Correlations in Low-Dimensional Quantum Many-Particle Systems

Erik Eriksson

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Opponent:	Prof. Karyn Le Hur, Centre de Physique Théorique, École Polytechnique, Frankrike
Betygsnämnd:	Doc. Eddy Ardonne, Fysikum, Stockholms universitet Prof. Edwin Langmann, Institutionen för teoretisk fysik, KTH Prof. Nancy Sandler, Department of Physics and Astronomy, Ohio University, USA
Examinator:	Prof. Stellan Östlund
Handledare:	Prof. Henrik Johannesson

Institutionen för fysik
Göteborgs universitet

GÖTEBORGS UNIVERSITET

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Erik Eriksson

Department of Physics
University of Gothenburg
SE-412 96 Gothenburg, Sweden

Abstract

This thesis concerns correlation effects in quantum many-particle systems in one and two dimensions. Such systems show many exotic non-Fermi liquid phenomena, which can be treated analytically using non-perturbative field-theory methods.

Quantum phase transitions between topologically ordered phases of matter, which do not break any symmetries, are studied. It is shown that although there is no local order parameter, a local measure from quantum information theory called reduced fidelity can detect such transitions.

Entanglement in quantum impurity systems is also studied. The general expression for scaling corrections in entanglement entropy from boundary perturbations is derived within conformal field theory, showing that the asymptotic decay of Kondo screening clouds follow the same power-law as the impurity specific heat.

Furthermore, the effects from spin-orbit interactions on Kondo physics in helical Luttinger liquids are studied. Such helical liquids occur on the edges of two-dimensional topological insulators. It is shown that Rashba and Dresselhaus interactions can potentially destroy Kondo singlet formation in such a system, and that the coupling to an electric field gives a mechanism to control transport properties.

The most recent work focuses on correlations in interacting one-dimensional Bose gases. The asymptotic expression for correlation functions in a generalized Gibbs ensemble, where all the local conservation laws appear, is obtained from Bethe Ansatz and conformal field theory.

In addition to the research papers with the above results, the thesis also contains an introductory text reviewing background material.