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Far-off-equilibrium expansion of a quark-gluon gas and the second law of thermodynamics

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The hydrodynamic evolution of a quark-gluon gas with non-zero quark masses and net baryon number is explored. For far-off-equilibrium initial conditions the expansion trajectories appear to violate simple rules based on the second law of thermodynamics. For Bjorken flow we present a detailed analysis within kinetic theory that provides a full microscopic understanding of these macroscopic phenomena and establish their thermodynamic consistency. We also demonstrate that, for certain far-off-equilibrium initial conditions, the well-known phenomenon of "viscous heating" turns into "viscous cooling" where, driven by dissipative effects, the temperature decreases faster than in adiabatic expansion.

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