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19/III-69

СООБЩЕНИЯ
ОБЪЕДИНЕННОГО
ИНСТИТУТА
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E2 - 4286

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ЛАБОРАТОРИЯ ТЕОРЕТИЧЕСКОЙ ФИЗИКИ

KINEMATICS AND REGGE DYNAMICS OF QUASI--TWO-BODY N-N INTERACTIONS

1969

E2 - 4286

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KINEMATICS AND REGGE DYNAMICS OF QUASI-TWO-BODY N-N INTERACTIONS

1. Introduction

Recently considerable progress has been achieved in studying the quasi-two-body reactions by means of the Regge theory. There arise many interesting questions connected with the complications due to high spins and unequal-mass kinematics which can be treated exactly[1,2].

For example, the t-channel helicity amplitudes may have singularitites or zeros at the thresholds and pseudothresholds $t=(m_i \pm m_j)^2$. It is important to take into account such kinematic singularities in the Regge model. Another aspect of the problem is connected with the existence of some relations between various helicity amplitudes at the thresholds and pseudothresholds. Such relations are called kinematic constraints and are discussed in a very general way, in ref.[2]. Applications of the general methods to the photoproduction of an Δ - isobar can be found in[3]. In the present paper we will consider the quasi-two-body reactions $N+N \to N+\Delta(\frac{3}{2}^+)$, $N+N^*(\frac{3}{2}^-)$ and $N+N'(\frac{1}{2}^+)$. These processes have been recently considered by Wang[4] in the framework of the Regge theory. However she did not consider the conspiracy relations and the threshold and pseudothreshold constraints. Here we present systematically the kinematics of these processes and give the conspiracy relations, the threshold and pseudothreshold constraints. Because, at present, the energy achieved by accelerators is not high enough we take into account the contribution of the all possible trajectories. Then we will accept the Wang one-trajectory approximation and find some consequences for the spin density matrix elements of the isobar which can be checked by experiment in near future. Other approximations (with the account of the π- trajectory with and without conspiracy) will be considered elsewhere. In Section 2 we present the kinematics of the processes, in Section 3 we consider the conspiracy relations and the pseudo-threshold constraints. In Section 4 we give the factorization condition. Section 5 deals with the reggeization of the amplitudes. In Section 6 the observables are expressed in terms of the reggeized amplitudes. Finally in Section 7 we consider some approximation, its consequences and draw conclusions.

2. Kinematics

In this section we use the notations from our previous work[3] ; $f^{t}_{CA;DB}(s,t)$ are the amplitudes in the crossing channel of the process $a + b \to c + d$, where c, A, D, b is the helicity of particles c, A, D, b and A, D denote also the antiparticles of particles a, d, respectively. Then the amplitudes with definite parities [5] can be written in the form [1]

$$\bar{f}^{t\pm}_{cA;Db} = \bar{f}^{t}_{cA;Db} \pm \bar{f}^{t}_{-c-A;Db} = K^{\pm}_{cA;Db} \tilde{f}^{t}_{cA;Db} , \tag{2.1}$$

where

$$\bar{f}^{t}_{cA;Db} = \left(\sin\frac{\vartheta_t}{2}\right)^{-|\lambda'-\mu'|} \left(\cos\frac{\vartheta_t}{2}\right)^{-|\lambda'+\mu'|} f^{t}_{cA;Db} \tag{2.2}$$

$$\lambda' = D - b \quad , \quad \mu' = c - A ,$$

$\tilde{f}^{t}_{cA;Db}$ are the amplitudes without kinematic singularities in s and t . We reggeize them by the method of Gell-Mann et al.[5] The quantities $K^{\pm}_{cA;Db}$ are the factors containing all the kinematic singularities in t of the corresponding amplitudes. They can be found by the methods of refs.[1,2]. We give them in Tables 1-3. In these tables $\varphi = \left[t - (M+m)^2\right]^{\frac{1}{2}}$,

$\psi = \left[t - (M-m)^2\right]^{\frac{1}{2}}$, m and M

are the masses of the nucleon and isobar respectively.

Table 1.

$K^{\pm}$ - functions for the process $N+N \to N+\Delta(1236, \frac{3}{2}^{+})$

Notations	Amplitudes	$K^{\pm}$-functions	Dominant parity
$2G_1^t$	$\bar{f}^{t+}_{\frac12\frac12;\frac32\frac12}$	ψ^{-1}	$(-1)^J$
$2G_2^t$	$\bar{f}^{t-}_{\frac12\frac12;\frac32\frac12}$	$t^{-\frac12}\varphi^{-1}(t-4m^2)^{\frac12}$	$(-1)^{J+1}$
$2G_3^t$	$\bar{f}^{t+}_{\frac12-\frac12;\frac32\frac12}$	$t^{-\frac12}\psi^{-1}$	$(-1)^J$
$2G_4^t$	$\bar{f}^{t-}_{\frac12-\frac12;\frac32\frac12}$	$\varphi^{-1}(t-4m^2)^{\frac12}$	$(-1)^{J+1}$
$4G_5^t$	$\bar{f}^{t+}_{\frac12\frac12;\frac32-\frac12}$	$\varphi(t-4m^2)^{\frac12}$	$(-1)^J$
$4G_6^t$	$\bar{f}^{t-}_{\frac12\frac12;\frac32-\frac12}$	$t^{-\frac12}\psi(t-4m^2)$	$(-1)^{J+1}$
$4G_7^t$	$\bar{f}^{t+}_{\frac12-\frac12;\frac32-\frac12}$	$t^{-\frac12}\varphi(t-4m^2)^{\frac12}$	$(-1)^J$
$4G_8^t$	$\bar{f}^{t-}_{\frac12-\frac12;\frac32-\frac12}$	$\psi(t-4m^2)$	$(-1)^{J+1}$
G_9^t	$\bar{f}^{t+}_{\frac12\frac12;\frac12\frac12}$	$\psi^{-2}\varphi^{-1}(t-4m^2)^{-\frac12}$	$(-1)^J$
G_{10}^t	$\bar{f}^{t-}_{\frac12\frac12;\frac12\frac12}$	$t^{-\frac12}\psi^{-1}\varphi^{-2}$	$(-1)^{J+1}$
$2G_{11}^t$	$\bar{f}^{t-}_{\frac12-\frac12;\frac12\frac12}$	ψ^{-1}	$(-1)^J$
$2G_{12}^t$	$\bar{f}^{t+}_{\frac12-\frac12;\frac12\frac12}$	$t^{-\frac12}\varphi^{-1}(t-4m^2)^{\frac12}$	$(-1)^{J+1}$
$2G_{13}^t$	$\bar{f}^{t+}_{\frac12\frac12;\frac12-\frac12}$	ψ^{-1}	$(-1)^J$
$2G_{14}^t$	$\bar{f}^{t-}_{\frac12\frac12;\frac12-\frac12}$	$t^{-\frac12}\varphi^{-1}(t-4m^2)^{\frac12}$	$(-1)^{J+1}$
$2G_{15}^t$	$\bar{f}^{t+}_{\frac12-\frac12;\frac12-\frac12}$	$t^{-\frac12}\psi^{-1}$	$(-1)^J$
$2G_{16}^t$	$\bar{f}^{t-}_{\frac12-\frac12;\frac12-\frac12}$	$\varphi^{-1}(t-4m^2)^{\frac12}$	$(-1)^{J+1}$

