Meson Production in Nucleon-Nucleon Reactions

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Introduction

We construct a Lagrangian which is invariant under global chiral transformations. The model includes the N_f=2 multiplets of scalar- (σ,a_0), pseudoscalar- (η,π), vector-(ω, ρ), and axialvector-mesons (f_1,a_1). In addition, the nucleon (*N*) is included in the model together with its chiral partner (*N**).

Spontaneous symmetry breaking

The σ field has a finite non-zero expectation value ϕ. After shifting ($\sigma \to \sigma+\phi$), mixing terms of the form: $\phi\partial_\mu \eta f_1^\mu$ and $\phi\partial_\mu \vec{\pi}\cdot\vec{a}_1^\mu$ appear.
To avoid these unphysical terms, the fields f_1 and a_1 are shifted as: ($f_1 \to f_1 + w\partial_\mu \eta$) and ($\vec{a}_1 \to \vec{a}_1 + w\partial_\mu \vec{\pi}$).

Baryons lagrangian

$$\begin{aligned}\mathcal{L}_{\rm bar} = &\,\overline{\Psi}_{1L} i\gamma_\mu D_{1L}^\mu \Psi_{1L} + \overline{\Psi}_{1R} i\gamma_\mu D_{1R}^\mu \Psi_{1R} + \overline{\Psi}_{2L} i\gamma_\mu D_{2R}^\mu \Psi_{2L} + \overline{\Psi}_{2R} i\gamma_\mu D_{2L}^\mu \Psi_{2R} \\ &- \widehat{g}_1\left(\overline{\Psi}_{1L}\Phi\Psi_{1R} + \overline{\Psi}_{1R}\Phi^\dagger\Psi_{1L}\right) - \widehat{g}_2\left(\overline{\Psi}_{2L}\Phi^\dagger\Psi_{2R} + \overline{\Psi}_{2R}\Phi\Psi_{2L}\right) \\ &- m_0(\overline{\Psi}_{1L}\Psi_{2R} - \overline{\Psi}_{1R}\Psi_{2L} - \overline{\Psi}_{2L}\Psi_{1R} + \overline{\Psi}_{2R}\Psi_{1L})\,.\end{aligned}$$

Fields and covariant derivatives

$$\Phi = \sum_{a=0}^{3} \phi_a t_a = (\sigma + i\eta_N)\, t^0 + (\boldsymbol{a}_0 + i\boldsymbol{\pi})\cdot \boldsymbol{t}\,,$$

$$V^\mu = \sum_{a=0}^{3} V_a^\mu t_a = \omega^\mu t^0 + \boldsymbol{\rho}^\mu \cdot \boldsymbol{t}\,,$$

$$A^\mu = \sum_{a=0}^{3} A_a^\mu t_a = f_1^\mu t^0 + \boldsymbol{a}_1^\mu \cdot \boldsymbol{t}\,,$$

$$D^\mu\Phi = \partial^\mu\Phi + ig_1(\Phi R^\mu - L^\mu\Phi)\,,$$

$$D_{1R}^\mu = \partial^\mu - ic_1 R^\mu, \quad D_{1L}^\mu = \partial^\mu - ic_1 L^\mu\,,$$

$$D_{2R}^\mu = \partial^\mu - ic_2 R^\mu, \quad D_{2L}^\mu = \partial^\mu - ic_2 L^\mu\,,$$

