「半導体」第12回

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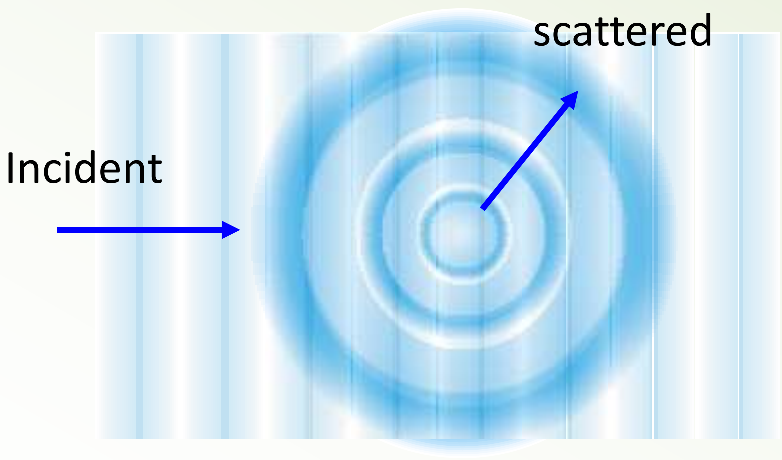
コヒーレント伝導 → 散乱問題



Casimir問題

$$J_1 = -J_3, \quad J_2 = -J_4$$

$J_2 = 0$ とおけば，通常の 4 端子測定問題．$V_{ij} \equiv V_i - V_j$ とすると

$$\begin{pmatrix} J_1 \\ J_2 \end{pmatrix} = \begin{pmatrix} \alpha_{11} & -\alpha_{12} \\ -\alpha_{21} & \alpha_{22} \end{pmatrix} \begin{pmatrix} V_{13} \\ V_{24} \end{pmatrix}$$

ただし，

$$\alpha_{11} = g_q[(1 - R_{11} - S^{-1}(T_{14} + T_{12})(T_{41} + T_{21})]$$
$$\alpha_{12} = g_q S^{-1}(T_{12}T_{34} - T_{14}T_{32})$$
$$\alpha_{21} = g_q S^{-1}(T_{21}T_{43} - T_{23}T_{41})$$
$$\alpha_{22} = g_q[(1 - R_{22} - S^{-1}(T_{21} - T_{23})(T_{32} + T_{12})]$$

$$S = T_{12} + T_{14} + T_{32} + T_{34} = T_{21} + T_{41} + T_{23} + T_{43}$$

4端子問題の一般解

$$\rho_{xx}(B) = \rho_{xx}(-B)$$

$$\alpha_{11}(B) = \alpha_{11}(-B), \quad \alpha_{22}(B) = \alpha_{22}(-B), \quad \alpha_{12}(B) = \alpha_{21}(-B)$$

通常の４端子問題に適用して，13:電流端子，24:電圧端子，とすると，

$$\mathcal{R}_{13,24} = \frac{V_2 - V_4}{J_1} = \frac{\alpha_{21}}{\alpha_{11}\alpha_{22} - \alpha_{12}\alpha_{21}}$$

