Quantum Coherence in Networks

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Magnetoconductance oscillations in mesoscopic rings are the most striking evidence of the quantum nature of the transport in mesocopic devices. These oscillation may be either $\Phi_0 = h/e$ periodic for single rings (Aharonov-Bohm oscillations) or $\Phi_0/2$ periodic for large networks (Altshuler-Aronov-Spivak oscillations). The problem of the transition between these two extreme situations have been explored by considering lines of silver rings of different lengths : in this case, simple arguments show that the AB oscillations decease as N-1/2, whereas the AAS oscillations are constant with N, N being the number of rings. In this talk, we will show that this so-called ensemble averaging indeed depends on the dimensionality of the system : from measurements of both AB and AAS oscillations in 2D networks, we will show that, when the phase coherence length of the electrons becomes of the order of the width of the network, the diffusive motion of the electrons is actually one-dimensional although the network is 2D. One thus observes a $1D \leftrightarrow 2D$ cross-over in the dependence of the amplitude of magnetoconductance oscillations as a function of the number of plaquettes of the network. This cross-over from mesoscopic to macroscopic behavior in the ensemble averaging shows that the usual addition of coherent blocs in mesoscopic physics is indeed very subtle.

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[2] F. Mallet, Y. Niimi, F. Schopfer, Y. Baines, D. Mailly, C. Texier,G. Montambaux, C. Bäuerle and L Saminadayar, submitted to Phys. Rev. Lett. (2007)