Quantum Transport and Topology

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1. Classical transport theory (continuity equation, diffusion equation, Einstein relation, Drude law etc)
2. Quantum description of transport (Green functions, disorder average, Born and self-consistent Born approximations, diffusion propagator, Kubo formula for conductivity, quantum derivation of Drude law)
3. Scaling theory of localization
4. Quantum corrections to conductivity (Cooperon diagram, weak localization, weak antilocalization with spin-orbit coupling, quantum corrections to diffusion equation)
5. Non-linear sigma-model (full derivation of the replica sigma model)
6. Perturbative renormalization of the NLSM (separation of fast and slow variables, alternative parametrizations, weak localization and antilocalization, two-loop weak localization in the unitary class, universal conductance fluctuations)
7. Symmetry classification of disordered systems (symmetries of the Hamiltonian and soft modes, 10 classes, Gade-Wegner theorem for chiral classes and quantum corrections to density of states)
8. Example about topology: quantum Hall effect (Pruisken term in the sigma model, two-parameter scaling)
9. Topological classification based on symmetries (homotopy groups of symmetric spases, Bott periodicity, types of topological terms: Z and Z_2 theta-terms and Wess-Zumino terms, table of topological insulators and superconductors)
10. Example of Z_2 topology: surface states of 3D topological insulators (scaling of conductivity, absence of localization)
11. Disorder effects in graphene (quantum Hall critical state, Z_2 topological state with potential disorder, random mass limit and absence of diffusion)
12. Random matrices and 0D sigma model (derivation with supersymmetry, level statistics, matrices with zero modes, Majorana bound states)
13. Exact solution of the 1D model (zero mode and dynamics of Anderson localization, topological effects in standard classes)
14. Other topological effects in 1D (chiral wires, Su-Schrieffer-Heeger model, Kitaev chain)
15. Spin and thermal quantum Hall effect (SQHE mapping on classical percolation, TQHE anomalous diffusion in class D wires, kinks in the sigma model, two-parameter scaling)
16. 2D chiral metals (vortices in the sigma model, non-perturbative localization, effects of topological terms)