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Nonlinear causality and strong hyperbolicity of baryon-rich Israel-Stewart hydrodynamics

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We present the first set of fully-nonlinear, necessary *and* sufficient conditions guaranteeing causal evolution of the initial data for the Israel-Stewart equations with shear and bulk viscosity from kinetic theory coupled to a nonzero baryon current. These nonlinear constraints not only provide causality: they also (a) guarantee the existence of a locally well-posed evolution of the initial data (they enforce strong hyperbolicity) when excluding the endpoints of the bounds, (b) arise from purely algebraic constraints that make no underlying symmetry assumptions on the degrees of freedom and (c) propagate the relevant symmetries of the degrees of freedom over the entire evolution of the problem. Our work enforces a mathematically rigorous foundation for future studies of viscous relativistic hydrodynamics with baryon-rich matter including neutron star mergers and heavy-ion collisions.

Category

Theory

Collaboration (if applicable)

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