Chiral Extrapolation of Light Mesons from the lattice

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Introduction

Lattice QCD calculations provide an ab-initio approach to the strong interaction and in particular to the scattering problem. Yet, those calculations are carried out at unphysical quark masses and sometimes with two instead of three flavors. A hadronic model based on Chiral Perturbation Theory is presented that allows to extrapolate lattice results to the physical point. The model is applied to lattice simulations in two ($N_f = 2$) and three ($N_f = 2 + 1$) flavors of several groups, for the $\rho(770)$ quantum numbers. Phase shifts are extrapolated both in mass and flavor, allowing to study the role of the $K\bar{K}$ channel that has been overlooked in many analyses.

Objectives

- Strong interaction is a fundamental interaction of nature responsible for formation of matter.
- Present theory of strong interactions is Quantum Chromodynamics (QCD).
- QCD is successful at high energies but could not be precisely solved at low energies until recently, since quarks become confined in colorless hadrons.
- The confinement together with mass generation have been paramount problems for the past 40 years.
- Current experimental challenge: exotics states are essential to understand quark confinement and flavor, allowing to study the role of the $K\bar{K}$ together with mass.

Numerical Results

Model [2]

\[ N_f = 2 \text{ lattice phase shifts are fitted with the } \pi\pi\text{-channel only including the known correlation between energy and phase shift (Lüscher function).} \]

The result is extrapolated to the physical pion mass $M_\pi = 138\text{ MeV}$ and then $K\bar{K}$ channel is switched on → post-diction of experimental phase shifts.

Analysis of $N_f = 2 + 1$ lattice data.

Workflow

- $N_f = 2$ lattice phase shifts are fitted with the $\pi\pi$-channel only including the known correlation between energy and phase shift (Lüscher function).
- The result is extrapolated to the physical pion mass $M_\pi = 138\text{ MeV}$ and then $K\bar{K}$ channel is switched on → post-diction of experimental phase shifts.
- Analysis of $N_f = 2 + 1$ lattice data.

Summary

- The $K\bar{K}$ channel can explain the systematically small lattice $\rho$ masses at the physical point after the chiral SU(2) extrapolation of the $N_f = 2$ lattice data.
- Consistency check in fit to $N_f = 2 + 1$ lattice data.
- A full one-loop calculation for confirmation and further improvement of the present results is desirable.

References


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Lattice QCD data are cited from [3, 4, 5] respectively, experimental data are from [6, 7].