Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Studies of Entanglement Entropy, and Relativistic Fluids for Thermal Field Theories

By

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In this dissertation we consider physical consequences of adding a finite temperature to quantum field theories. At small length scales entanglement is a critically important feature. It is therefore unsurprising that entanglement entropy is a useful tools in studying fields such as quantum phase transition, and quantum information. In this thesis we consider the corrections to entanglement and Rényi entropies due to addition of a finite temperature.

More specifically, we investigate the entanglement entropy of a massive scalar field in 1+1 dimensions at nonzero temperature. In the small mass (m) and temperature (T) limit, we put upper and lower bounds on the two largest eigenvalues of the covariance matrix used to compute the entanglement entropy. We argue that the entanglement entropy has $e^{-m/T}$ scaling in the limit $T << m$.

Additionally, we calculate thermal corrections to Rényi entropies for free massless fermions on $R \times S^d$. By expanding the density matrix in a Boltzmann sum, the problem of finding the Rényi entropies can be mapped to the problem of calculating a two point function on an n-sheeted cover of the sphere. We map the problem to a conical region in Euclidean space. By using the method of images, we calculate the two point function and recover the Rényi entropies.

At large length scales hydrodynamics is a useful way to study quantum field theories. We review recent interest in the Riemann problem as a method for generating a non-equilibrium steady state (NESS). The initial conditions consist of a planar interface between two halves of a system held at different temperatures in a relativistic hydrodynamic regime. The resulting fluid flow contains a constant temperature region with a nonzero flux. We discuss deforming the relativistic equations with a nonlinear term and how that deformation affects the region connecting the asymptotic fluids.

Finally, we study properties of a NESS generated when the dynamics of the system in question are governed by holographic duality to a black hole. We discuss the "phase diagram" associated with the steady state of the dual, dynamical black hole and its relation to the fluid/gravity correspondence.

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Dissertation Advisor: Christopher Herzog