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THE REACTION $\pi N \to \pi\pi N$ IN THE FRAMEWORK OF A MESON EXCHANGE MODEL *

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We investigate the process $\pi N \to \pi\pi N$ in a coupled channel meson exchange model. Preliminary results for $\pi^- p \to \pi^+\pi^- n$ total cross sections and angular correlation functions are presented.

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1. Introduction

Pion induced two-pion production on the nucleon has been under both experimental and theoretical [1,2] examination for many years. In particular one hopes to find the so-called "missing resonances", states which have been predicted by semi-relativistic quark model calculations [3] but have not yet been observed in πN-reactions. Most of the missing states are predicted to have small decay amplitudes to πN [4] which makes it necessary to look for them in reactions other than πN scattering.

On the theoretical side, coupled channel meson exchange models including the $\eta N, \rho N, \sigma N$ and the $\pi\Delta$ channels have been successful in describing πN scattering in an energy range up to 1.9 GeV [5]. The intention of this work is to apply the model of Ref. [5] to the reaction $\pi N \to \pi\pi N$.

2. The model

As a first step to study the two-pion decay of nucleon resonances, we performed a calculation at tree level with resonance parameters and coupling constants derived from the full model of Ref. [5]. The processes included are shown in Fig. 1.

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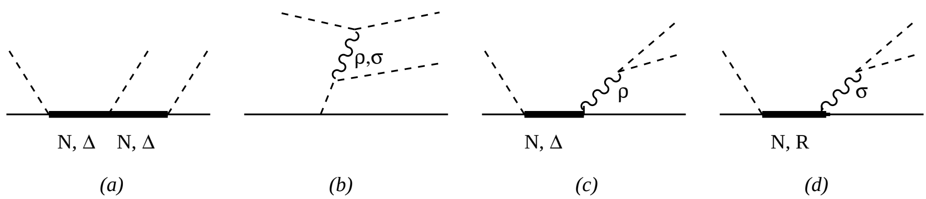

Fig. 1. Tree level diagrams

In this model, σ- and ρ-exchange are understood to be an effective parameterization of a correlated pion pair in the scalar–isoscalar channel respectively the ρ-channel, which has been calculated microscopically in Ref. [6].

So far the Roper resonance is only included in diagrams of the type of 1(d), where it makes a non-negligible contribution. But as we go to higher energies, we will also have to include the Roper resonance in diagrams 1(a) and 1(c).

3. Results and discussion

Our preliminary results for the $\pi^- p \to \pi^+\pi^- n$ total cross sections are displayed in Fig. 2. Tree level t-channel ρ-exchange in processes 1(b) overestimates $\pi\pi$ scattering, therefore also the $\pi N \to \pi\pi N$ cross sections. So the explicit inclusion of unitarization effects has to be considered next.

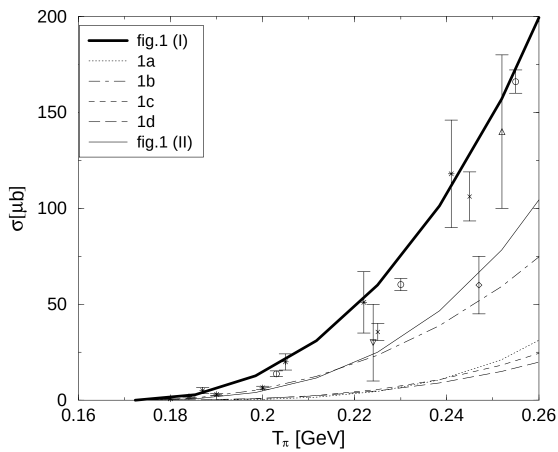

Fig. 2. Total cross sections for $\pi^- p \to \pi^+\pi^- n$. The line labels 1a–1d refer to the diagrams of Fig.1. "fig.1 (I)" is calculated including all diagrams, in "fig.1 (II)" t-channel ρ-exchange in 1d is omitted. Data are taken from Ref. [7].

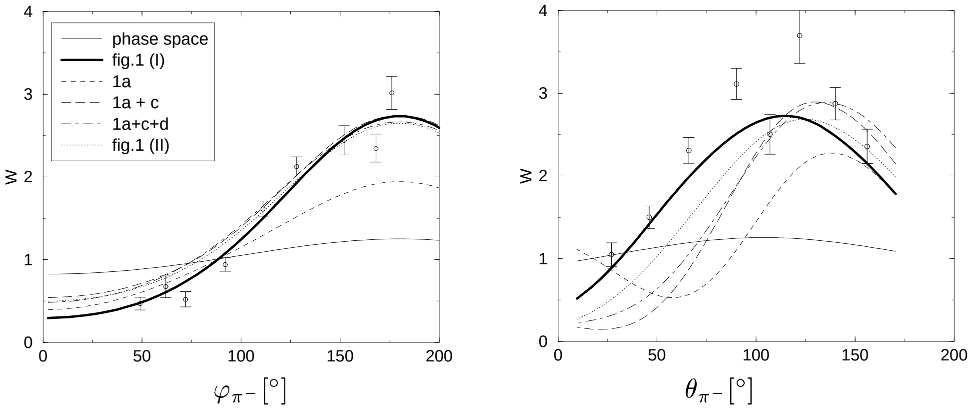

Fig. 3. Angular correlation functions for $\pi^- p \to \pi^+\pi^- n$. The kinematics are fixed to $T_\pi^{\rm in} = 0.284$ GeV, $k_{\pi^+}^{\rm lab} = 0.112$ GeV and $\theta_{\pi^+}^{\rm cm} = 78°$. The left-hand side shows the angular correlation function $W(\varphi_{\pi^-}^{\rm cm})$ with $\theta_{\pi^-}^{\rm cm}$ fixed to 115°, the right-hand side shows $W(\theta_{\pi^-}^{\rm cm})$ for $\varphi_{\pi^-}^{\rm cm} = 175°$. The data are from Ref. [8].

In Fig. 3 we show angular correlation functions W for the reaction channel $\pi^- p \to \pi^+\pi^- n$. The processes of Fig. 1(a) alone already reproduce the trend of the $W(\varphi_{\pi^-})$ data. By successive addition of the other processes one obtains a gradual improvement of the description for the $W(\varphi_{\pi^-})$ distribution as well as for $W(\theta_{\pi^-})$. The results hardly depend on the inclusion of t-channel ρ-exchange in diagrams 1(b).

Our meson exchange model is definitely successful in describing the $\pi^- p \to \pi^+\pi^- n$ data. Calculations for the other reaction channels are in process.

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