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Impurity particle driven through a quantum fluid by a constant force (ONLINE presentation)

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Consider a mobile impurity particle in a one-dimensional fluid. Assume a constant force is applied to the impurity. How will it move? What kind of steady state will be established after initial transient dynamics? How will the steady state velocity of the impurity depend on the applied force, fluid temperature and impurity-fluid coupling? These questions have been extensively studied in the past couple of decades. Nevertheless, complete and definite answers are still lacking even in the simplest setups. The most striking thing that can happen to the impurity is Bloch oscillations in the absence of a lattice predicted theoretically in 2009 and observed experimentally in 2017. Alarmingly, the conditions for the emergence of such oscillations are a matter of an unsettled debate. I will overview this debate and outline several specific questions that should be addressed, theoretically or experimentally, to gain an unambiguous understanding of the effect. The dependence of the steady state velocity on the applied force is another matter of controversy: I will argue that reconciling different approaches to this problem inevitably implies a bizarre non-monotonic functional dependence far from naive linear response expectations.

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