Topological protection from random Rashba spin-orbit backscattering: Ballistic transport in a helical Luttinger liquid

HONG-YI XIE, Rice Univ, HEQIU LI, Zhejiang University, YANG-ZHI CHOU, MATTHEW FOSSTER, Rice Univ — Rashba spin-orbit coupling enables irrelevant backscattering in a time-reversal symmetric helical Luttinger liquid (HLL). We study the Landauer conductance $G$ of a HLL in the presence of random Rashba coupling as well as the density-density (Luttinger) interaction. We prove that the transport is purely ballistic ($G = e^2/h$) at any temperature due to the topology. The solution involves a unitary transformation that corresponds to a spin-1/2 in a random, two-component time-dependent magnetic field that preserves the projection of the spin along one fluctuating component (integrable dynamics). Our result is exact for a fixed realization of disorder, and avoids difficulties that arise in disorder-averaged perturbative calculations such as bosonization. We compare the HLL with random Rashba coupling to the Dyson model describing an ordinary spinless quantum wire with particle-hole symmetry, which exhibits non-ballistic transport even at zero temperature.

1This research was supported by the Welch Foundation under Grant No. C-1809 and by an Alfred P. Sloan Research Fellowship No. BR2014-035

Hong-Yi Xie
Rice Univ

Date submitted: 04 Nov 2015

Electronic form version 1.4