Quantum Turbulence and Localization of Disordered Bosons

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We present a theory of quantum transport in the strongly disordered insulating phase of the one-dimensional charged bosons, which provides an insight into the interplay of strong correlations and disorder in Cooper-pair insulators. The transport is ensured by the energy exchange of tunneling Cooper pairs with the self-generated environment of the dipole charge excitations comprised of the same charged particles that mediate the transport. In an ideal system the low-temperature current would have been suppressed completely except for resonance voltages determined by the charging energy of a single junction. The mechanism that unblocks the charge transfer is the development of the Landau-Hopf turbulence in the spectral flow of the energy levels of the dipole excitations of the environment. At moderate temperatures the conductivity exhibits conventional insulating thermally activated behavior with the activation energy corresponding to the macroscopic Coulomb blockade effect. At low temperatures the current is dramatically suppressed. However, due to interaction of disorder with an infinite number of environmental degrees of freedom, even an infinitesimal broadening of environmental excitations energy levels results in a still finite conductivity.