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Abstract

Lattice measurements of the static quark-antiquark potential and holographic bulk reconstruction

Color confinement, the inability for free quarks to exist under normal conditions, is one of the most important properties of Quantum chromodynamics, the quantum field theory (QFT) describing the strong interaction. A simple representation of confinement can be obtained by considering a static (i.e. infinitely massive) quark-antiquark pair. There due to self-interaction of the gluons exchanged between the pair the potential obtains a term linear with respect to the distance. Separating the pair would therefore require infinite energy making them bound.

The static potential can be related to a QFT operator called the Wilson loop. Calculating an expectation value of an operator in QFT requires evaluating a path integral. A direct evaluation of a QFT path integral is impossible. However, a technique called lattice field theory can be applied to estimate them. In lattice field theory continuous space-time is replaced with a discrete lattice. Fermions like quarks are situated on the sites of the lattice while gauge fields like gluons are placed on the links between the sites. The discretization of space-time allows us to evaluate path integrals numerically using Monte Carlo methods.

An alternate way of computing the expectation value of the Wilson loop is provided by holographic duality which is an equivalence between a QFT in 4-dimensional flat space-time and a higher dimensional theory of gravity in curved space-time with the QFT living on the boundary of the higher dimensional space. The duality allows evaluation of hard, non-perturbative QFT calculations with easy computations on the gravity side. From the lattice data of the static potential we can construct a holographic model that could also produce those results in a process called bulk reconstruction. This holographic model can then be used to compute other QFT quantities that allow us to study confinement.

In the seminar I will present my work in measuring the static potential in different temperatures with lattice field theory and applying a machine learning method to perform bulk reconstruction from the lattice results. The lattice simulations are pedagogical in nature with me reproducing previous results and the bulk reconstruction is a proof-of-concept for the method with no further computations being done with the constructed holographic models. The final reconstructions and analysis are still being done but the initial results seem promising with the lattice measurements in good agreement with previous results and the holographic models seeming reasonable. The final results should be ready in time for the seminar.