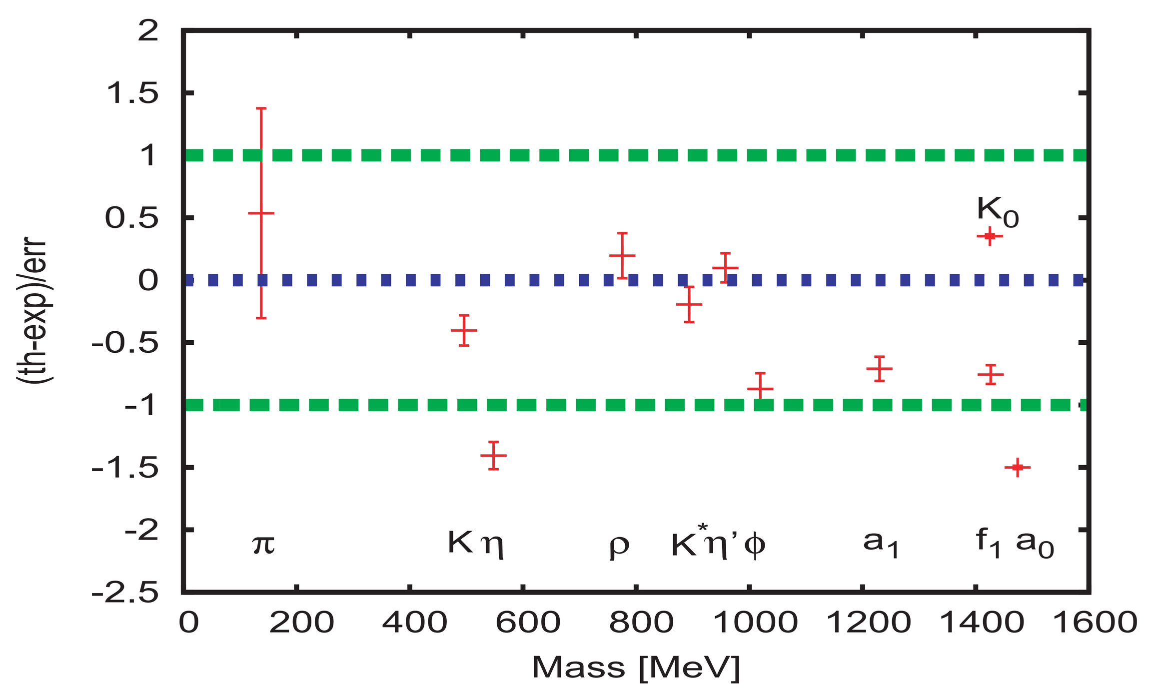
$$\Psi_1 = \frac{1}{\sqrt{2\cosh\delta}}(N e^{\delta/2} + \gamma_5 N^* e^{-\delta/2})\,,$$

$$\Psi_2 = \frac{1}{\sqrt{2\cosh\delta}}(\gamma_5 N e^{-\delta/2} - N^* e^{\delta/2})\,.$$

S.Gallas *et al.* (arXiv:0907.5084)

Mass- and width-fit

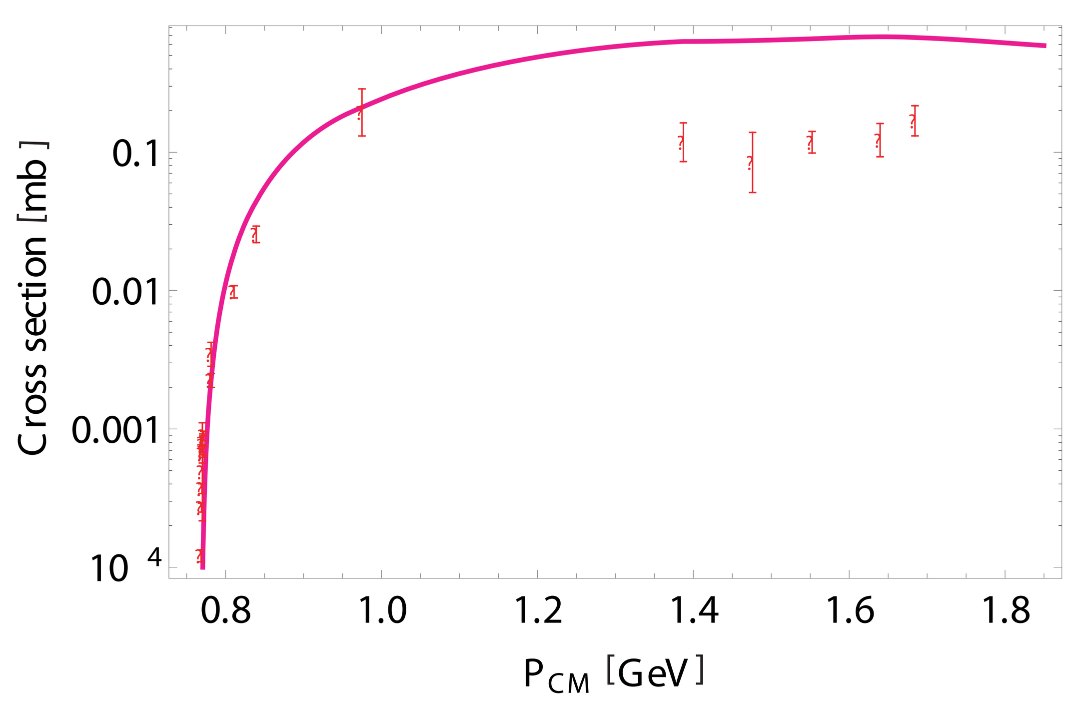
(in an N_f=3 extension of the model)



