Correlation Function Analysis

1 Introduction

Form-factors play a crucial role in understanding the interactions of hadrons with electro-weak currents in Lattice Quantum Chromodynamics (QCD). These quantities can be calculated from the time-dependence of three-point correlation functions. However, when multiple form-factors are involved, the analysis becomes complex as it necessitates fitting the time-dependence of numerous three-point functions. Furthermore, based on the symmetries, certain form-factors may appear in various combinations of hadrons and currents within the three-point functions, thereby requiring the solution of a linear system of equations to accurately extract the desired form-factors. This proposal outlines a project aimed at developing a generic software layer that can streamline this process, facilitating the extraction of multiple form-factors from three-point correlation functions in lattice QCD.

2 Objective

The primary objective of this project is to design and implement a versatile software layer that can effectively perform fits and solve linear systems of equations. By building upon existing frameworks in lattice QCD, this software layer will enable researchers to extract multiple form-factors with ease and efficiency.

3 Project Scope

The proposed software layer will encompass the following key functionalities:

3.1 Fit Computation

- Development of algorithms to perform fitting procedures on the time-dependence of three-point correlation functions.
- Implementation of robust statistical analysis techniques to optimize the fit parameters and quantify their uncertainties.
- Integration of advanced numerical methods to enhance the accuracy and efficiency of the fitting process.

3.2 Linear System Solution

- Design and implementation of algorithms to solve the linear system of equations arising from the combinations of hadrons and currents within the three-point functions.
- Incorporation of appropriate numerical methods to ensure the stability and reliability of the solutions.
- Consideration of symmetry properties to streamline the system solution process.

3.3 Integration and Compatibility

- Seamless integration of the developed software layer into existing lattice QCD frameworks.
- Compatibility with diverse computational architectures and platforms commonly employed in lattice QCD simulations.
- Development of user-friendly interfaces and documentation to facilitate ease of use and adoption by researchers.

4 Methodology

The project will follow the subsequent methodology to achieve its objectives:

4.1 Requirement Analysis

- Conduct a thorough analysis of the requirements and challenges involved in extracting multiple form-factors from three-point correlation functions in lattice QCD.
- Identify the necessary functionalities, algorithms, and numerical methods required for fitting and solving linear systems of equations.

4.2 Software Design and Development

- Based on the requirements analysis, design a modular software architecture that encompasses fit computation, linear system solution, and integration capabilities.
- Implement the algorithms and numerical methods for fitting and solving linear systems, ensuring compatibility with existing frameworks.
- Employ best practices in software engineering to guarantee code quality, maintainability, and extensibility.

4.3 Testing and Validation

- Conduct rigorous testing procedures to verify the correctness, accuracy, and robustness of the developed software layer.
- Perform validation against known cases and benchmark solutions to establish its reliability and efficiency.

4.4 Integration and Documentation

- Seamlessly integrate the software layer into existing lattice QCD frameworks, ensuring compatibility and interoperability.
- Develop comprehensive user documentation, including tutorials and examples, to assist researchers in utilizing the software effectively.

5 Expected Outcomes

The successful completion of this project will yield the following outcomes:

5.1 Generic Software Layer

- A versatile software layer capable of performing fits and solving linear systems of equations to extract multiple form-factors from three-point correlation functions in lattice QCD.
- An intuitive and user-friendly interface for ease of use by researchers.

5.2 Improved Efficiency and Accuracy

- Increased efficiency in analyzing form-factors through automated fitting procedures and streamlined linear system solutions.
- Enhanced accuracy in form-factor extraction through the incorporation of advanced statistical and numerical techniques.

5.3 Seamless Integration

- Compatibility of the developed software layer with existing frameworks used in lattice QCD simulations, enabling seamless integration into researchers' workflows.

6 Project Timeline

The proposed project is estimated to be completed within a timeframe of 6 months, divided into the following key phases:

- Requirements analysis and Trial designs: 2 months
- Software development and implementation: 2 month
- Testing, validation, and optimization: 1 months
- Integration, documentation, and finalization: 1 months

7 Conclusion

The development of a generic software layer to extract multiple form-factors from three-point correlation functions in lattice QCD will significantly enhance researchers' capabilities in studying hadron interactions with electroweak currents. By automating fitting procedures and solving linear systems of equations, this software layer will streamline the analysis process, improve efficiency, and provide more accurate results. Furthermore, its compatibility with existing frameworks will facilitate seamless integration, ensuring widespread adoption within the lattice QCD community.