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(I) Understanding the Quark Gluon Plasma using High-Performance Computing and Bayesian Analyses

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Constraining the properties of nuclear media at extreme densities has been a long-time goal of relativistic heavy-ion collision experiments. Mounting evidence gathered from these experiments suggests that a strongly interacting plasma of quarks and gluons –the Quark Gluon Plasma (QGP) –is being created within these collisions. The QGP can be well described using multi-stage simulations where relativistic dissipative hydrodynamics plays a key role. Recently, hydrodynamics has been systematically derived from the relativistic Boltzmann equation by isolating its long-distance moments in an irreducible moment expansion. This formulation of hydrodynamics is the basis of modern fluid simulations of the QGP. To compare hydrodynamical calculations against data, fluid dynamical simulations are followed by molecular dynamics of hadronic (quarks and gluon) bound states. The latter is responsible for simulating hadronic chemical and kinetic evolution far outside thermal equilibrium. A systematic extraction of QGP properties thus requires a combination of multi-stage simulations running on supercomputers, along with Bayesian model-to-data comparisons. As most of the particles produced in a heavy-ion collision are soft (with $p_T < 3$ GeV/c), Bayesian analyses of the QGP have focused on describing soft particle emissions. I will describe what constraints on the dissipative properties of the QGP, i.e., on its shear and bulk viscosity, were achieved using Bayesian analyses I have led, and outline a path towards an even deeper understanding of the QGP.

Keyword-1

Quark Gluon Plasma

Keyword-2

Bayesian Analyses

Keyword-3

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