Table 2. $K^{\pm}$– functions for process

NN → NN*(1500, $\frac{3}{2}^-$)

Notations	Amplitudes	$K^{\pm}$– functions	Dominant parity
$2H_1^t$	$\bar{f}^{t+}_{\frac{1}{2}\frac{1}{2};\frac{3}{2}\frac{1}{2}}$	φ^{-1}	$(-1)^J$
$2H_2^t$	$\bar{f}^{t-}_{\frac{1}{2}\frac{1}{2};\frac{3}{2}\frac{1}{2}}$	$t^{-\frac{1}{2}}\psi^{-1}(t-4m^2)^{\frac{1}{2}}$	$(-1)^{J+1}$
$2H_3$	$\bar{f}^{t+}_{\frac{1}{2}-\frac{1}{2};\frac{3}{2}\frac{1}{2}}$	$t^{-\frac{1}{2}}\varphi^{-1}$	$(-1)^J$
$2H_4^t$	$\bar{f}^{t-}_{\frac{1}{2}-\frac{1}{2};\frac{3}{2}\frac{1}{2}}$	$\psi^{-1}(t-4m^2)^{\frac{1}{2}}$	$(-1)^{J+1}$
$4H_5^t$	$\bar{f}^{t+}_{\frac{1}{2}\frac{1}{2};\frac{3}{2}-\frac{1}{2}}$	$\psi(t-4m^2)^{\frac{1}{2}}$	$(-1)^J$
$4H_6^t$	$\bar{f}^{t-}_{\frac{1}{2}\frac{1}{2};\frac{3}{2}-\frac{1}{2}}$	$t^{-\frac{1}{2}}\varphi(t-4m^2)$	$(-1)^{J+1}$
$4H_7^t$	$\bar{f}^{t+}_{\frac{1}{2}-\frac{1}{2};\frac{3}{2}-\frac{1}{2}}$	$t^{-\frac{1}{2}}\psi(t-4m^2)^{\frac{1}{2}}$	$(-1)^J$
$4H_8^t$	$\bar{f}^{t-}_{\frac{1}{2}-\frac{1}{2};\frac{3}{2}-\frac{1}{2}}$	$\varphi(t-4m^2)$	$(-1)^{J+1}$
H_9^t	$\bar{f}^{t+}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}$	$\varphi^{-2}\psi^{-1}(t-4m^2)^{-\frac{1}{2}}$	$(-1)^J$
H_{10}^t	$\bar{f}^{t-}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}$	$t^{-\frac{1}{2}}\varphi^{-1}\psi^{-2}$	$(-1)^{J+1}$
$2H_{11}^t$	$\bar{f}^{t-}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}}$	φ^{-1}	$(-1)^J$
$2H_{12}^t$	$\bar{f}^{t+}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}}$	$t^{-\frac{1}{2}}\psi^{-1}(t-4m^2)^{\frac{1}{2}}$	$(-1)^{J+1}$
$2H_{13}^t$	$\bar{f}^{t+}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}}$	φ^{-1}	$(-1)^J$
$2H_{14}^t$	$\bar{f}^{t-}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}}$	$t^{-\frac{1}{2}}\psi^{-1}(t-4m^2)^{\frac{1}{2}}$	$(-1)^{J+1}$
$2H_{15}^t$	$\bar{f}^{t+}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}}$	$t^{-\frac{1}{2}}\varphi^{-1}$	$(-1)^J$
$2H_{16}^t$	$\bar{f}^{t-}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}}$	$\psi^{-1}(t-4m^2)^{\frac{1}{2}}$	$(-1)^{J+1}$

Table 3. $K^{\pm}$ – functions for process

$NN \to NN'(1470, \frac{1}{2}^{+})$

Notations	Amplitudes	$K^{\pm}$ functions	Dominant parity
F_1^t	$\bar{f}^{t+}_{\frac12\frac12;\frac12\frac12}$	$\varphi^{-1}(t-4m^2)^{-\frac12}$	$(-1)^J$
F_2^t	$\bar{f}^{t-}_{\frac12\frac12;\frac12\frac12}$	$t^{-\frac12}\psi^{-1}$	$(-1)^{J+1}$
$2F_3^t$	$\bar{f}^{t-}_{\frac12-\frac12;\frac12\frac12}$	ψ	$(-1)^J$
$2F_4^t$	$\bar{f}^{t+}_{\frac12-\frac12;\frac12\frac12}$	$t^{-\frac12}\varphi(t-4m^2)^{\frac12}$	$(-1)^{J+1}$
$2F_5^t$	$\bar{f}^{t+}_{\frac12\frac12;\frac12-\frac12}$	ψ	$(-1)^J$
$2F_6^t$	$\bar{f}^{t-}_{\frac12\frac12;\frac12-\frac12}$	$t^{-\frac12}\varphi(t-4m^2)^{\frac12}$	$(-1)^{J+1}$
$2F_7^t$	$\bar{f}^{t+}_{\frac12-\frac12;\frac12-\frac12}$	$t^{-\frac12}\psi$	$(-1)^J$
$2F_8^t$	$\bar{f}^{t-}_{\frac12-\frac12;\frac12-\frac12}$	$\varphi(t-4m^2)^{\frac12}$	$(-1)^{J+1}$

