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S E M I N A R
on
Semiconductor Physics and Nanotechnology

Mo, 23.05.2022, 11:15 Uhr,

Seminar in
person in the Physics lecture hall *or* via Zoom

"Beyond 40 years of quantum Hall effect: Revision of the edge channel picture"

Ao.Univ.-Prof. Mag. et Dr.rer.nat. Josef Oswald, Institute of Physics, Montanuniversität Leoben

Quantum coherence over long distances is a major ingredient of modern concepts for quantum communication and quantum computing. Quantum Hall edge channels allow a fundamental study of coherent quantum transport effects up to macroscopic length scales. However, even more than 40 years after discovery, a microscopic picture of the integer quantum Hall effect has still been missing (discovery 1980, 1985 Nobel price to Klaus von Klitzing).

State of the art computing opens now a new window to this famous effect [1-4]. In our record-breaking Hartree-Fock simulations we use up to 3000 electrons in almost macroscopic systems of 1000x1000nm size and we demonstrate that the so far common knowledge about the integer quantum Hall effect (IQHE) will need major revisions. While it is believed that the IQHE is driven by single-particle physics only, the two years later discovered fractional quantum Hall effect (discovery 1982, 1998 Nobel price to H.Störmer, D.Tsui and R.Laughlin) is understood to rely on many-particle physics.

Our recent studies reveal that also the integer quantum Hall effect rests decisively on many-particle physics. In particular, the formation of so-called compressible and in-compressible edge stripes and edge channels turns out to develop essentially different from the common understanding so far. In contrast to the even up to now most frequently referenced theory of Chklovskii, Shklovskii and Glazman (1992) [5], electron-electron interactions do not widen up the narrow edge channels that have been introduced by the early models via neglecting electron-electron interactions. Quite oppositely, our modelling demonstrates that especially many-particle physics stabilizes narrow edge channels also in the presence of electron-electron interactions.

For a broad understanding, our results show nicely that many-particle physics allows us to think intuitively in terms of non-interacting single electrons moving in an effective potential.

[1] J. Oswald, "Hybridization of wide compressible edge stripes and narrow quantum channels driven by many body interactions in the quantum Hall effect regime", arXiv:2106.12386v1
[2] R. A. Römer and J. Oswald, "The microscopic picture of the integer quantum Hall regime", Annals of Physics **435**, 168541 (2021)
[3] D. Werner and J. Oswald, "Size scaling of the exchange interaction in the quantum Hall effect regime", Physical Review B **102**, 235305 (2020)
[4] J. Oswald and R. A. Römer, "Microscopic details of stripes and bubbles in the quantum Hall regime", Physical Review B **102**, 121305 (2020)
[5] D. B. Chklovskii, B. I. Shklovskii, and L. I. Glazman, "ELECTROSTATICS OF EDGE CHANNELS", Physical Review B **46**, 4026 (1992)

Zoom – Link:
https://zoom.us/j/97536372260?pwd=bXB2aEMxQ25XZ3NvTUxnTER6Y3JjUT09
Meeting-ID: 975 3637 2260
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