THE CHIRAL EXTRAPOLATION GAME

CHIRAL EFFECTIVE FIELD THEORY

1. The Quenched Rho Meson Mass

-Motivation and Aim:
-Lattice Quantum Chromodynamics (QCD) is an ab initio method for simulating computationally intensive subatomic physics on a finite-sized periodic box, which produces discrete momenta values.

-The Kentucky Group have produced precision Lattice QCD results for the mass of the quenched rho meson, at low and high energies/quark masses.

-Our Goal: to predict the mass-energy of the Roper resonance of nucleons, which are difficult to calculate on the Lattice. Now that the scheme has been proved predictive, the future research, this scheme will be applied to other observables such as magnetic moments of nucleons, which have large chiral curvature, and the mass-energy of the Roper resonance of nucleons, which are of current experimental interest.

2. Chiral Effective Field Theory

-State of the Art:
-Should we do a simple linear fit? No, that would ignore the chiral physics:

\[ m^2 = \left\{ a_0 + a_2 m^2 + \cdots \right\} + \sum_i \sum_{\rho_i} \left[ \cdots \right] \]

-By taking the non-trivial chiral curvature from the loop diagrams into account, and calculating systematic errors in the integrals’ coefficients and in the intrinsic scale ($\Lambda = 0.65 + 0.26 - 0.14 \text{ GeV}$), we produce Fig. 1.

-Now, the Kentucky Group data is revealed for comparison in Fig. 2!

3. Results

(see Graphical Results)

-Research and Critical Discussion:
-We have discovered that for any choice of cut-off function $\psi(k^2)$ in the integrals, an intrinsic energy scale $\Lambda$ can be calculated from the data itself! The intrinsic scale depends on the quality and amount of low energy data, and to what order we calculate the $\chi$ EFT expansion of $m^2$.

-By taking the non-trivial chiral curvature from the loop diagrams into account, and calculating systematic errors in the integrals’ coefficients and in the intrinsic scale ($\Lambda = 0.65 + 0.26 - 0.14 \text{ GeV}$), we produce Fig. 1.

-Now, the Kentucky Group data is revealed for comparison in Fig. 2!

4. Conclusion

- Future Direction and Updated Plan:
The results clearly indicate a successful procedure for using high energy Lattice QCD data to extrapolate an observable to the low energy region. In future research, this scheme will be applied to other observables such as magnetic moments of nucleons, which have large chiral curvature, and the mass-energy of the Roper resonance of nucleons, which is difficult to calculate on the Lattice.

-Note that an upturn occurs even for the lower standard deviation of the extrapolated data. The naive linear extrapolation is non-trivially wrong.

-In Fig. 3, each data point is subtracted about a particular data point, which helps to clarify the plot by removing much of the correlated statistical error in the Kentucky Group data. Almost all data points lie within the corresponding extrapolations’ systematic error bars.

4. Conclusion

- Future Direction and Updated Plan:
The results clearly indicate a successful procedure for using high energy Lattice QCD data to extrapolate an observable to the low energy region. In future research, this scheme will be applied to other observables such as magnetic moments of nucleons, which have large chiral curvature, and the mass-energy of the Roper resonance of nucleons, which is difficult to calculate on the Lattice.

-Now that the scheme has been proved predictive, the plan is to predict the finite volume corrections for such other lattice QCD observables which are of current experimental interest.

Special thanks to--
Principal Supervisor: Derek Leinweber,
Co-Supervisor: Rod Crewther and Ross Young (Argonne National Lab)