3. Conspiracy relations, threshold and pseudothreshold constraints

As is known, the helicity amplitudes should obey the so-called conspiracy relations at $t=0$ as well as the threshold and pseudothreshold relations at $t=(m_i \pm m_j)^2$. The conspiracy relations were first derived by Volkov and Gribov for forward NN scattering[6]. Högaasen and Salin[7] have considered this problem for the general case. The most complete treatment of this problem is given in ref.[2]. Using the method of this work (see also refs.[8,9]) we get the following conspiracy relations:

For the processes $N+N \to N+\Delta\,(1236,\tfrac{3}{2}^+)$ and $N+N \to N+N^*(1518,\tfrac{3}{2}^-)$

$$t^{\frac12}\left(\bar f^{\,t}_{\frac12\frac12;\frac32\frac12} - \bar f^{\,t}_{-\frac12-\frac12;\frac32\frac12}\right) = -i\,t^{\frac12}\left(\bar f^{\,t}_{\frac12-\frac12;\frac32\frac12} + \bar f^{\,t}_{-\frac12\frac12;\frac32\frac12}\right) \tag{3.1}$$

$$t^{\frac12}\left(\bar f^{\,t}_{\frac12\frac12;\frac32-\frac12} - \bar f^{\,t}_{-\frac12-\frac12;\frac32-\frac12}\right) = -i\,t^{\frac12}\left(\bar f^{\,t}_{\frac12-\frac12;\frac32-\frac12} + \bar f^{\,t}_{-\frac12\frac12;\frac32-\frac12}\right) \tag{3.2}$$

$$t^{\frac12}\left(\bar f^{\,t}_{\frac12\frac12;\frac12\frac12} - \bar f^{\,t}_{-\frac12-\frac12;\frac12\frac12}\right) = -\frac{i}{2}\,t^{\frac12}\left(\bar f^{\,t}_{\frac12-\frac12;\frac12\frac12} + \bar f^{\,t}_{-\frac12\frac12;\frac12\frac12}\right) \tag{3.3}$$

$$t^{\frac12}\left(\bar f^{\,t}_{\frac12\frac12;\frac12-\frac12} - \bar f^{\,t}_{-\frac12-\frac12;\frac12-\frac12}\right) = -i\,t^{\frac12}\left(\bar f^{\,t}_{\frac12-\frac12;\frac12-\frac12} + \bar f^{\,t}_{-\frac12\frac12;\frac12-\frac12}\right) \tag{3.4}$$

For process: $N+N \to N+N'\,(1470,\tfrac{1}{2}^+)$

$$t^{\frac{1}{2}}\left(\bar{f}^{t}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}} - \bar{f}^{t}_{-\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}}\right) = -\frac{i}{2}\, t^{\frac{1}{2}}\left(\bar{f}^{t}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}} + \bar{f}^{t}_{-\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\right) \tag{3.5}$$

$$t^{\frac{1}{2}}\left(\bar{f}^{t}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}} - \bar{f}^{t}_{-\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}}\right) = -i\, t^{\frac{1}{2}}\left(\bar{f}^{t}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}} + \bar{f}^{t}_{-\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}}\right) \tag{3.6}$$

It is seen from Tables 1-3 and the relations (3.1) - (3.6) that (3.1), (3.2), (3.4), (3.6) belong to the third and (3.3) and (3.5) to the second class of the conspiracy according to the group theory classification [10-12]. Some information on the solution of the conspiracy relations (conspiratorial or evasive [13]) can be obtained from the factorization condition, which will be considered in the next section. Here we write down the conspiracy relations only for the processes involved in the factorization condition, Namely, for process

$\bar{N}'(\frac{1}{2}^{+}) + N \to \bar{N}'(\frac{1}{2}^{+}) + N$

$$t\left(\bar{f}^{t}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}} + \bar{f}^{t}_{-\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}}\right) = -t\left(\bar{f}^{t}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}} - \bar{f}^{t}_{-\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}}\right) \tag{3.7}$$

for $N + \bar{N} \to N + \bar{N}$

$$f^{t}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}} - f^{t}_{-\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}} = f^{t}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}} - f^{t}_{-\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}} \tag{3.8}$$

The relation (3.8) can be found in ref.[6]. The relations for process $\bar{\Delta}+N\rightarrow\bar{\Delta}+N$ are considered in ref.[3]. The conspiracy relations for $\bar{N}^*(\frac{3}{2}^-)+N\rightarrow\bar{N}^*(\frac{3}{2}^-)+N$ are the same as for process $\bar{\Delta}(\frac{3}{2}^+)+N\rightarrow\bar{\Delta}(\frac{3}{2}^+)+N$. In order to find the threshold and pseudothreshold relations which the helicity amplitudes[14] should obey we use, as was already mentioned, the method of Cohen-Tanoudji-Morel-Navelet[2]. Here we only stress that the threshold at $t=4m^2$ is relatively far from the physical region of the s-channel , so that we shall consider the pseudothreshold relations at $t=(M-m)^2$. They read:

For process $N+N\rightarrow N+\Delta\,(1236)$

$$\psi^2\left[\sqrt{3}\,G^t_{(4,3)}-G^t_9-G^t_{(16,15)}+iy\left(-\sqrt{3}G^t_1+\sqrt{3}\,G^t_{(8,7)}-G^t_{11}-G^t_{13}\right)+\sqrt{3}\,y^2G^t_5\right]\simeq\psi^2 \quad (3.9)$$

$$\psi^2\left[\sqrt{3}\,G^t_{(4,3)}+G^t_9+G^t_{(16,15)}+iy\left(\sqrt{3}\,G^t_1+\sqrt{3}\,G^t_{(8,7)}-G^t_{11}+G^t_{13}\right)-\sqrt{3}\,y^2G^t_5\right]\simeq\psi^2 \quad (3.10)$$

$$\psi^2\left[-\sqrt{3}\,G^t_{(4,3)}-G^t_9-G^t_{(16,15)}+iy\left(\sqrt{3}\,G^t_1+\sqrt{3}\,G^t_{(8,7)}-G^t_{11}+G^t_{13}\right)+\sqrt{3}\,y^2G^t_5\right]\simeq\psi^2 \quad (3.11)$$