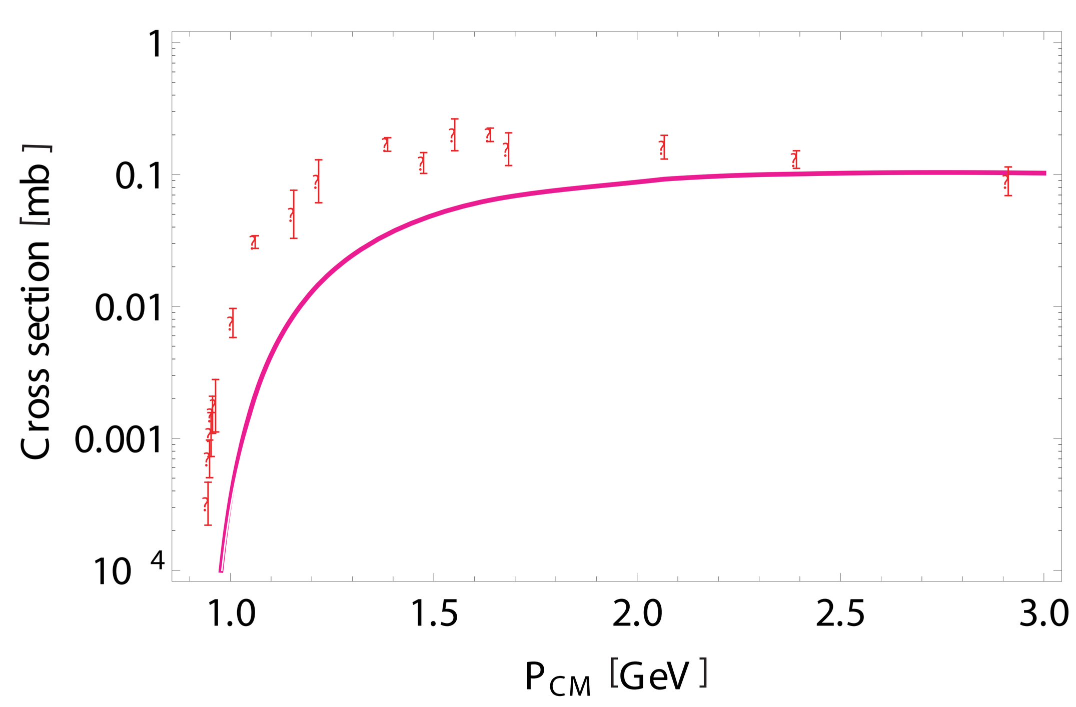
D.Parganlija *et al.* (arXiv:1208.0585)

Results for production cross sections*

pp→ppη



pp→ppω



* using cut-off form factors

Summary

- Chirally symmetric lagrangian
- Results for mesons masses and widths in good agreement with expreriment
- Cross section for exclusive η production well described by the model
- Cross section for exclusive ω production under-estimated by the calculation
- Need for vertex cut-off form factors

Outlook

- Inclusion of three-meson vertices
- Calculation of production cross sections for π- and ρ-mesons
- Calculation of di-lepton production cross sections
- Study of differential cross sections
- Comparison of p+p, p+n, n+n reactions

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