Derivation of a Kubo-like formula for charge and spin transport

Giovanna Marcelli (University of Tübingen)

Abstract: We study the linear response coefficients of a gapped, periodic and one-particle quantum system to the perturbation of a small electric field, modelled by a potential εX_j with $\varepsilon \ll 1$, in terms of the conductivity tensor σ_{ij} for both charge and spin transport. The conductivity σ_{ij} is associated with the current operator defined as $\mathrm{i}[H_0, SX_i]$, where H_0 is the unperturbed Hamiltonian and S is a self-adjoint operator acting only on the internal degrees of freedom of the system (e.g. spin). This is of relevance for 2-dimensional quantum (spin) Hall systems, where S is the identity operator (resp. S is the third component of the spin operator).

The method relies on the characterization of a *non-equilibrium almost-stationary state* (NEASS), defined via space-adiabatic perturbation theory.

Whenever S is a conserved quantity, i.e. $[H_0, S] = 0$, we recover the Kubo formula for the conductivity, and consequently its quantization in appropriate units. When instead $[H_0, S] \neq 0$, we show that further correction terms appear in the Kubo-like formula for σ_{ij} .

This talk is based on joint work with D. Monaco (Roma TRE, Rome), G. Panati (La Sapienza, Rome) and S. Teufel (Universität Tübingen).