P-wave chiral dynamics for K^-p scattering in coupled channels

D. Jido[a], E. Oset[b] and A. Ramos[c]
[a] *Reseacrh Center for Nuclear Physics, Osaka University,*
Ibaraki, Osaka 567-0047, Japan
b Departamento de Física Teórica and IFIC, Centro Mixto Universidad de Valencia-CSIC,
Institutos de Investigación de Paterna, Aptd. 22085, E-46071 Valencia, Spain
[c] *Departament d'Estructura i Constituents de la Matèria, Universitat de Barcelona,*
E-08028 Barcelona, Spain

The s-wave $\Lambda(1405)$ state is one of the clear examples of baryonic resonances that can be generated dynamically from meson-baryon scattering in the strangeness $S = -1$ sector. In Ref. [1] it was shown that this resonance could be obtained from a unitary coupled channel calculation taking, as driving term, the lowest order chiral Lagrangian $[\mathcal{O}(q)]$ in s-wave. The calculation used only one parameter, the cut-off to regularize the intermediate meson-baryon loops, which was adjusted to reproduce some well measured branching ratios at the K^-p threshold. The model also provided a remarkably good description of the elastic and inelastic cross sections for K^-p scattering at low energies.
It is interesting to explore the role of p-waves in K^-p scattering and related channels to elucidate at which energies they start to have an influence on the total and differential cross sections. In addition, meson-baryon dynamics in the strangeness $S = -1$ sector at subthreshold energies is p-wave dominated due to the presence of the $L = 1$ $\Sigma^*(1385)$ resonance. Although this resonance is only visible through $\pi\Lambda$ or $\pi\Sigma$ invariant mass distributions in free space, it can acquire a more prominent role in $\bar{K}N$ scattering inside a nuclear medium.
The incorporation of p-waves in the strangeness $S = -1$ sector using unitarized chiral dynamics was done in Refs. [2,3], where the chiral expansion was truncated at $\mathcal{O}(q^2)$ and $\mathcal{O}(q^3)$, respectively, with the consequent increase in the number of parameters, although this number was reduced in Ref. [3] by using constraints from the large N_c limit of QCD. The aim of our work [4] is to keep the simplicity of the s-wave model of Ref. [1]. Hence, starting from the p-wave terms of the lowest order chiral lagrangian and introducing explicitly the $\Sigma^*(1385)$ field with couplings to the meson-baryon states derived from SU(6) symmetry, we obtain the scattering amplitudes through a N/D unitarization method, equivalent, in practice, to solving a Bethe-Salpeter equation with a cut-off. Our procedure leaves no freedom for the p-waves, once the s-waves are fixed, thus giving genuine predictions for the p-wave scattering observables. We find that the p-wave amplitudes do not contribute significantly to the total cross sections but are more visible in the differential cross sections, producing a slope in $d\sigma/d\Omega$ as a function of $\cos\theta$ which is in good agreement with the data. Our scheme also generates the total width of the $\Sigma^*(1385)$, as well as the branching rations into $\pi\Lambda$ and $\pi\Sigma$ states, which come out to be in agreement with the experimental values.

References

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