$$\psi^2\left[-\sqrt{3}\,G^t_{(4,3)}+G^t_9-G^t_{(16,15)}+iy\left(-\sqrt{3}\,G^t_1+\sqrt{3}\,G^t_{(8,7)}-G^t_{11}-G^t_{13}\right)-\sqrt{3}\,y^2G^t_5\right]\simeq\psi^2 \quad (3.12)$$

$$\psi^2\left[G^t_{(3,4)}+\sqrt{3}\,G^t_{10}-\sqrt{3}\,G^t_{(15,16)}+iy\left(-G^t_2+G^t_{(7,8)}-\sqrt{3}G^t_{12}-\sqrt{3}G^t_{14}\right)-y^2G^t_6\right]\simeq\psi^3 \quad (3.13)$$

$$\psi^2\left[G^t_{(3,4)}+\sqrt{3}\,G^t_{10}+\sqrt{3}\,G^t_{(15,16)}+iy\left(-G^t_2-G^t_{(7,8)}+\sqrt{3}\,G^t_{12}-\sqrt{3}\,G^t_{14}\right)-y^2G^t_6\right]\simeq\psi^3 \tag{3.14}$$

$$\psi^2\left[\sqrt{3}\,G^t_{(3,4)}-G^t_{10}-G^t_{(15,16)}+iy\left(\sqrt{3}\,G^t_2+\sqrt{3}\,G^t_{(7,8)}+G^t_{12}-G^t_{14}\right)-\sqrt{3}\,y^2G^t_6\right]\simeq\psi^3 \tag{3.15}$$

$$\psi^2\left[-\sqrt{3}\,G^t_{(3,4)}-G^t_{10}+G^t_{(15,16)}+iy\left(\sqrt{3}\,G^t_2-\sqrt{3}\,G^t_{(7,8)}-G^t_{12}-G^t_{14}\right)-\sqrt{3}\,y^2G^t_6\right]\simeq\psi^3 \tag{3.16}$$

$$\psi^2\left[-G^t_{(4,3)}-\sqrt{3}\,G^t_9+\sqrt{3}\,G^t_{(16,15)}+iy\left(G^t_1-G^t_{(8,7)}-\sqrt{3}\,G^t_{11}-\sqrt{3}\,G^t_{13}\right)-y^2G^t_5\right]\simeq\psi^4 \tag{3.17}$$

$$\psi^2\left[-G^t_{(4,3)}+\sqrt{3}\,G^t_9+\sqrt{3}\,G^t_{(16,15)}+iy\left(-G^t_1-G^t_{(8,7)}-\sqrt{3}\,G^t_{11}+\sqrt{3}\,G^t_{13}\right)+y^2G^t_5\right]\simeq\psi^4 \tag{3.18}$$

For process $N+N\rightarrow N+N^*(1518,\tfrac{3}{2}^-)$

$$\psi^2\left[i\sqrt{3}\,H^t_{(3,4)}+i\,H^t_{10}+i\,H^t_{(15,16)}+y\left(-\sqrt{3}\,H^t_2-\sqrt{3}\,H^t_{(7,8)}+H^t_{12}-H^t_{14}\right)-i\sqrt{3}\,y^2H^t_6\right]\simeq\psi^2 \tag{3.19}$$

$$\psi^2\left[-\sqrt{3}\,H^t_{(3,4)}+i\,H^t_{10}-i\,H^t_{(15,16)}+y\left(-\sqrt{3}\,H^t_2+\sqrt{3}\,H^t_{(7,8)}-H^t_{12}-H^t_{14}\right)-i\sqrt{3}\,y^2H^t_6\right]\simeq\psi^2 \tag{3.20}$$

$$\psi^2\left[-i\sqrt{3}\,H^t_{(3,4)}+i\,H^t_{10}-i\,H^t_{(15,16)}+y\left(\sqrt{3}\,H^t_2-\sqrt{3}\,H^t_{(7,8)}+H^t_{12}+H^t_{14}\right)-i\sqrt{3}\,y^2H^t_6\right]\simeq\psi^2 \tag{3.21}$$

$$\psi^2\left[i\sqrt{3}\, H^t_{(3,4)} + i H^t_{10} + i H^t_{(15,16)} + y\left(\sqrt{3}\, H^t_2 + \sqrt{3}\, H^t_{(7,8)} - H^t_{12} + H^t_{14}\right) - i\sqrt{3}\, y^2 H^t_6\right] \simeq \psi^2 \tag{3.22}$$

$$\psi^2\left[i H^t_{(4,3)} + i\sqrt{3}\, H^t_9 + i\sqrt{3}\, H^t_{(16,15)} + y\left(H^t_1 + H^t_{(8,7)} - \sqrt{3}\, H^t_{11} + \sqrt{3}\, H^t_{13}\right) - i y^2 H^t_5\right] \simeq \psi^3 \tag{3.23}$$

$$\psi^2\left[i H^t_{(4,3)} - i\sqrt{3}\, H^t_9 + i\sqrt{3}\, H^t_{(16,15)} + y\left(-H^t_1 + H^t_{(8,7)} - \sqrt{3}\, H^t_{11} - \sqrt{3}\, H^t_{13}\right) + i y^2 H^t_5\right] \simeq \psi^3 \tag{3.24}$$

$$\psi^2\left[-i\sqrt{3}\, H^t_{(4,3)} - i H^t_9 + i H^t_{(16,15)} + y\left(-\sqrt{3}\, H^t_1 + \sqrt{3}\, H^t_{(8,7)} + H^t_{11} + H^t_{13}\right) - i\sqrt{3}\, y^2 H^t_5\right] \simeq \psi^3 \tag{3.25}$$

$$\psi^2\left[-i\sqrt{3}\, H^t_{(4,3)} + i H^t_9 + i H^t_{(16,15)} + y\left(\sqrt{3}\, H^t_1 + \sqrt{3}\, H^t_{(8,7)} + H^t_{11} - H^t_{13}\right) + i\sqrt{3}\, y^2 H^t_5\right] \simeq \psi^3 \tag{3.26}$$

$$\psi^2\left[-i H^t_{(3,4)} + i\sqrt{3}\, H^t_{10} + i\sqrt{3}\, H^t_{(15,16)} + y\left(H^t_2 + H^t_{(7,8)} + \sqrt{3}\, H^t_{12} - \sqrt{3}\, H^t_{14}\right) + i y^2 H^t_6\right] \simeq \psi^4 \tag{3.27}$$

$$\psi^2\left[i H^t_{(3,4)} + i\sqrt{3}\, H^t_{10} - i\sqrt{3}\, H^t_{(15,16)} + y\left(H^t_2 - H^t_{(7,8)} - \sqrt{3}\, H^t_{12} - \sqrt{3}\, H^t_{14}\right) + i y^2 H^t_6\right] \simeq \psi^4 \tag{3.28}$$

