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Emergence of slow modes: the governing degrees of freedom in rapidly-expanding quark–gluon plasma

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A crucial open question is why many models of expanding systems exhibit an apparent simplification in their description while gradients in the system are still large and hydrodynamics is not expected to apply. We discuss a new conceptual approach to understand the pre-equilibrium bulk evolution of a system in terms of a reduced set of slow modes. We propose that the emergent dominance of these modes at early times results in a simplified description of the evolution, but is distinct from hydrodynamics since the slow modes are qualitatively distinct from the hydrodynamic modes.

For concreteness we consider a kinetic theory describing a general expanding system with transverse flow and spatial gradients. For a class of collision integrals, these slow modes can be explicitly identified as the instantaneous ground states of an effective Hamiltonian describing the evolution of moments of the distribution function. We show explicitly that the structure of these modes is rich and that only some are "pre-hydrodynamic" in the sense that they become hydrodynamic modes in the hydrodynamic limit. We propose and test that the pre-equilibrium evolution should be described by a reduced set of slow modes whenever the gradients are small compared to the energy gap between the ground and excited states. This suggests a simplified description even when gradients are large, as long as they are small compared to an energy gap which may also be large, for example at early times.

Based on Brewer, Yan, and Yin [arXiv:1910.00021] and Brewer, Ke, Yan, and Yin (in preparation)

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