Abstract Submitted
for the MAR12 Meeting of
The American Physical Society

Entanglement Entropy of Fermi Liquids via Multi-dimensional Bosonization[1] WENXIN DING, National High Magnetic Field Laboratory & Florida State University, ALEXANDER SEIDEL, Washington University in St. Louis, KUN YANG, National High Magnetic Field Laboratory & Florida State University — The logarithmic violations of the area law, i.e. an "area law" with logarithmic correction of the form $S \sim L^{d-1} \log L$, for entanglement entropy are found in both 1D gapless system and for high dimensional free fermions. The purpose of this work is to show that both violations are of the same origin, and in the presence of Fermi liquid interactions such behavior persists for 2D fermion systems. In this paper we first consider the entanglement entropy of a toy model, namely a set of decoupled 1D chains of free spinless fermions, to relate both violations in an intuitive way. We then use multi-dimensional bosonization to re-derive the formula by Gioev and Klich [Phys. Rev. Lett. 96, 100503 (2006)] for free fermions through a low-energy effective Hamiltonian, and explicitly show the logarithmic corrections to the area law in both cases share the same origin: the discontinuity at the Fermi surface (points). In the presence of Fermi liquid (forward scattering) interactions, the bosonized theory remains quadratic in terms of the original local degrees of freedom, and after regularizing the theory with a mass term we are able to calculate the entanglement entropy perturbatively up to second order in powers of the coupling parameter for a special geometry via the replica trick.

[1]This work is supported support by National Science Foundation under NSF Grant No. DMR-1104545 (W. Ding and K. Yang) and is supported by the National Science Foundation under NSF Grant No. DMR-0907793.

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Date submitted: 09 Nov 2011 Electronic form version 1.4