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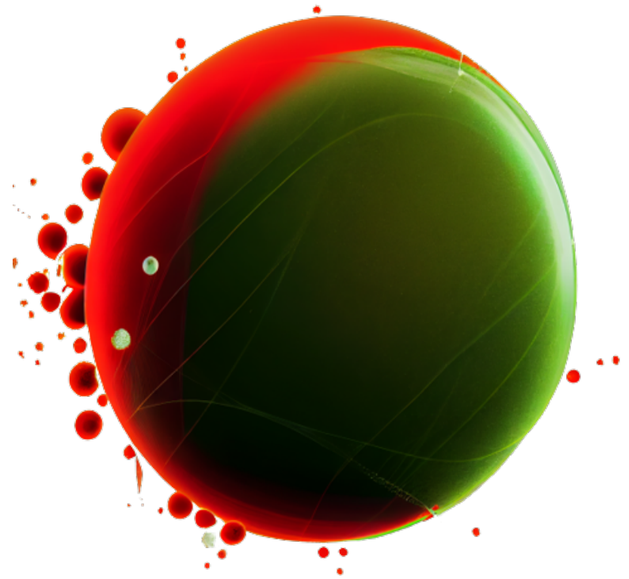
Threshold pion photoproduction off nucleons using the nuclear model with explicit pions

This thesis investigates pion photoproduction off nucleons near the threshold using a nuclear model with explicit pions. In this model, the nucleons do not interact through a potential but emit and absorb mesons which are treated explicitly, and we limit the model to the one meson approximation. We focus on the case where the mesons are pions and calculate the total cross-section of pion photoproduction near the threshold. Specifically, we find the set of parameters for which the model quantitatively can describe the total cross section near the threshold.

We introduce the nuclear model with explicit mesons and describe the advantages of using this model within the regime of few-body, low-energy nuclear physics. We then consider the specific case where the mesons are pion and consider a pion-nucleus system where we introduce a phenomenological form factor which depends on a strength parameter and a range parameter. We then consider a numerical approach to solving the Schrödinger equation describing the pion-nucleon system and evaluate how changing the phenomenological form factor will affect the solutions. We also discuss a relativistic expansion of the kinetic operators to deduce the importance of relativistic effects on the pion-nucleon system. We find that the relativistic effects are negligible for most sets of parameters. To further test the model, we introduce a new operator which is inspired by an effective field theory. We find that the operator is compatible with the nuclear model but is also numerically intensive, and perhaps another numerical approach is more suitable for this operator.

We then focus on pion photoproduction and how this can be described within the framework of the nuclear model. As a first approach, we consider a dipole approximation and calculate the total cross-section for the photoproduction of charged pions off protons. We find that the dipole approximation is only valid very close to the threshold. We then consider the central challenge of this thesis: a general expression for the differential cross-section and the total cross-section near the threshold. We compute these expressions for all four pion photoproduction processes. We conclude that the model is able to describe the experimental cross-section for neutral pions off protons quantitatively, and we present the sets of parameters. At the time of writing, no experimental data exists for neutral pion photoproduction off neutrons near the threshold, but a theoretical prediction was made. In the case of charged pion photoproduction off nucleons, expressions for the total cross section and the charge density were found. The model has some problems accurately describing the behaviour of the total cross-section of charged pions, and perhaps the one-pion approximation is insufficient, and further work is needed.



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