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Recent development of hydrodynamic modeling

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In this talk, I give an overview of recent development in hydrodynamic modeling of high-energy nuclear collisions. First, I briefly discuss about current situation of hydrodynamic modeling by showing results from the integrated dynamical approach in which Monte-Carlo calculation of initial conditions, quark-gluon fluid dynamics and hadronic cascading are combined. In particular, I focus on rescattering effects of strange hadrons on final observables. Next I highlight three topics in recent development in hydrodynamic modeling. These include (1) medium response to jet propagation in di-jet asymmetric events, (2) causal hydrodynamic fluctuation and its application to Bjorken expansion and (3) chiral magnetic wave from anomalous hydrodynamic simulations.

1. Recent CMS data suggest the existence of QGP response to propagation of jets. To investigate this phenomenon, we solve hydrodynamic equations with source term which exhibits deposition of energy and momentum from jets. We find a large number of low momentum particles are emitted at large angle from jet axis. This gives a novel interpretation of the CMS data.

2. It has been claimed that a matter created even in p-p/p-A collisions may behave like a fluid. However, fluctuation effects would be important in such a small system. We formulate relativistic fluctuating hydrodynamics and apply it to Bjorken expansion. We found the final multiplicity fluctuates around the mean value even if initial condition is fixed. This effect is relatively important in peripheral A-A collisions and p-p/p-A collisions.

3. Anomalous transport of the quark-gluon fluid is predicted when extremely high magnetic field is applied. We investigate this possibility by solving anomalous hydrodynamic equations. We found the difference of the elliptic flow parameter between positive and negative particles appears due to the chiral magnetic wave.

Finally, I provide some personal perspective of hydrodynamic modeling of high energy nuclear collisions in the next decade.