Abstract

An outstanding problem in the theoretical formulation of the πNN system, where pion production and absorption is included, has been obtaining the simultaneous dressing of both nucleons in the framework of time-ordered perturbation theory. Previous descriptions of the πNN system, such as the "Unitary $NN - \pi NN$" model, used Hilbert space truncation to states of no more than one pion, which prevented the nucleons in two-nucleon states from obtaining full dressing. This, in turn, gave rise to a renormalisation problem, which has long been thought to be responsible for an inadequate description of several observables including the T_{20} tensor polarisation of πd elastic scattering and the differential cross section for $pp \to \pi^+ d$ scattering.

A solution to this problem has been proposed through the use of convolution integrals to sum all possible contributions occurring in disconnected processes, thereby taking into account simultaneous nucleon dressing in the two-nucleon propagator and in other processes where a nucleon is a spectator. These convolution integrals allow new equations to be derived where nucleons are fully dressed. Interestingly, the use of these convolution integrals leads to 4-dimensional πNN equations, while still being equivalent to a 3-dimensional description. The only approximation made in the derivation of these equations is neglecting connected three-body forces.

In this thesis, we develop the convolution approach to the coupled $NN - \pi NN$ system by deriving a set of equations that simultaneously describe πd elastic scattering, $pp \to \pi^+ d$ scattering and NN elastic scattering. We then proceed to solve these πNN convolution equations and make a comparison to previously formulated equations to determine whether this convolution approach is the long-sought-after solution to the problems of the "Unitary $NN - \pi NN$" model. Solving the 4-dimensional πNN convolution equations, however, is a difficult task, due to the presence of moving singularities in the integral equations. We are successfully able to solve our 4-dimensional convolution equations using cubic spline interpolation, however, we can only include one partial wave channel in intermediate states, due to the computational intensity of these 4-dimensional equations.