4.9. Some problems with separable potentials*

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In a former work reported at the Symposium on the Nuclear Three Body Problem, Budapest 1971 we treated $^1S_0$ p—p scattering with a rank two potential of the form:

$$V(p', p) = \lambda_1 g_1(p') g_1(p) + \lambda_2 g_2(p') g_2(p),$$

where

$$g_1(q) = \frac{1}{q^2 + \beta^2}$$

$$g_2(q) = \frac{q^2}{(q^2 + \bar{\beta}^2)^2}.$$

We fit the parameters with the phase shifts[1] and find:

$\bar{\beta} = 1,2540\ \mathrm{fm}^{-1}$ $\qquad\lambda_1 = -0,5442\ \mathrm{fm}^{-2}$

$\beta = 3,2992\ \mathrm{fm}^{-1}$ $\qquad\lambda_2 \to \infty$

and get a badness of fit value $\chi^2 = 289$.

If we take $\lambda_2 = 0$ (usually called the Yamaguchi potential[2], we obtain:

$\beta = 1,1538\ \mathrm{fm}^{-1}$
$\lambda_1 = -0,3760\ \mathrm{fm}^{-2}$
$\chi^2 = 760.$

The improvement by taking into account the repulsive core is considerable.

If the badness of fit value is not exactly equal to our best value, but within 10% deviation the rank 2 potential still is much better than Yamaguchi. So we could take also a finite λ_2, f. i. $\lambda_2 = 12,2\ \mathrm{fm}^{-2}$, then we obtain for the other parameters:

$\beta = 1,2440\ \mathrm{fm}^{-1}$ $\qquad\lambda_1 = 0,5033\ \mathrm{fm}^{-2}$

$\bar{\beta} = 2,3601\ \mathrm{fm}^{-1}$ $\qquad\chi^2 = 321.$

We denote this set as the λ_2-set.

The other three parameters can be varied in both directions to get the same badness of fit value. For instance we found:

β set:	$\beta = 1.2537,\ 1.2543\ \mathrm{fm}^{-1}$	$\lambda_1 = -0.5442\ \mathrm{fm}^{-2}$
	$\beta = 3.2992\ \mathrm{fm}^{-1}$	$\lambda_2 \to \infty$
$\bar{\beta}$ set:	$\beta = 1.2540\ \mathrm{fm}^{-1}$	$\lambda_1 = 0.5442\ \mathrm{fm}^{-2}$
	$\beta = 3.3083,\ 3.2880\ \mathrm{fm}^{-1}$	$\lambda_2 \to \infty$
λ_1 set:	$\beta = 1.2540\ \mathrm{fm}^{-1}$	$\lambda_1 = -0.5437,\ -0.5447\ \mathrm{fm}^{-2}$
	$\beta = 3.2992\ \mathrm{fm}^{-1}$	$\lambda_2 \to \infty.$

* Work supported by the Österreichischer Forchungsrat, Projekt 1211.

The parameters β, $\overline{\beta}$ and λ_1 are quite insensitive to small (10%) variations in χ^2 except λ_2, which changes drastically.

In the $^3S_1$ state, there is also the tensor force. This was investigated by many authors with the ansatz of Yamaguchi[3]. But these ansatz gives no polarization in N—N scattering[4]. One way to get out of this trouble is to use again a rank two potential of the form:

$$V(p', p) = \lambda_1 g_1(p') g_1(p) + \lambda_2 g_2(p') S(\vec{\hat{p}}') g_2(p) S(\vec{\hat{p}})$$

where the form factors g_1 and g_2 are given before and S is the usual tensor-operator. The parameters of this potential will also be fitted.

References

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4.10. Analysis of the off mass shell-behaviour of the hadronic scattering matrix as constructed by means of an effective Lagrangian model*

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Abstract: Starting from an effective Lagrangian model relativistic covariant and gauge invariant scattering amplitudes for certain hadronic interactions with an additional emitted or absorbed photon are constructed, which allow one to examine the validity of this Lagrangian model for off mass shell-hadrons.

Lagrange function for some hadrons and introduction of the photon. In this work a dynamical model for some hadrons is developed, which is based on an interaction Lagrangian for the pion nucleon system[1]. This Lagrange function includes the relativistic fields of the mesons σ ($\mathcal{J} = 0^+$, $I = 0$), π and ϱ, the nucleons n and p and the baryon resonance $\Delta(1238)$

$$(\mathcal{J} = {}^3/_2{}^+,\ I = {}^3/_2):$$

$$L_{\rm int}(x) = g_{\sigma\pi\pi}\, \sigma(x) \frac{\vec{\pi}^2(x)}{2} + g_{\sigma NN}\, \overline{N}(x)\, N(x)\, \sigma(x) + g_{\rho\pi\pi}\, \vec{\varrho}^{\,\mu}(x)\, [\pi(x) \times \partial_\mu \vec{\pi}(x)] +$$

$$+ g_{\rho NN}\, \overline{N}(x)\, \gamma_\mu \frac{\vec{\tau}}{2} N(x)\, \vec{\varrho}^{\,\mu}(x) + g_{NN\pi}\, \overline{N}(x)\, \gamma_\mu\, \gamma^5 \vec{\tau}\, N(x)\, \partial^\mu \vec{\pi}(x) +$$

$$+ g_{\Delta N\pi} \overline{N}(x)\, \vec{\tau}\, N_\mu(x)\, \partial^\mu \vec{\pi}(x).$$

* Supported by the Fonds zur Förderung der wissenschaftlichen Forschung in Österreich.