For process $N+N \to N+N'(1470, \frac{1}{2}^+)$

$$\psi\left[F_2^t - iy F_4^t + iy F_6^t + F_{(7,8)}^t\right] \simeq \psi^2 \tag{3.29}$$

$$\psi\left[F_2^t + iy F_4^t - iy F_6^t - F_{(7,8)}^t\right] \simeq \psi^2 \tag{3.30}$$

4. Factorization

The factorization condition can be written in the form[4]

$$\left[\gamma_2^{\pm}(t) K_2^{\pm}(t) \left(P_{cA} P_{Db}\right)^{\alpha - M_2}\right]^2 =$$

$$\left[\gamma_1^{\pm}(t) K_1^{\pm}(t) \left(P_{Db}\right)^{2(\alpha - M_1)}\right]\left[\gamma_3^{\pm}(t) K_3^{\pm}(t) \left(P_{cA}\right)^{2(\alpha - M_3)}\right], \tag{4.1}$$

where $\gamma^{\pm}_{cA;Db}$ is the dynamical part of the residue functions. The index I corresponds to process $D+b \to D+b$, the index 2 to $D+b \to c+A$, the index 3 to $c+A \to c+A$. By means of Tables 1-3 we can rewrite explicitly (4.1) in the form of Tables 4-5. The factorization condition for the auxiliary processes are given in Tables 6-7, while for process $\bar{\Delta} N \to \bar{\Delta} N$ in ref.[3] The factorization condition for $N + N \to N + N^*$ $(1518, \frac{3}{2}^-)$ is also given in Table 4, only in this case process $\bar{N}^*(\frac{3}{2}^-) + N \to \bar{N}^*(\frac{3}{2}^-) + N$

should imply index 1, and process $\overline{N}^*(\frac{3}{2}^-)+N \rightarrow N+\overline{N}$ should imply index 2.

The solutions for the factorization condition with minimum t-dependence are given in Tables 8,9.

It follows from Tables 8-9 that the factorization requires:

1. The relations (3.1) (3.2) (3.6) should be satisfied by the conspiratorial solution.

2. The relations (3.3) and (3.5) should be satisfied by the evasive solution.

For the auxiliary processes we are led to the following conclusions:

1. The relations (3.7) and (3.8) are satisfied by the conspiratorial solution.

2. The solution for the conspiracy relations for process $\overline{\Delta} N \rightarrow \overline{\Delta} N$ can be found in ref.[3].

5. Reggeization

For reggeization of the parity-conserving helicity amplitudes we follow the method given in[5]. In order to decide what Regge poles contribute to the definite partial amplitudes it is convenient to decompose each of them into amplitudes for transitions between states of definite parity. A nucleon-antinucleon helicity states with definite parity together with possible trajectories are given in Tables 10,11.

Table 4

Factorization condition for $\bar{\Delta}+N\to N+\bar{N}$	Factorization satisfied
$t\left(\gamma^{+2}_{\frac12\frac12;\frac32\frac12}\right)^2=\gamma^{+1}_{\frac32\frac12;\frac32\frac12}\cdot\gamma^{+3}_{\frac12\frac12;\frac12\frac12}$	no
$\left(\gamma^{-2}_{\frac12\frac12;\frac32\frac12}\right)^2=\gamma^{-1}_{\frac32\frac12;\frac32\frac12}\cdot\gamma^{-3}_{\frac12\frac12;\frac12\frac12}$	yes
$\left(\gamma^{+2}_{\frac12-\frac12;\frac32\frac12}\right)^2=\gamma^{+1}_{\frac32\frac12;\frac32\frac12}\cdot\gamma^{+3}_{\frac12-\frac12;\frac12-\frac12}$	yes
$t\left(\gamma^{-2}_{\frac12-\frac12;\frac32\frac12}\right)^2=\gamma^{-1}_{\frac32\frac12;\frac32\frac12}\cdot\gamma^{-3}_{\frac12-\frac12;\frac12-\frac12}$	no
$t^2\left(\gamma^{+2}_{\frac12\frac12;\frac32-\frac12}\right)^2=\gamma^{+}_{\frac32-\frac12;\frac32-\frac12}\cdot\gamma^{+3}_{\frac12\frac12;\frac12\frac12}$	no
$t\left(\gamma^{-2}_{\frac12\frac12;\frac32-\frac12}\right)^2=\gamma^{-1}_{\frac32-\frac12;\frac32-\frac12}\cdot\gamma^{-3}_{\frac12\frac12;\frac12\frac12}$	no
$t\left(\gamma^{+2}_{\frac12-\frac12;\frac32-\frac12}\right)^2=\gamma^{+1}_{\frac32-\frac12;\frac32-\frac12}\cdot\gamma^{+3}_{\frac12-\frac12;\frac12-\frac12}$	no
$t^2\left(\gamma^{-2}_{\frac12-\frac12;\frac32-\frac12}\right)^2=\gamma^{-1}_{\frac32-\frac12;\frac32-\frac12}\cdot\gamma^{-3}_{\frac12-\frac12;\frac12-\frac12}$	no
$\left(\gamma^{+2}_{\frac12\frac12;\frac12\frac12}\right)^2=\gamma^{+1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{+3}_{\frac12\frac12;\frac12\frac12}$	yes
$\left(\gamma^{-2}_{\frac12\frac12;\frac12\frac12}\right)^2=t\gamma^{-1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{-3}_{\frac12\frac12;\frac12\frac12}$	no
$\left(\gamma^{+2}_{\frac12-\frac12;\frac12\frac12}\right)^2=\gamma^{+1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{+3}_{\frac12-\frac12;\frac12-\frac12}$	yes
$t\left(\gamma^{-2}_{\frac12-\frac12;\frac12\frac12}\right)^2=\gamma^{-1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{-3}_{\frac12-\frac12;\frac12-\frac12}$	no
$t\left(\gamma^{+2}_{\frac12\frac12;\frac12-\frac12}\right)^2=\gamma^{+1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{+3}_{\frac12\frac12;\frac12\frac12}$	no
$\left(\gamma^{-2}_{\frac12\frac12;\frac12-\frac12}\right)^2=\gamma^{-1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{-3}_{\frac12\frac12;\frac12\frac12}$	yes
$\left(\gamma^{+}_{\frac12-\frac12;\frac12-\frac12}\right)^2=\gamma^{+1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{+3}_{\frac12-\frac12;\frac12-\frac12}$	yes
$t\left(\gamma^{-2}_{\frac12-\frac12;\frac12-\frac12}\right)^2=\gamma^{-1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{3}_{\frac12-\frac12;\frac12-\frac12}$	no

