Wigner-Mott Scaling of Transport Near Two-Dimensional Metal-Insulator Transitions

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Introduction

Since late 1990s, many experiments appeared reporting the existence of metallic phase in high-quality MOSFETs and 2D metal-insulator transition (MIT) tuned by the change of concentration of charge carriers. All later experiments [1] have confirmed these observations to the lowest accessible temperatures (~4mK). Here we provide evidence [2] that the electron-electron scattering dominates the transport in a broad concentration and temperature range on the metallic side of the metal-insulator transition in Si MOSFETS and GaAs/AlGaAs heterostructures.

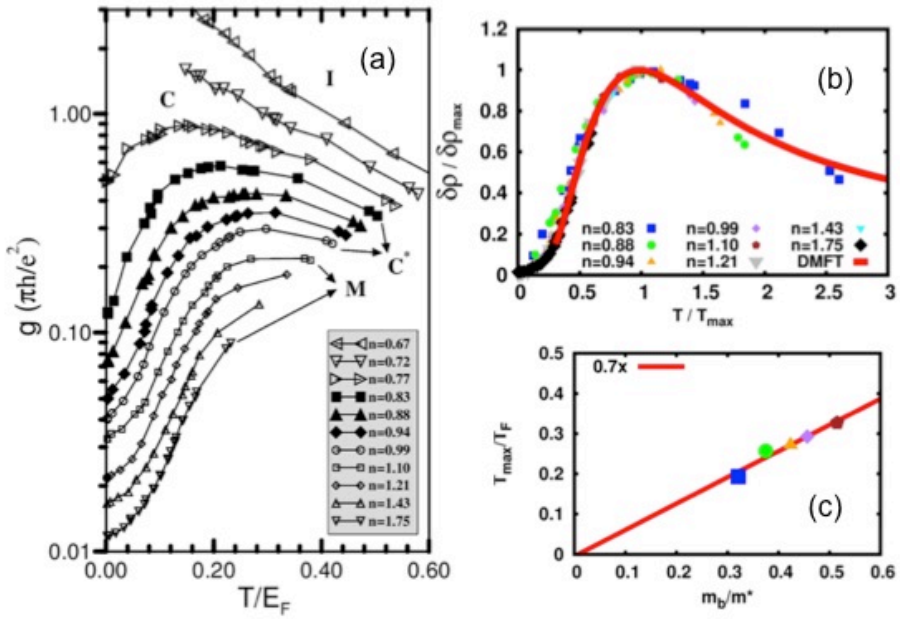

Figure 1 (a) R*esistivity as a function of temperature from the experiments on Si MOSFET. (b) Scaled resistivity as a function of scaled temperature for different electron concentrations, for the same experimental data. The solid red line is obtained from the DMFT solution [2] of the half-filled Hubbard model. (c) The scaling parameter T_{max} in Si-MOSFETs is inversely proportional to the effective mass m*.*

DMFT theory and caling of resistivity curves

In this work [2] we show that all resistivity curves on the metallic side of the transition can be collapsed to a single scaling function, when the temperature is scaled by the coherence temperature T*. This represents a characteristic energy scale (renormalized Fermi temperature) which determines the transport properties in the incoherent regime. We use the scaling ansatz $\delta\rho(T) = \delta\rho_{max}(n)\, f[T/T_{max}(n)]$, which follows from the premise (confirmed for strongly correlated materials with week and moderate disorder) that the resistivity assumes additive form $\rho(T) = \rho_0 + \delta\rho(T)$. Here ρ_0 is the residual resistivity due to impurities and defects, and $\delta\rho(T)$ is a strongly temperature dependent contribution due to the inelastic (electron-electron) scattering, which is responsible for the destruction of Landau quasi-particles. This scaling ansatz works very well for all experimental data from different experiments on Si-MOSFTEs and GaAs hetero-structures [1]. The critical behavior of the scaling parameter T_{max} reveals power-law dependence on reduced concentration $(n-n_c)/n_c$. For Si-MOSFETs, using complementary experiments which determined the electron effective mass m^* we find that $T_{max} \sim 1/m^*$. Exactly the same trends are found from our DMFT theory [2].

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References

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