MAR08-2007-003273

Abstract for an Invited Paper
for the MAR08 Meeting of
the American Physical Society

Transition from a one-dimensional to a quasi-one-dimensional state in interacting quantum wires[1]

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At low density, all electrons in a quantum wire occupy the lowest state of transverse quantization, and it is natural to view the system as one-dimensional. As the density is increased, the electrons start to populate the second subband, resulting in a transition to a quasi-one-dimensional state. I will discuss this transition in the presence of electron-electron interactions in a model that neglects electron spins. Clearly, in the non-interacting case the transition is accompanied by the emergence of a second gapless excitation mode. On the other hand, at very strong interactions, the one-dimensional electrons form a Wigner crystal, and the transition corresponds to it splitting into two chains. Unlike the non-interacting electrons, this two-row (zigzag) crystal still has only one acoustic excitation branch. This raises the question of how the nature of the transition to a quasi-one-dimensional state changes with interaction strength. We can show that in the vicinity of the transition already arbitrarily weak interactions open a gap in the second excitation mode. We then argue that only one gapless mode exists near the transition at any interaction strength.

[1]This work was supported by the U.S. Dept. of Energy, Office of Science, under contract DE-AC02-06CH11357.