KMI Colloquium

“Possible Mechanism of Entropy Production and Early Thermalization in the Little Bang”

Prof. Teiji Kunihiro
(Kyoto University)

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Abstract:

We first propose a broadly applicable formalism for the description of coarse grained entropy production in quantum mechanical processes, on the basis of the Husimi transform of the quantum state. We demonstrate within simple models that the growth rate of the Wehrl entropy associated with the Husimi function approaches the classical Kolmogorov-Sinai entropy or the sum of the positive Lyapunov exponents, which gives the entropy production rate in classical systems.

Then we study the thermalization process in classical Yang-Mills field theory starting from color-glass condensate (CGC)-like initial conditions with a fluctuating noise. Paying attention to possible emergence of chaotic behavior that can lead to entropy production, we first investigate the initialvalue sensitivity of trajectories. We find that the distance between two trajectories starting from initial conditions with small but finite random fluctuations incorporated to the CGC-like background field shows a rapid increase after a short time, depending on the strength of the fluctuation: Such an increase does not occur at all when random fluctuations are absent in the initial condition. Next we extract the exponential growth rate in or the Lyapunov exponent. We find that the positive Lyapunov exponents prevail to many modes in the early stage of time-evolution, and then the number of the positive Lyapunov exponents remains some finite portion of all the degrees of freedom. Thus we conclude that a definite amount of entropy can be produced within the classical gluon field dynamics. It could imply a rather early thermalization of the system though still in a non-equilibrium regime, if the system evolves from CGC-like initial conditions with random fluctuations, which QCD suggests to be the case for relativistic heavy-ion collisions.