Transport properties of disordered quantum chains with many-body interactions

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Abstract

Many-body localized (MBL) systems have recently attracted a lot of attention. It was known that they exhibit many unusual behaviours but for a long time they were a subject of only theoretical (or numerical) research. Few years ago it became possible to create such systems in laboratory and experimentally verify their properties, at the same time stimulating more theoretical works.

This dissertation concerns transport properties of one dimensional MBL systems. We focus on 1D system of spinless fermions with disorder driven by external magnetic field. That field causes Bloch oscillations but we show that for strong disorder the frequency is constant and independent of any other parameters. Moreover, the current decay is a result of destructive interference of currents flowing between the neighboring sites. Interestingly, those local currents do not exhibit any signs of damping, indicating that MBL prevented that system from heating.

Then we switch to spin-1/2 systems, namely disordered Hubbard model. There is an ongoing discussion whether the disorder in charge sector can cause full localization. We create an effective spin model assuming that charges are frozen. Within this effective model we show that full MBL cannot exist without introducing disorder also in spin sector. We investigate the energy transport and find that it is supressed. While we cannot exclude that it is a finite-size effect, it still contrasts with the relatively fast spin relaxation.