Table 5

Factorization condition for $\bar{N}'(\frac{1}{2}^+)+N\to N+\bar{N}$	Factorization satisfied
$\left(\gamma^{+2}_{\frac12\frac12;\frac12\frac12}\right)^2 = \gamma^{+1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{+3}_{\frac12\frac12;\frac12\frac12}$	yes
$\left(\gamma^{-2}_{\frac12\frac12;\frac12\frac12}\right) = t\,\gamma^{-1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{-3}_{\frac12\frac12;\frac12\frac12}$	no
$\left(\gamma^{+2}_{\frac12-\frac12;\frac12\frac12}\right) = \gamma^{+1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{+3}_{\frac12-\frac12;\frac12-\frac12}$	yes
$t\left(\gamma^{-2}_{\frac12-\frac12;\frac12\frac12}\right)^2 = \gamma^{-1}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{-3}_{\frac12-\frac12;\frac12-\frac12}$	no
$t\left(\gamma^{+2}_{\frac12\frac12;\frac12-\frac12}\right)^2 = \gamma^{+1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{+3}_{\frac12\frac12;\frac12\frac12}$	no
$\left(\gamma^{-2}_{\frac12\frac12;\frac12-\frac12}\right)^2 = \gamma^{-1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{-3}_{\frac12\frac12;\frac12\frac12}$	yes
$\left(\gamma^{+2}_{\frac12-\frac12;\frac12-\frac12}\right)^2 = \gamma^{+1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{+3}_{\frac12-\frac12;\frac12-\frac12}$	yes
$t\left(\gamma^{-2}_{\frac12-\frac12;\frac12-\frac12}\right)^2 = \gamma^{-1}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{-3}_{\frac12-\frac12;\frac12-\frac12}$	no

Table 6

Factorization condition for $\bar{N}+N\to N+\bar{N}$	Factorization satisfied
$\left(\gamma^{\pm}_{\frac12-\frac12;\frac12\frac12}\right)^2 = t\,\gamma^{\pm}_{\frac12\frac12;\frac12\frac12}\cdot\gamma^{\pm}_{\frac12-\frac12;\frac12-\frac12}$	no
$\left(\gamma^{\pm}_{\frac12\frac12;\frac12-\frac12}\right)^2 = t\,\gamma^{\pm}_{\frac12-\frac12;\frac12-\frac12}\cdot\gamma^{\pm}_{\frac12\frac12;\frac12\frac12}$	no

Table 7

Factorization condition for $\bar{N}'(\frac{1}{2}^{+})+N\to N+\bar{N}'(\frac{1}{2}^{+})$	Factorization satisfied
$t(\gamma^{\pm}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}})^2=\gamma^{\pm}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\cdot\gamma^{\pm}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}}$	no
$t(\gamma^{\pm}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2}})^2=\gamma^{\pm}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}}\cdot\gamma^{\pm}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}$	no

Table 8 x)

$\bar{N}N\to N\bar{N}$	$\bar{\Delta}+N\to\bar{\Delta}+N$	$\bar{\Delta}+N\to N+\bar{N}$
$\gamma^{+\,3}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim t$	$\gamma^{\pm\,1}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim t$	$\gamma^{\pm\,2}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim t$
$\gamma^{-3}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}}\sim t$	$\gamma^{\pm\,1}_{\frac{3}{2}-\frac{1}{2};\frac{3}{2}-\frac{1}{2}}\sim t$	$\gamma^{\pm\,2}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim\sqrt{t}$
The remaining behave like const. at t=0		

x) This Table is also valid for process $\bar{N}^{*}(\frac{3}{2}^{-})+N\to N+\bar{N}$ with replacement of the indices after eq. (4.1).

Table 9

$N+\bar{N}\to N+\bar{N}$	$\bar{N}'(\frac{1}{2}^+)+N\to\bar{N}'(\frac{1}{2}^+)+N$	$\bar{N}'(\frac{1}{2}^+)+N\to N+\bar{N}$
$\gamma^{+3}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim t$ $\gamma^{-3}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2}}\sim t$	$\gamma^{\pm 1}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim t$	$\gamma^{\pm 2}_{\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim t$ $\gamma^{\pm 2}_{\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2}}\sim\sqrt{t}$
The remaining behave like const. at t=0		

Table 10

Parity-helicity states of $N\bar{N}$ system x)

States	S	P	PG	G	Regge trajectories with I=1
$\vert\frac{1}{2}\frac{1}{2}\rangle_- = \vert 0-\rangle$	0	$(-1)^{J+1}$	+	$\pm$	$B(1^+)$ $\pi(0^-)$
$\vert\frac{1}{2}-\frac{1}{2}\rangle_- = \vert 1-\rangle$	1	$(-1)^{J+1}$	−	$\pm$	$B(2^-)$ $A_1(1^+)$
$\vert\frac{1}{2}\frac{1}{2}\rangle_+ = \vert 0+\rangle$	1	$(-1)^{J}$	−	$\pm$	$\rho(1^-)$ $A_2(2^+)$
$\vert\frac{1}{2}-\frac{1}{2}\rangle_+ = \vert 1+\rangle$	1	$(-1)^{J}$	−	$\pm$	$\rho(1^-)$ $A_2(2^+)$

x) This Table is taken from ref.[15].

Table 11.

