from each other and the wave functions have little overlap. Such an approximation may not actually be too poor as discussed by Kinoshita and one of the authors (H.N.) in Ref. 8).

(iv) The ND mechanism is specified by such a mechanism that Pomeron is exchanged nowhere in multi-peripheral chain as shown in Fig. 1(a). We simply parametrize it by only one term. The D mechanism is characterized by the existence of Pomeron exchange in the multi-peripheral chain. Though the number of exchanged Pomeron may increase at high energies, it is assumed that the number of it is limited to only one as shown in Fig. 1, because the contributions from multi-Pomeron exchange mechanism are considered to be small in the energy region below $p_T<100\text{ GeV/c}$.

Under the above assumptions, we may parametrize the amplitudes $T_{n_{\text{ND}}}$ and $T_{n_{\text{D}}}$ as follows:

\begin{align}
T_{n_{\text{ND}}} &= C_n \cdot C_{\text{ND}} \prod_{i=1}^{n-1} e^{\alpha_{\text{ND}i}}, \\
T_{n_{\text{D}}} &= \sum_{k=1}^{n-1} C_k \cdot C_{\text{D}k} \prod_{i=1}^{n-1} e^{\alpha_{\text{D}i}} \cdot \prod_{f=1}^{n-1} e^{\beta_{\text{D}f}},
\end{align}

where $C_n$ is a normalization constant which is free from any reaction mechanism but depends on $n$, and $C_{\text{ND}}$ and $C_{\text{D}k}$ are relative weights of the respective mechanisms and assumed to be independent of $n$, for simplicity. The sum over $k$ is taken only for the terms which Pomeron exchange is allowed in multi-peripheral

![Fig. 1. Multi-peripheral diagrams which characterize the ND and D pictures. The wavy and the dashed lines represent a Pomeron and a meson, respectively.](https://academic.oup.com/ptp/article-abstract/51/2/546/1875840)
In the following discussion, the D mechanism is classified into three types; (1) Pomeron couples to particle \(a\) and a dissociated system \(b^*\) is produced \((D_b)\), (2) Pomeron couples to particle \(b\) and a dissociated system \(a^*\) is produced \((D_a)\) and (3) Pomeron is exchanged in an inner section of the multi-peripheral chain and two dissociated systems \(a^*\) and \(b^*\) are produced \((D_{ab})\), which are shown in Figs. 1(b), (c) and (d). Though the \(D_{ab}\) term contributes to the reactions with \(n=5\) and 6, the contribution from this term is small compared with \(D_a\) and \(D_b\) term. Thus, we neglect this term for simplicity. It is noted that this procedure to construct the reaction amplitude is considerably different from the one of the CLA model.

§ 3. The analyses of partial cross sections and invariant mass distributions in \(\pi^-p\) collision

1. The partial cross section

We analyze the partial cross section \(\sigma_n(s)\) for the following reactions in order to investigate the energy dependence of cross section and the role of the ND and D mechanism in each reaction:

\[
\begin{align*}
\pi^-p &\rightarrow \pi^-\pi^0p, \\
&\rightarrow \pi^-\pi^+\pi^-p, \\
&\rightarrow \pi^-\pi^+\pi^-\pi^0p, \\
&\rightarrow \pi^-\pi^+\pi^-\pi^-p. \\
\end{align*}
\]

(3.1)

According to the procedure in the previous section, the amplitudes for the above reactions are expressed by

\[
\begin{align*}
T_3 &= T_3^{ND} + T_3^{D_y}, \\
T_4 &= T_4^{ND} + T_4^{D_y} + T_4^{D_{x}}, \\
T_5 &= T_5^{ND} + T_5^{D_y}, \\
T_6 &= T_6^{ND} + T_6^{D_y} + T_6^{D_{x}}. \\
\end{align*}
\]

(3.2)

