$\pi N \to \eta N$ CROSS SECTIONS AND THE INFLUENCE OF BARYONIC RESONANCES*

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We present a coupled channel meson exchange model for investigating the structure of the $N^*(1535)$ resonance and the coupling between πN and ηN. The curvature of the differential $\pi N \to \eta N$ cross sections calls for a coupling between πN and ηN in the D_{13} partial wave.

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A strong coupling of the πN and ηN reaction channels near the ηN threshold is observed in many hadronic reactions. Unfortunately, in contrast to the πN partial wave amplitudes, very little is known about the $\pi N \to \eta N$ transition amplitudes. On one hand, the data for this transition is not very accurate, on the other hand, microscopic models are missing.

The Jülich coupled channel $\pi N/\eta N/\sigma N/\pi\Delta$ model [1] provides a very good description of the experimental πN amplitudes up to c.m. energies of 1600 MeV. The description of the S_{11} partial wave in terms of a threshold effect due to the strong coupling to the ηN channel as well as a genuine $N^*(1535)$ resonance are discussed in Ref. [1]. Fig. 1 shows that the quantitative description of the S_{11} partial wave around the ηN threshold needs a genuine $N^*(1535)$ resonance (solid line) which largely decays into ηN. Furthermore, the slope of the $\pi N \to \eta N$ cross section near threshold can only be described correctly with the $N^*(1535)$ resonance. This is demonstrated by the dotted-dashed line in Fig. 1, calculated with reduced $\pi N \to \eta N$ coupling.

In our model, the inelasticity in the S_{11} partial wave is completely generated by a flux into the ηN channel. If we fit the πN observables, the

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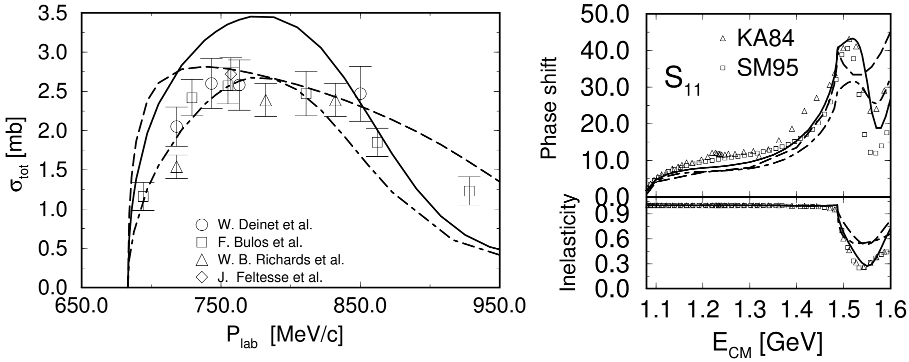

Fig. 1. Total $\pi N \to \eta N$ cross section. Solid line: with $N^*(1535)$ resonance, dashed line: without $N^*(1535)$ resonance, dotted-dashed line: with $N^*(1535)$ resonance and reduced $\pi N \to \eta N$ coupling.

$\pi N \to \eta N$ cross section is overestimated by $\approx 25\%$. Therefore a simultaneous description of both processes is not possible in our restricted model-space. The multichannel resonance model of Manley and Saleski [2] analyses the $\pi N/\pi\pi N$ system. They report, that ≈ 20 % of the inelastic S_{11} cross section is generated by flux into $\pi\pi N$ states. Although our model already contains an effective description of $\pi\pi N$ states (as σN and $\pi\Delta$ channels), it turned out that the coupling of these channels to the πN S_{11} is very small, because neither σN nor $\pi\Delta$ can be in a relative S-wave. The solution to this problem is the additional coupling to the ρN channel which is not yet included in the model. The ρN system can form a S_{11} state in coupling to the πN S_{11}. This coupling is large and leads to a considerable flux into the ρN channel (treated in the same way as in [1] as effective description of $\pi\pi N$). Work to include the ρN channel into the model is in progress.