Parity-helicity states of $N\bar{N}$ system

States	S	P	PG	G	Regge trajectories with I=0
$\|\frac{1}{2}\frac{1}{2}\rangle_- \equiv \|0-\rangle$	0	$(-1)^{J+1}$	$-$	$\pm$	No
$\|\frac{1}{2}-\frac{1}{2}\rangle_- \equiv \|1-\rangle$	1	$(-1)^{J+1}$	$+$	$\pm$	No
$\|\frac{1}{2}\frac{1}{2}\rangle_+ \equiv \|0+\rangle$	1	$(-1)^{J}$	$+$	$\pm$	$P, P', \omega(1^-)$
$\|\frac{1}{2}-\frac{1}{2}\rangle_+ \equiv \|1+\rangle$	1	$(-1)^{J}$	$+$	$\pm$	$P, P', \omega(1^-)$

In these tables $\dot{S}$, P, G and I are total spin, parity, G-parity and isospin of NN system, respectively.

After some calculations (for more details see ref. [3]) it is possible to represent the reggeized amplitudes in the form:

$$L_j^t = \sum_i \frac{g(\alpha_i)}{\Gamma(\alpha_i+1)} h^{\alpha_i}_{cA;Db}(\alpha_i)\, K^{\pm}_{cA;Db}(t)\, \gamma^{\alpha_i}_{cA;Db} \left(\frac{s}{s_0}\right)^{\alpha_i - M} \qquad (5.1)$$

where $L_j^t = G_j^t$, H_j^t or F_j^t, $K^{\pm}$ - functions are given in Tables 1-3; $M = \max\{|\lambda'|, |\mu'|\}$, $\gamma^{\alpha_i}_{cA,Db} = \frac{(2\alpha_i+1)\Gamma(\alpha_i+1)}{\sqrt{\pi}} \beta$ are the reduced residue functions of the appropriate process; $g(\alpha_i) = \frac{1+\tau_i \exp(-i\pi\alpha_i)}{2\sin\pi\alpha_i}$,

where τ_i is the signature of the given trajectory; $h^{\alpha_i}_{cA;Db}(\alpha_i)$ are functions depending on the trajectories.

We assume that trajectories P, P', A_1, A_2 are connected with nonsense-nonsense channel and ρ, π, B, ω are connected with sense-sense channel. Then we can find explicitly these functions which are given in Table 12.

Table 12 x)

Functions $h(\alpha_i)$ for all three processes considered

Trajectory	π, ρ, B, ω	A_1, A_2, P, P'
$(\frac{1}{2}\frac{1}{2};\frac{3}{2}\frac{1}{2})$	2α	2α
$(\frac{1}{2}-\frac{1}{2};\frac{3}{2}\frac{1}{2})$	$2\alpha^2$	$\frac{2\alpha}{\alpha+1}$
$(\frac{1}{2}\frac{1}{2};\frac{3}{2}-\frac{1}{2})$	$4\alpha(\alpha-1)$	$4\alpha(\alpha-1)$
$(\frac{1}{2}-\frac{1}{2};\frac{3}{2}-\frac{1}{2})$	$4\alpha^2(\alpha-1)$	$\frac{4\alpha(\alpha-1)}{\alpha+1}$
$(\frac{1}{2}\frac{1}{2};\frac{1}{2}\frac{1}{2})$	1	$\alpha(\alpha+1)$
$(\frac{1}{2}-\frac{1}{2};\frac{1}{2}\frac{1}{2})$	2α	2α
$(\frac{1}{2}\frac{1}{2};\frac{1}{2}-\frac{1}{2})$	2α	2α
$(\frac{1}{2}-\frac{1}{2};\frac{1}{2}-\frac{1}{2})$	$2\alpha^2$	$\frac{2\alpha}{\alpha+1}$

x) Here instead of $h_{cA;Db}$ we write simply $(cA;Db)$

From isospin conservation and restrictions on P-parity, P_J-parity and G-parity it follows that the contribution to the amplitudes $G_1^t, G_3^t, G_5^t, G_7^t, G_9^t, G_{11}^t, G_{13}^t, G_{15}^t$ is given by the trajectories ρ and A_2 ; to the amplitudes $G_2^t, G_6^t, G_{10}^t, G_{14}^t$ by the trajectories B, π and to $G_4^t, G_8^t, G_{12}^t, G_{16}^t$ only by A_1.

The contribution to the amplitudes $H_1^t, H_3^t, H_5^t, H_7^t, H_9^t, H_{11}^t, H_{13}^t, H_{15}^t$ and $F_1^t, F_3^t, F_5^t, F_7^t$ is given by the trajectories ρ, A_2, P, P' and ω ; to $H_2^t, H_6^t, H_{10}^t, H_{14}^t, F_2^t, F_6^2$ give contribution B and π trajectories and to $H_4^t, H_8^t, H_{12}^t, H_{16}^t, F_4^t, F_8^t$ only A_1 give contribution.

It should be noted that in our parametrization (5.1) the reduced residue functions differ from the Wang ones (see below, Section 7).

6. Observable quantities

The differential cross section without polarization expressed in terms of the t-channel amplitudes reads[16]

$$\frac{d\sigma}{dt} = \frac{1}{4\pi s p_{ab}^2}\frac{1}{(2J_a+1)(2J_b+1)}\sum_{c,A,D,b}\left| f^t_{cA;Db}(s,t)\right|^2 \qquad (6.1)$$

From eq. (2.2), Tables 1-3 and parity conservation (17) we have: for $N+N \to N+\Delta(1236, \frac{3}{2}^+)$

$$16\pi s\, p_{NN}^2 \frac{d\sigma}{dt} = |G_9^t|^2 + |G_{10}^t|^2 + (1+x^2)\Big[|G_3^t|^2 + |G_4^t|^2 + |G_{15}^t|^2 + |G_{16}^t|^2 + y^2\big(|G_7^t|^2 + |G_8^t|^2\big)\Big] + y^2\Big[|G_1^t|^2 + |G_2^t|^2 + |G_{11}^t|^2 + |G_{12}^t|^2 + |G_{13}^t|^2 + |G_{14}^t|^2 + y^2\big(|G_5^t|^2 + |G_6^t|^2\big)\Big] + 4x\,\mathrm{Re}\big[G_3^t G_4^{t*} + G_{15}^t G_{16}^{t*} + y^2 G_7^t G_8^{t*}\big] \tag{6.2}$$

Replacing in (6.2) $G_i^t \to H_i^t$ we get the appropriate expression for process $N+N \longrightarrow N+N^*(1518, \frac{3}{2}^-)$. For $N+N \to N+N$ $(1470, \frac{1}{2}^+)$ we have

$$16\pi s\, p_{NN}^2 \frac{d\sigma}{dt} = |F_1^t|^2 + |F_2^t|^2 + (1+x^2)\big(|F_7^t|^2 + |F_8^t|^2\big) + y^2\big(|F_3^t|^2 + |F_4^t|^2 + |F_5^t|^2 + |F_6^t|^2\big) + 4x\,\mathrm{Re}\, F_7^t F_8^{t*} . \tag{.6.3}$$

By means of (5.1), Tables 1-3 and 12 we can express $\frac{d\sigma}{dt}$ through the Regge parameters α_i and $\gamma_{cA;D\ell}^{\alpha_i}$.