D\(_x\) mechanism is forbidden from the conservation law of G-parity when the final multiplicity \(n\) is odd and thus, we have only two terms which come from ND and D\(_x\) mechanism for these reactions. On the other hand, we have an additional term D\(_x\) for the reactions with the even multiplicity. We calculate the energy dependence of the partial cross sections and fit the data which are shown in Fig. 2. Experimental data are fitted by the following relative weight of the three mechanisms:

\[
\begin{align*}
C_{ND} : C_{D_y} = 8 : 2 & \quad \text{for odd } n, \\
C_{ND} : C_{D_y} : C_{D_{x}} = 8 : 2 : 1.3 & \quad \text{for even } n.
\end{align*}
\]
Fig. 2. The partial cross sections in $\pi^+p$ collisions. The experimental data are taken from Ref. 12. (a) $\pi^-p \rightarrow \pi^-p\pi^0$, (b) $\pi^-p \rightarrow \pi^-\pi^+\pi^-p$, (c) $\pi^+p \rightarrow \pi^-\pi^+\pi^-\pi^0p$ and (d) $\pi^+p \rightarrow \pi^-\pi^+\pi^-\pi^0p$. The solid lines represent the contributions of ND and D types and the dashed line is the total contribution.
These parameters are determined so as to fit $\sigma_n$ over all. Also, the normalization factor $C_n$ is chosen so as to fit the experimental data. The fits are shown in Fig. 2.

From this analysis the following results can be derived:

(a) The cross section of ND steeply rises from threshold, reaches the maximum point and then decreases as $P_L^{-\nu}$ ($\nu \simeq 2$). On the other hand, those of $D_N$ and $D_\pi$ slowly rises from threshold and approaches a constant with increasing energy. In all reactions, ND is dominant in the low-energy region and D changes the role in the high-energy regions as seen in Fig. 2. We call this the *switch-over mechanism*.

(b) In D mechanism, $D_\pi$ gives a larger contribution to $\sigma_n$ than $D_N$, though $C_{D\pi} \simeq C_{DN}$. This comes from the universal $t_\pi$-cut mechanism and final particle mass effect. The $D_\pi$ part gives rise to the different energy dependence between $\sigma_n(s)$ and $\sigma_4(s)$.

(c) Let us consider the contribution to the inelastic total cross section from the above types. We neglect the partial cross sections with the large multiplicities. Thus the following cross sections can be estimated from our results:

$$
\sigma_T^{ND} = \sigma_T^{ND} + \sigma_T^{D} + \sigma_T^{8} + \sigma_T^{9},
$$

where $\sigma_T^{ND}$ and $\sigma_T^{D}$ denote the total contribution from ND and D mechanism, respectively. The energy dependences of $\sigma_T^{ND}$ and $\sigma_T^{D}$ are shown in Figs. 3(a) and (b). $\sigma_T^{ND}$ shows a slowly decreasing behaviour with energy, while $\sigma_T^{D}$

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**Fig. 3.** (a) The partial cross sections of ND mechanism and $\sigma_T^{ND}$ which are shown in the solid lines and the dott-dashed line, respectively. (b) The partial cross sections of D mechanism and $\sigma_T^{D}$. The solid lines represent $\sigma_T^{D\pi}$, the dashed lines $\sigma_T^{D\pi}$ and the dott-dashed line $\sigma_T^{D}$. 
Fig. 4. The predicted energy development of the ratio of the occupation of $\sigma_n(s)$ by D mechanism. The shaded regions come from D mechanism.

increases slowly with energy. Though only these cross sections do not saturate the inelastic total cross section, it is meaningful to calculate the ratio $\sigma_T^D/\sigma_T^{ND}$, which turns out $\approx \frac{1}{3}$ at $P_L\approx 16\text{ GeV/c}$ in our case. Uehara estimated this ratio as $1/2$ at such an energy, which is not inconsistent with our result.

(d) We consider how many ratios the D type occupies in $\sigma_n(s)$ at a fixed $s$. At the three incident momenta, the ratio is presented in Fig. 4. At small multiplicities the ratio becomes large as the energy increases but at large multiplicities the ratio is small.

