§29. Quantum Nernst Effect in a Bismuth Single Crystal

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We reported[1)] a theoretical calculation explaining the quantum Nernst effect observed experimentally in a bismuth single crystal. Generalizing the edge-current picture in two dimensions, we showed that the peaks of the Nernst coefficient survive in three dimensions due to a van Hove singularity. We also evaluateed the phonon-drag effect on the Nernst coefficient numerically. Our result agrees with the experimental result for a bismuth single crystal (See Fig. 1).

The Nernst effect is a thermoelectric phenomenon which yields a transverse voltage when there is a magnetic field perpendicular to a temperature gradient. In 2005, we[2)] predicted the *quantum* Nernst effect of the two-dimensional electron gas in a semiconductor heterojunction under a strong magnetic field, using the edge current picture of the quantum Hall effect.[3)] In the quantum Nernst effect, the Nernst coefficient shows sharp peaks when a Landau level crosses the Fermi level and the thermal conductance in the direction of the temperature gradient is quantized. We[4)] also showed that impurities do not change the conclusions much.

In 2007, Behnia *et al.*[5, 6)] have reported quantum oscillation of the Nernst coefficient in a bismuth single crystal, which was similar to our prediction.[2)] It is remarkable that the strong quantum effect is observable in three dimensions; the quantized plateaus of the Hall conductance can be hardly identified in three dimensions.

In the present study, we showed that the quantum Nernst effect survive in three dimensions due to a van Hove singularity. We presented an extension of the edge-current picture in two dimensions to three dimensions, in order to explain Behnia *et al.*'s[5)] experiment for a bismuth single crystal. The naive extension reproduced the quantum oscillation of the experimental result qualitatively. Furthermore, consideration[7, 8)] of the phonon-drag effect led us to a theoretical result quantitatively consistent with the experimental result. The peaks are sharper than those in the experiment probably because we neglected impurity scattering of carriers (Fig. 1). For simplicity, we also assumed the Fermi surface of bismuth is ellipsoid and considered only the hole contribution. Going beyond these approximations would be an interesting future problem.[9)]

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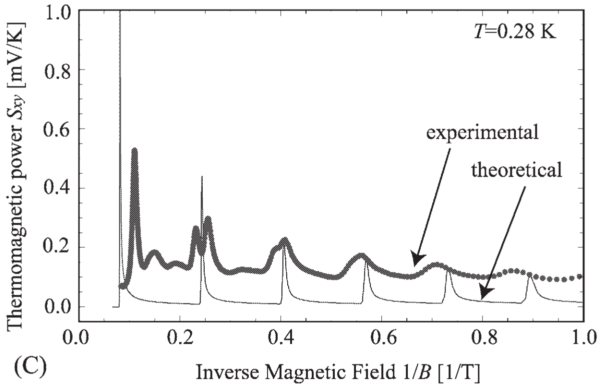

Fig. 1: Comparison between our theoretical result and the experimental result by Behnia *et al.*[5, 6)] of the thermomagnetic power in three dimensions at $T=0.28$ K.

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