MAR06-2005-006173

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Quantum phase slips with and without disorder

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The rate of quantum phase slips (QPS) in one-dimensional superfluids and superconductors can be computed from first principles in two limiting cases. One [1] is the uniform (no-disorder) limit, appropriate for suitably prepared atomic gases. The other [2] is the limit when the core resistance of a QPS is effectively infinite, appropriate for a sufficiently long disordered superconducting wire. In the latter case, the calculation applies on the superconducting side of the superconductor-insulator transition, where the dilute instanton gas approximation can be used. It is essential to first compute the instanton rate for a given disorder configuration and then average over disorder, as opposed to working with instantons of a disorder-averaged effective theory. Curiously, in neither of the above cases the system is in the XY universality class: in the uniform limit, the QPS rate is suppressed exponentially at low temperatures, as a consequence of the momentum conservation, while the second case (a relatively long disordered wire) maps onto dissipative quantum mechanics, with the dissipative coefficient controlled by the plasmon impedance Z. The role of a finite core resistance can be understood within the picture of effective resistors, representing different dissipative effects, connected in parallel.

[1] S. Khlebnikov, Phys. Rev. Lett. **93**, 090403 (2004); Phys. Rev. A **71**, 013602 (2005).
[2] S. Khlebnikov and L. P. Pryadko, Phys. Rev. Lett. **95**, 107007 (2005).