(2) The invariant mass distribution

The invariant mass distribution of exclusive reactions in $\pi^- p$ collision is studied here in order to check the validity of the results in (1). Since each mechanism exhibits a characteristic distribution in invariant mass distributions, we can also check the component of the reaction amplitudes. As there are no data of invariant mass distributions for the reaction considered in (1), we use the one with fixed number of pions in the process $\pi^- p \rightarrow \pi^- (m\pi + N)^+$ for $m=1, 2, 3$ and $4^{,15}$ where $\pi^-_f$ is a leading particle.
Fig. 5. The invariant mass distributions of $\pi^-p \rightarrow \pi^-(\pi N)$ at $P_L=16\text{GeV}/c$ for $m=1, 2, 3$ and 4. The experimental data are taken from Ref. 14) and shown in the dotted line. The solid lines represent the results calculated in our model by the Monte Carlo method, and are composed of the total sum of the contributions from all mechanisms, ND and D.
Fig. 5'. The invariant mass distribution of $\pi^- p \to \pi^- (3\pi N)^+$ at $P_L = 16$ GeV/c. The dotted line is experimental data. The solid line represents the result calculated with the normalization factor which is one-third of the case in Fig. 5.

Experimental data given in Fig. 5 show the following features:

(i) For $m=1$, there is a large enhancement for $1.2$ GeV $< M(\pi N) < 1.7$ GeV and a low and nearly flat tail for $M(\pi N) > 2$ GeV.

(ii) For $m=2$, there is a small and broad enhancement around $1.6$ GeV, a flat plateau for $2$ GeV $< M(2\pi N) < 3$ GeV and a linear rising for $M(2\pi N) > 3$ GeV.

(iii) For $m=3$, there is a linear rising for $M(3\pi N) < 2$ GeV and a flat plateau for $M(3\pi N) > 2$ GeV.

(iv) For $m=4$, there is an only linear rising for $M(4\pi N) > 2$ GeV.

The process $\pi^- p \to \pi^- (m\pi + N)^+$ in this experiment contains various channels with one nucleon and $m$ pions and is not same as the reactions considered in (1). Therefore the normalization factor $C_n$ which is determined from the analysis in (1) cannot be taken for the analysis of invariant mass distributions in this section. However, we are not concerned with the quantitatively detailed discussion of the fitting to the data but the characteristic role of each mechanism, ND and D, in invariant mass distributions. Therefore, we assume that the experimental data in Fig. 5 come effectively from the reactions considered in (1) and put this effect on the normalization factor of each reaction. This normalization factor in the analysis of invariant mass distributions contains some constant factor multiplied on $C_n$ which is determined from the analysis in (1) and we take this constant factor commonly for reactions with a different value of $m$.

We calculate the following quantity:

$$\frac{d\sigma_n(s)}{dM(m\pi N)} = \frac{d\sigma_n^{ND}(s)}{dM(c_1\cdots c_n)} + \frac{d\sigma_n^{D}(s)}{dM(c_1\cdots c_n)},$$

(3·5)
Fig. 6. Typical examples of the energy dependence of the invariant mass distribution of each mechanism. (A) ND mechanism in $\pi^-p\rightarrow\pi^-\pi^0N$, (B) $D_\pi$ mechanism in $\pi^-p\rightarrow\pi^-\pi^0N$ and (C) $D_\pi$ mechanism in $\pi^-p\rightarrow\pi^-\pi^0N$. In all cases, the unit of the axis of ordinate is arbitrary.

where $M(c_2\cdots c_n) = \sqrt{(\sum_{i=3}^{n} q_i)^2}$.

The calculation was carried out by Monte Carlo method. First, we consider the features of each mechanism in the invariant mass distribution. As the typical examples shown in Fig. 6 make clear, the results are summarized as follows:

(1) The invariant mass distribution of ND mechanism shows the following fea-
tures: In the energy region near threshold, it shows a sharp peak, and the shape of it crumbles through dumpling-type to a thin board-type with increasing energy.

(2) In the case of $D_N$ mechanism, there is an enhancement near low kinematic boundary, and it becomes greater with energy. However, the peak position of it does not change largely. This bump corresponds to the so-called cluster of $N^*$.

(3) In the case of $D_\pi$ mechanism, there is an enhancement near the upper kinematic boundary and it also becomes greater with energy. The peak position of this enhancement moves to a side of large invariant mass as the upper kinematic boundary increases.

(4) These features are seen commonly for all multiplicity.

