Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Some Studies on Partition Functions in Quantum Field Theory and Statistical Mechanics

By

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Quantum field theory and statistical mechanics share many common features in their formulations. A very important example is the similar expression of the partition function. Exact computations of the partition function can help us understand non-perturbative physics and calculate many physical quantities. In this thesis, we study some examples in both quantum field theory and statistical mechanics, in which one can compute the partition function exactly.

Recently, people have found a consistent way of defining supersymmetric theories on curved backgrounds. Using the supersymmetric localization method one is able to calculate the exact partition function of some supersymmetric gauge theories on compact manifolds. We discuss the localization of supersymmetric gauge theories on squashed S^3, round S^2 and T^2. The cases with line operators or surface operators are also discussed.

Entanglement entropy and Rényi entropy are key concepts in some branches of condensed matter physics, and they also play an increasingly important role in high energy physics and black-hole physics. A generalized and related concept is the supersymmetic Rényi entropy. We review these concepts and their relation with the partition function on a sphere. We also consider the thermal correction to the Rényi entropy at finite temperature. As an application to high energy physics, we use the supersymmetric Rényi entropy to check some correspondences between conformal field theory and gravity.

Partition functions can also be used to relate two apparently different theories. One example discussed in the thesis is the Gross-Pitaevskii equation and a string-like nonlinear sigma model. Moreover, a (2+1)-dimensional system consisting of only vortex solutions of the Gross-Pitaevskii equation can be described by a statistical model called point-vortex model. We evaluate its partition function exactly, and find a phase transition at negative temperature. The order parameter, the critical exponent and the correlation function are also discussed.

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