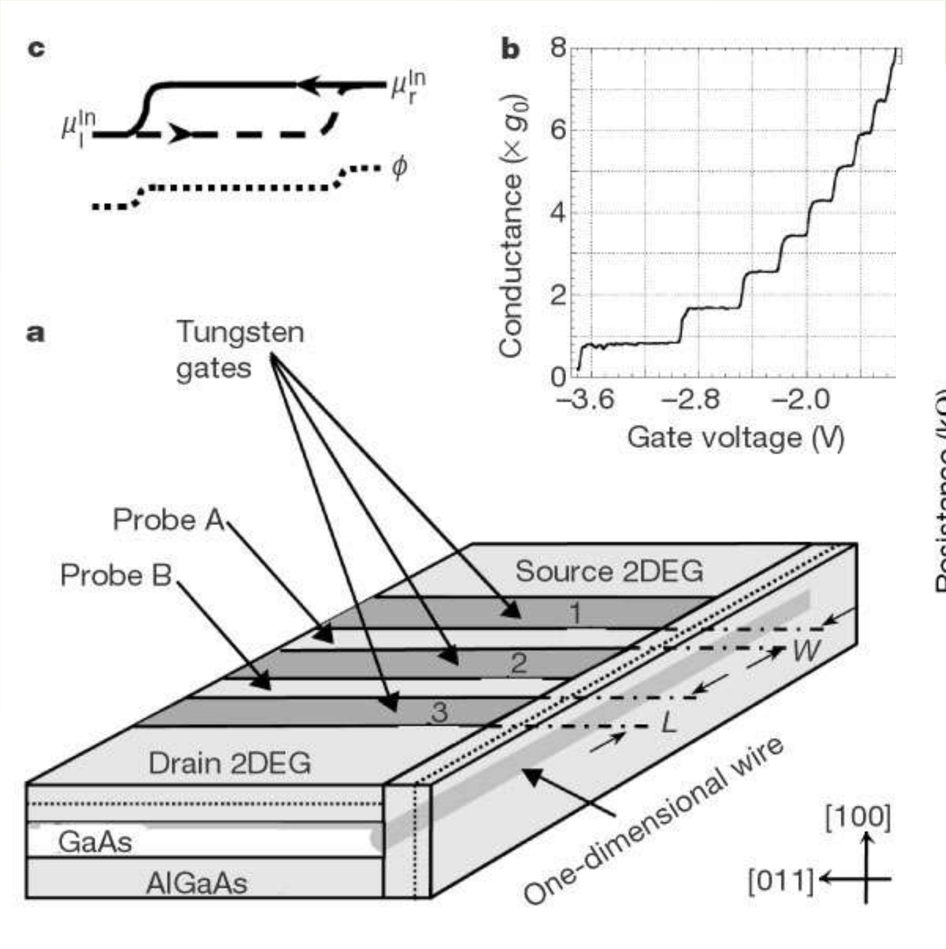
$$\mathcal{R}_{24,13} = \frac{\alpha_{12}}{\alpha_{11}\alpha_{22} - \alpha_{12}\alpha_{21}}$$

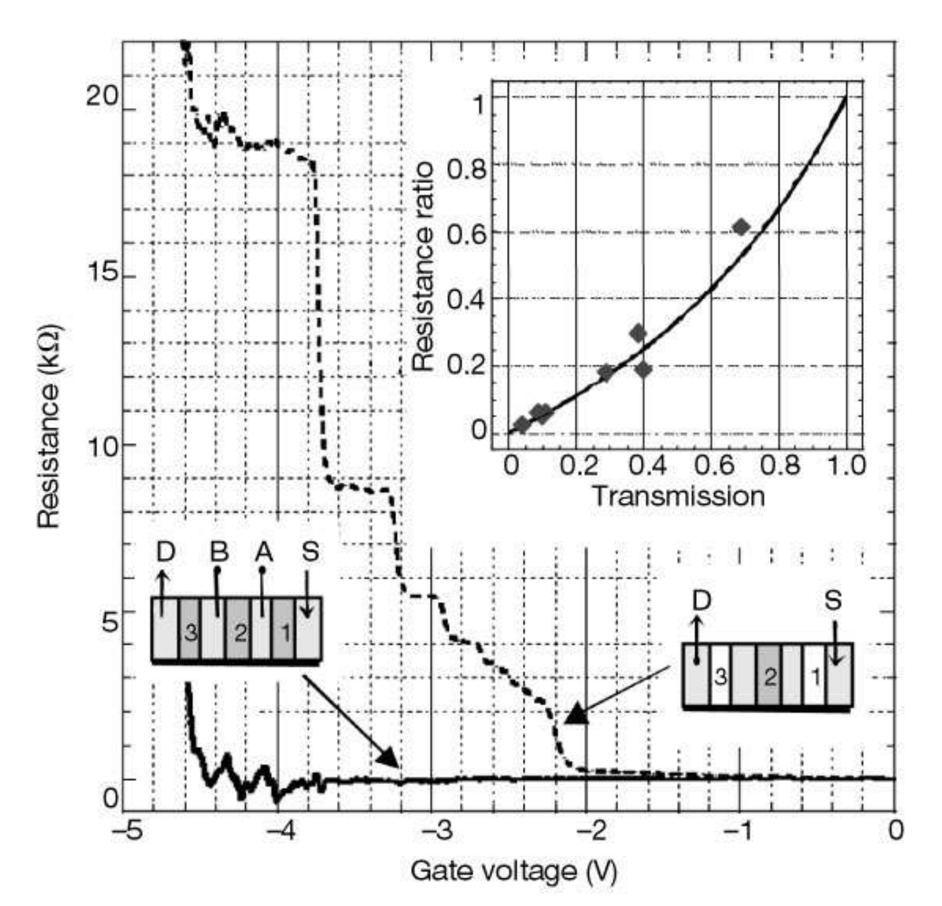
$$\mathcal{R}_{mn,kl} = r_q \frac{T_{km}T_{ln} - T_{kn}T_{lm}}{D} \qquad D \equiv r_q^2(\alpha_{11}\alpha_{22} - \alpha_{12}\alpha_{21})S$$