We proceed the investigation of the $\pi N \to \eta N$ transition by calculating differential cross sections. In Fig. 2 the solid line is calculated with the model reported in [1]. The resulting differential cross sections are dominated by the S_{11} $\pi N \to \eta N$ transition and therefore flat. A detailed investigation of the partial wave decomposed differential cross sections shows, that only the interference term between the S_{11} and $P_{13} \pm D_{13}$ leads to some sizable angular dependencies. The P_{13} is dominated by t- and u-channel meson and baryon exchange. Their strength is fixed by the background they provide to the S_{11} transition amplitude. A possible mechanism to improve the model is the inclusion of the $N^*(1520)$ resonance. The couplings $f_{N^*N\pi(\eta)}$ are estimated from the partial decay widths. We find couplings of similar size ($f^2_{N^*N\pi} \approx f^2_{N^*N\eta} \approx 4\pi 0.0006$) when using $\Gamma_{\pi N} = 0.55\Gamma_{N^*}$, $\Gamma_{\eta N} = 0.001\Gamma_{N^*}$ and $\Gamma_{N^*(1520)} \approx 140$MeV as suggested in Refs. [4, 5]. The drastic difference between the $N^* \to \pi N$ and $N^* \to \eta N$ branching ratios is therefore not an

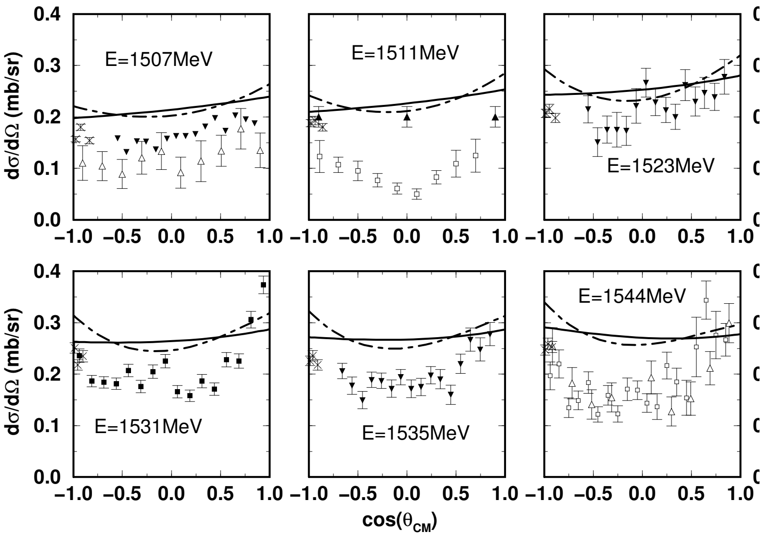

Fig. 2. Differential $\pi N \to \eta N$ cross sections for different energies and $J \leq 3/2$. Solid line: without $N^*(1520)$ resonance in the D_{13} partial wave, dotted-dashed line: with $N^*(1520)$ resonance. The data are taken from [3].

effect of very different coupling constants but a consequence of the strong dependence on the on shell momentum ($f^2 \sim q_{\pi(\eta)}^{-5} \Gamma_{\pi(\eta)}$) and the nearby ηN threshold.

The coupling of the $N^*(1520)$ to the ηN channel now leads to a larger $\pi N \to \eta N$ partial wave amplitude D_{13}. The additional coupling is such that the values for both terms $[P_{13} \pm D_{13}]$ are very similar. The interference with the large S_{11} amplitude results in a sizable angular dependence in the differential cross sections (dotted-dashed line in Fig. 2).

In summary we found the need for a genuine $N^*(1535)$ resonance for the qualitative description of the πN phase shifts in the S_{11}. The overestimation of the $\pi N \to \eta N$ transitions is due to the missing flux into $\pi\pi N$ states, which are not yet included completely into the model — the ρN channel is missing. The investigation of the differential cross section calls for the inclusion of the $N^*(1520)$ resonance which considerably influences the curvature of the cross sections due to the interference of the S_{11} and P_{13}/D_{13} transition amplitudes.

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