

# **Final Technical Report**

## **Manifestations of quantum phase transitions in transport through nanosystems**

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The award led in a number of important new results in the theory of interacting low-dimensional quantum systems. A short summary of our findings is given below

- Equilibration of a one-dimensional system of interacting electrons requires processes that change the numbers of left- and right-moving particles. At low temperatures such processes are strongly suppressed, resulting in slow relaxation towards equilibrium. We study this phenomenon in the case of spinless electrons with strong long-range repulsion, when the electrons form a quasi-periodic chain, the so-called one-dimensional Wigner crystal. The relaxation in this regime is accomplished via the umklapp scattering of phonons in the crystal. We evaluated exactly the rate of the umklapp scattering and studied its manifestations in the conductance of a strongly interacting quantum wire. [1]
- We computed the relaxation rate of high-energy quasiparticles in a weakly interacting one-dimensional Bose gas. Unlike in higher dimensions, the rate is a non-monotonic function of temperature, with a maximum at the crossover to the state of suppressed density fluctuations. At the maximum, the relaxation rate may significantly exceed its zero-temperature value. We also found the dependence of the differential inelastic scattering rate on the transferred energy, which yields information about temperature dependence of local pair correlations. Results of this work are important for the ongoing experiments with colliding cold atomic clouds. [2]
- We developed a method of an asymptotically exact treatment of threshold singularities in the dynamic response functions of gapless integrable models. Application of the method to the evaluation of the dynamic structure factor of

interacting spinless fermions on a lattice revealed unexpected features in the dependence of the exponent characterizing the threshold singularity on the system's parameters. These results can be verified in inelastic neutron scattering experiments [3].

- We evaluated the spectral function of interacting fermions in one dimension. We found that in a striking departure from the predictions of the Luttinger liquid theory, the spectrum nonlinearity restores the main feature of the Fermi liquid: a Lorentzian peak in the spectral function on the particle mass shell. The spectral function is measured in momentum-resolved tunneling experiments, and our results appear to be in agreement with the latest experimental data. [4]
- We demonstrated theoretically that the standard setup for measurement of the Coulomb drag between two quantum wires acts as a charge current to spin current converter when placed in a magnetic field. We evaluated the efficiency of the conversion and found that it may approach 100% at low temperatures. [5]

#### **Publications resulted from the research supported by the award**

1. Equilibration of a One-Dimensional Wigner Crystal  
K. A. Matveev, A. V. Andreev, and M. Pustilnik,  
Phys. Rev. Lett. **105**, 046401 (2010).
2. Relaxation of a High-Energy Quasiparticle in a One-Dimensional Bose Gas  
S. Tan, M. Pustilnik, and L. I. Glazman,  
Phys. Rev. Lett. **105**, (2010).
3. Threshold singularities in the dynamic response of integrable models  
V. V. Cheianov and M. Pustilnik  
Phys. Rev. Lett. **100**, 126403 (2008)
4. Fermi-Luttinger liquid: spectral function of interacting one-dimensional fermions  
M. Khodas, M. Pustilnik, A. Kamenev, and L. I. Glazman  
Phys. Rev. B **76**, 155402 (2007)
5. Generation of spin current by Coulomb drag  
M. Pustilnik, E. G. Mishchenko, and O. A. Starykh  
Phys. Rev. Lett. **97**, 246803 (2006)