$$\mathcal{R}_{mn,kl}(B) = -\mathcal{R}_{kl,mn}(-B)$$

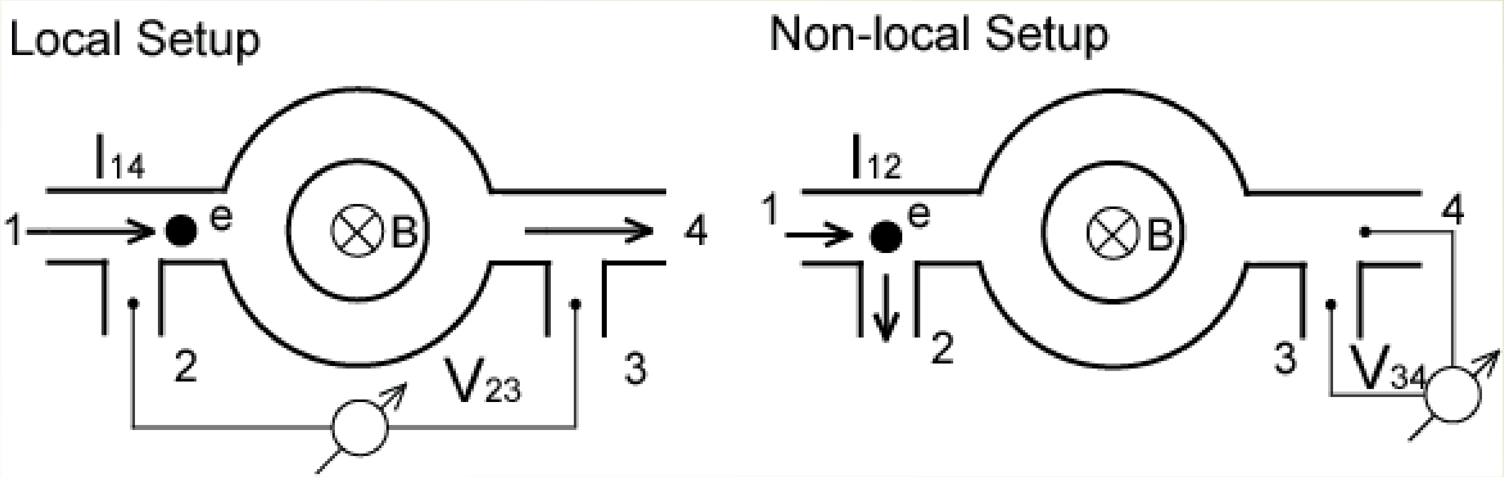