Next, we analyze experimental data at $P_L=16$ GeV/c. We take the value of $(3\cdot3)$ used in the analysis of partial cross sections as the relative weights $C^{ND}$, $C^{D_N}$ and $C^{D_\pi}$ and the results obtained by our model are shown by the solid line in Fig. 5. Here we fix the normalization factor as follows:

$$1 \text{ event/1 bin} = 1.3 \times 10^{-8} \text{ mb/GeV}.$$  

Our results give a good agreement with the data except for the case of $m=3$ and show the following features:

(i)' For $m=1$, $\sigma_3^{D_\pi} > \sigma_3^{ND}$. Therefore the large enhancement from 1.2 GeV to 1.7 GeV is to be explained by $D_\pi$ mechanism and the flat tail by $ND$ mechanism.

(ii)' For $m=2$, $\sigma_4^{ND} > \sigma_4^{D_\pi} > \sigma_4^{P\pi}$. ND mechanism has a dumpling-type spectrum at this energy. A nearly flat plateau for $2 \text{ GeV} < M(2\pi N) < 3 \text{ GeV}$ is explained by this mechanism. $D_\pi$ mechanism produces a small enhancement near about 1.6 GeV and $D_\pi$ mechanism produces a large enhancement in the large invariant mass region near about 4.5 GeV.

(iii)' For $m=3$, $\sigma_6^{ND} > \sigma_6^{D_\pi}$. In this case, the prediction in our model is too high compared with the experimental data. Since the discrepancy with the data is seen only in this case, we consider that this experimental data of $\pi^- p \rightarrow \pi^- (3\pi N)^+$ may be wrong. If we take one third of the value used in this analysis as the normalization factor, we get the result seen in Fig. 5'.

(iv)' For $m=4$, $\sigma_8^{ND} > \sigma_8^{D_\pi} > \sigma_8^{P\pi}$. The invariant mass distribution is explained mainly by ND mechanism at this energy.

It is concluded that at $P_L=16$ GeV/c reactions with small multiplicity is specified by $D$ mechanism and ones with large multiplicity by $ND$ mechanism. This result comes from the fact that the threshold energy of reactions with large multiplicity is high compared with the one of reactions with small multiplicity. The threshold energy is very important in analyzing the data of exclusive reactions at a fixed energy.
§ 4. The gross structure of the reaction mechanism of exclusive reactions

From the analyses of the previous section, we study the gross structure of the reaction mechanism of exclusive reactions. As shown in Fig. 2, $\sigma_n(s)$ has three characteristic energy regions by the contribution of ND and D mechanism as follows:

Region (I): The energy region is from the threshold to the point slightly beyond the energy corresponding to the maximum peak of $\sigma_n(s)$. In this region the ND type dominate; $\sigma_n^{\text{ND}} > \sigma_n^{\text{D}}$.

Region (II): Here $\sigma_n(s)$ is attributed to both ND and D mechanism with a comparable order; $\sigma_n^{\text{ND}} \sim \sigma_n^{\text{D}}$.

Region (III): The high-energy region where $\sigma_n(s)$ comes mainly from the D type; $\sigma_n^{\text{D}} > \sigma_n^{\text{ND}}$.

We sketch this feature in Fig. 7 on the multiplicity-the incident momentum plane. The regions (I), (II) and (III) construct a band scheme.

We discuss the importance of this viewpoint. Yap Sue-Pin et al.\cite{16} and we\cite{10} analyzed the experimental data of Hansen et al.\cite{14} by the universal $t_t$-cut mechanism and showed that the empirical formula

$$ P_n^{\text{max}} = an^b $$

between the multiplicity ($n$) and the momentum ($P_n^{\text{max}}$) corresponding to the maximum point of $\sigma_n(s)$ is explained by the universal $t_t$-cut mechanism, where $a$ increases with the mass of incoming particle and $b$ is approximately constant at a value of 2.5. This result is understood as follows: The maximum point of $\sigma_n(s)$ belongs to region (I) and therefore the main part of $\sigma_n(s)$ comes from ND mechanism, i.e., the universal $t_t$-cut mechanism. Therefore their analyses are successful. Myozyo and one of the authors (H.N.)\cite{17} discussed the connection of the experimental features of Eq. (4·1) with the energy dependence of the averaged multiplicity. They showed that the behaviour of the maximum point of $\sigma_n$ characterizes the energy dependence and the absolute of the

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{band_scheme.png}
\caption{The illustration of the band scheme on the multiplicity-the incident momentum plane.}
\end{figure}
avg. multiplicity. Its result implies that ND mechanism is the main origin of the multiplicity-increase up to TeV energy region. Also, our analysis of the rank structure of exclusive reactions by the $t$-cut mechanism\textsuperscript{19} is supported since we are concerned with Region (I) in Ref. 18).

