Thermopower Measurements of Two-Dimensional Electron Gas in GaAs Quantum Well Device

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Introduction

The two-dimensional electron gas (2DEG) in the GaAs quantum well system has been an ideal playground for studying fractional quantum Hall (FQH) physics for decades. The non-Abelian physics at filling factor v=5/2 remains a very interesting challenge. Recent theories [1,2] suggest that the thermoelectric tensor can provide detailed information on the entropy in the FQH regime [6]. Specifically, the thermopower is predicted to be strongly enhanced due to large ground-state degeneracy of non-Abelian state at v=5/2. Previous thermoelectric studies [3,4,5,7,8] suffered from large phonon-drag contamination at temperatures T as low as 150 mK. Using an etched phononic lattice, we reduced the phonon drag contribution (S_{xx}~T^3) and achieved T-linear behavior in S_{xx} as high as 300 mK. We performed thermoelectric measurements on high-mobility samples (20x10^6 cm^2/Vs) at different filling factors and various T. Interestingly, enhancement of S_{xx} below 150 mK is observed in the v=5/2 state.

Experimental

The high-quality GaAs-AlGaAs quantum well wafer was grown in Pfeiffer's lab. After etching the phonon lattice, we polished the wafer down to 80 um to further reduce the thermal conduction. Field-dependence and temperature-dependence of thermopower data above 300 mK were obtained with He3 insert, using an in-house magnet. Subsequently, we performed DC thermopower measurement at NHMFL, Tallahassee, down to 100mK. The v=5/2 state had the highest signal to noise ratio so that data is presented here.

Results and Discussion

The thermopower S_{xx} at different half-integer filling factors fit S_{xx} =αT+βT^3 above ~300 mK. Below 300 mK, it reverts to fermionic behavior S_{xx} =αT. Below 400 mK, S_{xx} at v=5/2 for electron and ν^*=5/2 for composite fermion become closely comparable. Finally, at v=5/2, S_{xx} /T diverges as temperature decreases, instead of remaining constant. This non-fermionic behavior, consistent with non-Abelian statistics, invites detailed future experiments.

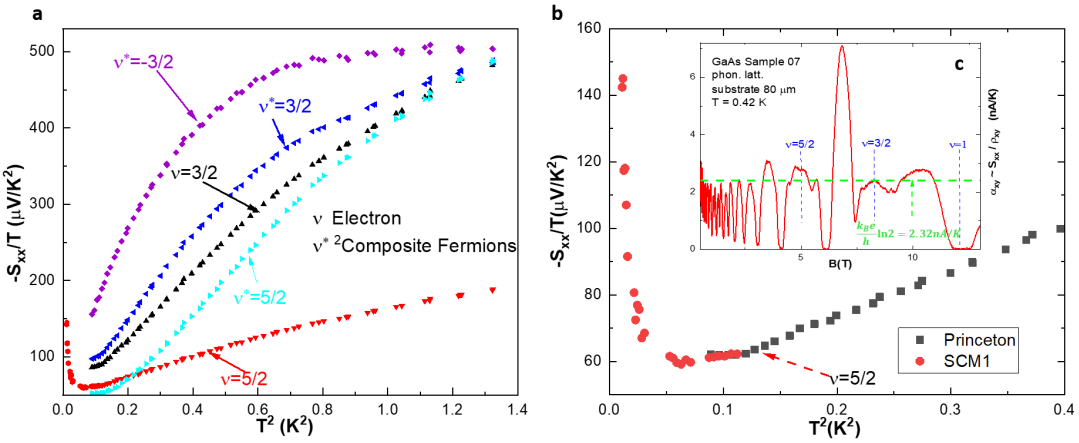

Fig.1 a. Profiles of thermopower S_{xx} vs. T for various filling factors plotted as - S_{xx} /T vs. T^2, S_{xx} ~αT demonstrates the fermionic behavior free of phonon drag. b. Temperature-dependence of S_{xx} at v=5/2. Below 150mK, S_{xx} significantly deviates from fermionic behavior. Data below 300mK were taken at SCM1, NHMFL, Tallahassee c. Thermoelectric coefficient α_{xy} vs. H at 0.42K

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