Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Fluctuations in ultra-relativistic heavy ion collisions

By

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Fluctuations are one of the main probes into the new state of dense nuclear matter called the Quark Gluon Plasma (QGP), which is created in the ultra-relativistic heavy ion collisions. In this dissertation we improve upon the existing descriptions of heavy ion collisions in three different directions: we study the new signatures of initial state fluctuations, the propagation of perturbations in the early stages of the collision, and the effect of thermal fluctuations on the hydrodynamic expansion of the QGP. First, we use Principal Component Analysis (PCA) to study event-by-event fluctuations in the spectrum of harmonic flow, $v_n(p_T)$ for $n = 0$–5, in hydrodynamic simulations of Pb+Pb collisions at the LHC. The PCA procedure finds two dominant contributions to the two-particle correlation function: the leading component is identified with the standard event plane $v_n(p_T)$ and the subleading component is responsible for factorization breaking and reflects the radial excitation in the initial state. Second, we use leading order effective kinetic theory (accurate at weak coupling) to simulate the pre-equilibrium evolution of transverse energy and flow perturbations. We construct the linear response Green functions, which map initial perturbations to the energy momentum tensor at a time when hydrodynamics becomes applicable. Finally, we develop a set of kinetic equations for thermal noise correlators which are equivalent to nonlinear hydrodynamics with noise. We use the hydro-kinetic equations to analyze thermal fluctuations for a Bjorken expansion and determine the coefficient of the first fractional power ($\propto 1/(\tau T)^{3/2}$) of the nonlinear noise corrections to energy momentum tensor.

Date: January 26, 2017
Time: 9:30 am
Place: Physics Building, C-133

Program: Physics
Dissertation Advisor: Derek Teaney