The spin density matrix of the produced resonance can also be expressed via the t-channel helicity amplitudes [18]. In the Jackson frame it reads:

$$\rho_{m'm} = \frac{\sum\limits_{cA,\ell} f^{t*}_{cA;m'\ell}\, f^{t}_{cA;m\ell}}{\sum\limits_{c,A,D,\ell} |f^t_{cA;D\ell}|^2} \tag{6.4}$$

It is possible to express the matrix elements through the amplitudes with definite parities G_i^t, H_i^t and F_i^t by means of (5.1) and Tables 1,2,3, 12. But we shall not consider this in detail.

7. Simple approximation

As is seen from Sec.5, almost all boson trajectories contribute to the amplitude of the processes considered. If the energy is high enough we can take into account only the contribution of a single pole with the highest trajectories as was already done by Wang[4]. Let us take into account only the ρ trajectory exchange in reaction $N+N \to N+\Delta$ (1236) and the Pomeranchuk trajectory exchange in reaction $N+N \to N+N^*(\frac{3}{2}^-)$ and $N+N \to N+N'$ $(1/2^+)$. Then only the amplitudes with odd indices $G_1^t, G_3^t, \ldots, H_1^t, H_3^t, \ldots, F_1^t, F_3^t, \ldots$ do not vanish. The amplitudes $G_3^t, G_7^t, G_{15}^t, H_3^t, H_7^t, H_{15}^t$ and F_7^t must have an additional multiplier t, provided there is no conspiracy. Taking into consideration these remarks and using (6.2) (6.3) and (5.1), after substitution (see the last sentence of Sec.5)

$$\frac{1}{4\sqrt{\pi}} \gamma^{\rho,P}_{\frac12 \frac12 ; \frac12 \frac12} \to \gamma^{\rho,P}_{\frac12 \frac12 ; \frac12 \frac12}$$

$$\frac{1}{2\sqrt{\pi}} \left(\gamma^{\rho,P}_{\frac12 -\frac12 ; \frac32 \frac12}, \gamma^{\rho P}_{\frac12 \frac12 ; \frac32 \frac12}, \gamma^{\rho P}_{\frac12 -\frac12 ; \frac12 -\frac12}, \gamma^{\rho P}_{\frac12 -\frac12 ; \frac12 \frac12}, \gamma^{\rho,P}_{\frac12 \frac12 , \frac12 -\frac12} \right) \to$$

$$\gamma^{\rho,P}_{\frac12 -\frac12 ; \frac32 \frac12}, \gamma^{\rho P}_{\frac12 \frac12 ; \frac32 \frac12}, \gamma^{\rho P}_{\frac12 -\frac12 ; \frac12 -\frac12}, \gamma^{\rho P}_{\frac12 -\frac12 ; \frac12 \frac12}, \gamma^{\rho P}_{\frac12 \frac12 ; \frac12 -\frac12}$$

$$\frac{1}{\sqrt{\pi}} \left(\gamma^{\rho,P}_{\frac12 -\frac12 ; \frac32 -\frac12}, \gamma^{\rho,P}_{\frac12 \frac12 ; \frac32 -\frac12} \right) \to \left(\gamma^{\rho P}_{\frac12 -\frac12 ; \frac32 -\frac12}, \gamma^{\rho, P}_{\frac12 \frac12 , \frac32 -\frac12} \right)$$

we get the Wang's results (see eqs. (24), (37) and (30) in ref. [4]). At very high energies only the amplitudes $G_9^t, H_9^t,$ and F_1^t give the main oontribution and it is possible to retain only these amplitudes in the expressions for the observable quantities. Then from (3.1)-(3.6) we see that there is no oonspiraoy and the pseudothreshold relations demand that the oorresponding residue funotions behave like ψ^2 near $t=(M-m)^2$. From these oonsiderations and eqs. (6.4) and (5.1) it follows for prooesses $N+N \to N+\Delta$ and $N+N \to N+N^*(3/2^-)$

$$\rho_{33} = Re\,\rho_{31} = Re\,\rho_{3,-1} = 0 \qquad (7.1)$$

Henoe, in the Jaokson frame [18] the angular distribution of the isobar decay products is

$$W_{\Delta, N^*(\frac{3}{2}^-)}(\vartheta, \varphi) \sim const \; cos\,\vartheta . \qquad (7.2)$$

For prooess $N+N \to N+N'(\frac{1}{2}^+)$ the isobar density matrix can be represented in the form

$$\rho = \begin{pmatrix} \frac{1}{2}+\rho_{\frac{1}{2}\frac{1}{2}} & \rho_{\frac{1}{2}-\frac{1}{2}} \\ \rho^*_{\frac{1}{2}-\frac{1}{2}} & \frac{1}{2}-\rho_{\frac{1}{2}\frac{1}{2}} \end{pmatrix} .$$

It is known [19] that only the parameter $\rho_{\frac{1}{2}\frac{1}{2}}$ can be measured experimentally. Then, under the assumption considered, we obtain

$$\rho_{\frac{1}{2}\frac{1}{2}} = \frac{1}{2} . \tag{7.3}$$

The expressions (7.2) and (7.3) are simple consequences of this approximation. Further we shall consider these processes under some other approximations, taking into account for example, the contribution of π- trajectory with and without conspiracy. The study of $N+N \to N+\Delta$ is also useful for understanding π- conspiracy, as it has been noted in ref. [20].

The authors are grateful to Professors Nguyen Van Hieu and A.N.Tavkhelidze for the interest in the work and useful discussions.

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Received by Publishing Department

on February 10, 1969.