Also a development of the invariant mass distribution with energy is also specified by regions (I), (II) and (III). When we fix the momentum at $P_L=16$ GeV/c and change the multiplicity, we have already obtained Fig. 5. This figure is easily understood as follows: The reaction of $n=3$ belongs to Region (III) at this energy and therefore $D_N$ contributes mainly to the invariant mass distribution, the reaction of $n=4$ belongs to Region (II) and therefore ND and D ($=D_x+D_N$) contribute comparably, and the reactions of $n=5$ and 6 belong to Region (I) and therefore ND contributes mainly.

Next we are concerned with the energy development of the invariant mass distribution with a fixed multiplicity. As an example, we take the process $\pi^-p\rightarrow\pi^-(2\pi N)^+$. At 16 GeV/c (Region (II)), $\sigma_t^{ND} = \sigma_t^{D} > \sigma_t^p$, but at 64 GeV/c (Region (III)), $\sigma_t^p$, $\sigma_t^{D*} > \sigma_t^{ND}$. Therefore a clear enhancement at small invariant mass region which comes from $D_N$, appears as in Fig. 8. At low energy near threshold, it is expected that the invariant mass distribution is governed mainly by ND.

Recently, Uehara\textsuperscript{9} pointed out that in the reaction $\pi^-p\rightarrow\pi^-(4\pi N)^+$ at $P_L=16$ GeV/c, the linear rising distributions of $M(4\pi N)>2$ GeV comes from $\pi_s^*p$.
channel, where \( \pi_n^* \) denotes a diffractively produced dissociated pion system containing five pions. At this energy, however, the main part of this linear rising is caused by ND mechanism according to our analysis. Also Hama\(^5\) analyzed the same data from the viewpoint of the monistic D mechanism. This analysis seems to be faced with the difficulty in explaining the energy dependence of partial cross sections. In fact, the prediction of this model for the invariant mass distribution disagrees with data of \((2\pi N)^+\). It seems to be difficult to fit the various data by only D mechanism. So, ND mechanism must be added to it just as our analysis. Thus when one analyzes the exclusive reaction, one must notice to which region among the three regions (I), (II) and (III) the incident momentum belongs.

§ 5. Concluding remarks

1. From the above investigation, it is clarified that the gross feature of the exclusive reactions with a fixed multiplicity, say several, in the energy region from threshold to \( P_L \leq 100 \text{ GeV}/c \) is understood by the coexistence of ND and D mechanisms and the energy behaviour of relative magnitude of them. As seen in Fig. 3, \( \sigma_T^{\text{ND}} \) shows a slowly decreasing behaviour with energy, while \( \sigma_T^{\text{D}} \) increases slowly with energy. This suggests that ND and D correspond to the multi-peripheral model\(^1\) and the diffractive excitation model\(^5\),\(^6\) respectively. In our model, the relative magnitude of ND and D is characterized by the appropriate weight, for example \( (3\cdot3) \) in the reaction \( \pi p \rightarrow p + (n-1)\pi \). The existence of this relative weight produces the switch-over mechanism of ND and D. Therefore when we look out over the whole exclusive reactions, it is seen that the gross feature of them is characterized by the various areas on the multiplicity-the incident momentum plane, i.e., Regions (I), (II) and (III). We call this a band scheme.

2. In this paper we have assumed that the ND mechanism is effectively composed of only one term. The ND mechanism, however, has to be divided into \( \Xi \) and \( \bar{H} \)-type mechanism as was discussed by Kinoshita and one of the authors (H.N.), taking the urbaryon rearrangement diagram into account.\(^8\) This is related to what the elastic Pomeron is and to what energy dependence the ratio \( \sigma_T^{\text{D}}/\sigma_T^{\text{ND}} \) has. As shown in this paper, the ND type is dominant in the inelastic total cross section below \( P_L \leq 100 \text{ GeV}/c \). Above TeV region, however, the type D may become possibly dominant.

3. The Pomeron exchanged in the inelastic reactions introduced here explains the constant behaviour of \( \sigma_n(s) \). The question what this Pomeron is, remains in the future.

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