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Gas of wavepackets and an ab initio derivation of generalised hydrodynamics

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The hydrodynamic approximation is an extremely powerful tool to describe the behaviour of many-body systems such as gases. At the Euler scale, the approximation is based on the idea of local entropy maximisation: locally, within fluid cells, the system relaxes to a state that takes the Gibbs form. In conventional gases, these are thermal states, which include the few conserved quantities admitted by the model. In integrable systems, these are the so-called generalised Gibbs ensembles, which include the infinite set of conserved quantities, and the corresponding hydrodynamic theory is called generalised hydrodynamics (GHD). GHD applies for instance to experimentally realized one-dimensional interacting Bose gases described by the Lieb-Liniger model, and many more one-dimensional integrable systems, such as classical soliton gases and the hard-rod model. However, the local entropy maximisation is an assumption, and in general it is hard to establish the hydrodynamic equations from first principles (from the microscopic dynamics of the model). The GHD equations have a very specific structure: they can be interpreted as "kinetic" equations for a phase-space density, in position-quasimomentum space. Thus suggests that there is a more kinetic way of deriving them. In this talk I will explain how to construct a gas of wavepackets in the Lieb-Liniger model, whose effective dynamics gives rise, without the assumption of local entropy maximisation, to the GHD equations. I will explain how this provides a blueprint for deriving the GHD equations from the Schroedinger equations. The main idea is a map to the scattering coordinates of the wavepackets' dynamics, and is similar in spirit to the techniques used in the known rigorous proof of the hydrodynamic equations for the hard-rod gas.

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