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Impurities in a Bose gas

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Abstract:

Cold atomic gases are systems of unrivalled purity. Many of their extraordinary features have been studied in the past years and exceptional experimental controllability of quantum many-body states has been seen. In real materials, however, impurities play a decisive role. For example, they can give rise to phase inhomogeneities and they affect quantum transport. Quantum transport experiments through small nanostructures are thus important cornerstones in non-equilibrium physics and dynamics of strongly interacting quantum systems. Besides this fundamental interest, quantum transport has a large number technological implications. The flow of electrical current in nanowires and nanotubes as well as the flow of atoms in the next generation of precision inertial sensors using guided atom laser beams are fundamentally governed by quantum dynamics in one spatial dimension. The maybe most ideal situation to grasp is a single impurity particle set into motion along a one-dimensional quantum environment. We will report on an investigation of the scenario of single of few spin impurity atoms propagating through a Tonks-Girardeau gas. The impurities are initially localized and subsequently accelerated by a constant force very much analogous to electrons subject to a bias voltage. We follow the motion of the impurity in situ and characterize the interaction-induced dynamics. We observe a very complex non-equilibrium dynamics, including the emergence of large density fluctuations in the remaining Bose gas, and multiple scattering events leading to dissipation of the impurity's motion.