Diffusion thermopower of quantum Hall systems measured in Hall-bar and Corbino geometry

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It has been pointed out that the radial thermopower S_{rr}^{C} measured in the Corbino geometry is qualitatively different from the longitudinal thermopower S_{xx}^{H} in the Hall-bar geometry in the quantum Hall systems (QHS) [1, 2]. In terms of the conductivity and the thermoelectric conducitivity tensors, $\hat{\sigma}$ and $\hat{\epsilon}$, which relate the electric field $\boldsymbol{E}$ and the temperature gradient $\boldsymbol{\nabla} T$ to the current density $\boldsymbol{j}$ as $\boldsymbol{j} = \hat{\sigma}\boldsymbol{E} - \hat{\epsilon}\boldsymbol{\nabla} T$, the thermopowers are given as $S_{rr}^{\mathrm{C}} = \epsilon_{rr}/\sigma_{rr}$ and $S_{xx}^{\mathrm{H}} \simeq \epsilon_{yx}/\sigma_{yx}$, respectively, where we made use of the relation $\sigma_{xx} \ll |\sigma_{yx}|$ for the latter. The great majority of the thermopower measurements have been carried out on the Hall-bar samples thus far [3]. In the present paper, we report our measurement performed on both the Corbino and Hall-bar setups.

The thermopower generally contains contributions from two distinct mechanisms: diffusion and phonon drag. While the latter is known to be dominant in the GaAs/AlGaAs QHS [1, 3], it is the former that is expected to be more sensitive to the electronic properties of the systems. In order to detect the diffusion contribution selectively, we introduce the gradient only to the electron temperature T_{e} by employing the microwave heating technique. In the method, microwaves propagating through the coplanar waveguide (CPW) placed on the surface are absorbed by the electrons beneath the slots of the CPW and raise the T_{e} (Fig. 1 inset), thereby generating the gradient $\boldsymbol{\nabla} T_{\mathrm{e}}$ toward the large Ohmic contact designed as the low-temperature anchor of the device.

The Corbino thermopower S_{rr}^{C} thus measured is plotted in Fig. 2 along with the conductivity σ_{rr}. In the QH plateau regions, S_{rr}^{C} takes large positive (negative) values just below (above) integer fillings and inverts the sign at the center of the plateaus. This is in marked contrast to S_{xx}^{H}, which vanishes within the QH plateau regions. The behavior of S_{rr}^{C} is in agreement with the diffusion Corbino thermopower calculated in a recent theory [2] treating disorder within the self-consistent Born approximation.

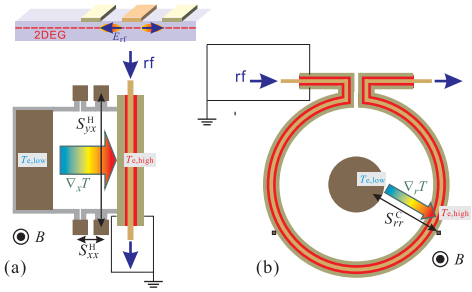

Fig. 1: Measurement devices in Hall-bar (a) and Corbino (b) setups. Upper inset depicts the close-up cross section of the heater section.

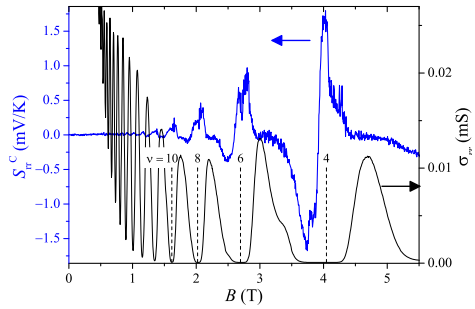

Fig. 2: Thermopower S_{rr}^{C} and conductivity σ_{rr} measured in the Corbino geometry.

[1] H. van Zalinge, R. W. van der Heijden, J. H. Wolter, Phys. Rev. B **67**, 165311 (2003).
[2] Y. Barlas, K. Yang, Phys. Rev. B **85**, 195107 (2012).
[3] R. Fletcher, Semicond. Sci. Technol. **14**, R1 (1999) and references therein.