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Optimized fluid dynamics for heavy ion collisions

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Local momentum anisotropies are large in the early stages of the quark-gluon plasma created in relativistic heavy-ion collisions, due to the extreme difference in the initial longitudinal and transverse expansion rates. In such situations, fluid dynamics derived from an expansion around an isotropic local equilibrium state is bound to break down. Instead, we resum the effects of the slowest nonhydrodynamic degree of freedom (associated with the deviation from momentum isotropy) and include it at leading order, defining a local anisotropic quasi-equilibrium state, thereby treating the longitudinal/transverse pressure anisotropy nonperturbatively. Perturbative transport equations are then derived to deal with the remaining residual momentum anisotropies [1]. This procedure yields a complete transient effective theory called viscous anisotropic hydrodynamics [1,2].

The anisotropic hydrodynamic approach, especially after perturbative inclusion all residual viscous terms, has been shown to dramatically outperform viscous hydrodynamics in several simplified situations for which exact solutions exist but which share with realistic expansion scenarios the problem of large dissipative currents [1,3,4]. We will discuss the present status of applying viscous anisotropic hydrodynamics to the phenomenological description of the quark-gluon plasma in realistic expansion scenarios. To satisfy the high-performance needs of the JETSCAPE Collaboration, standard [5] and anisotropic viscous hydrodynamics algorithms were implemented on graphical processing units (GPU), leading to a 100-fold speed-up. Results from these accelerated 3+1-dimensional viscous hydrodynamic simulations for event-by-event fluctuating initial conditions will be compared between the standard and anisotropic frameworks and with experimental data.

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Preferred Track

Collective Dynamics

Collaboration

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