量子細線の4端子抵抗測定

R. de Picciotto et al. Nature **411**, 51 (2001)

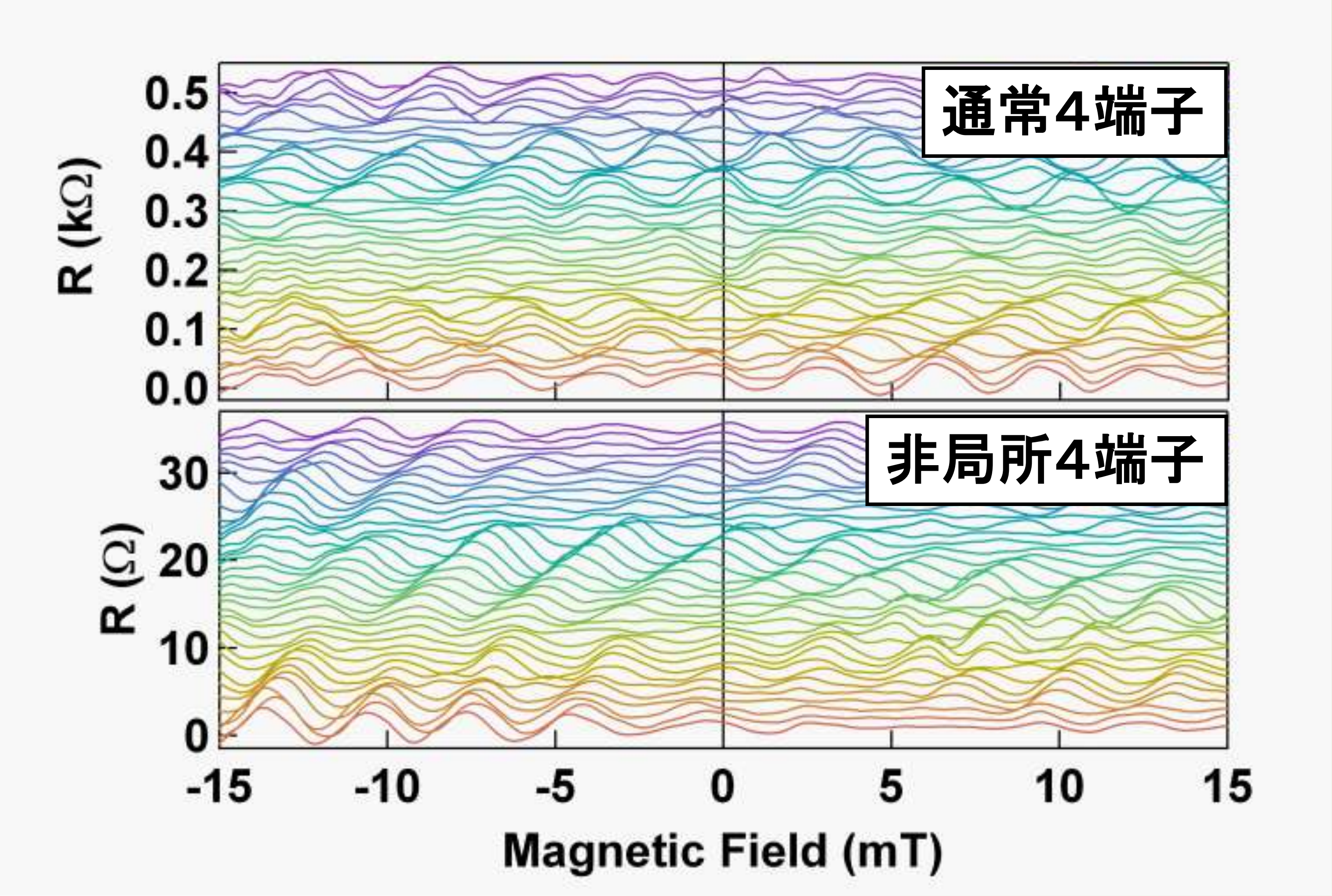




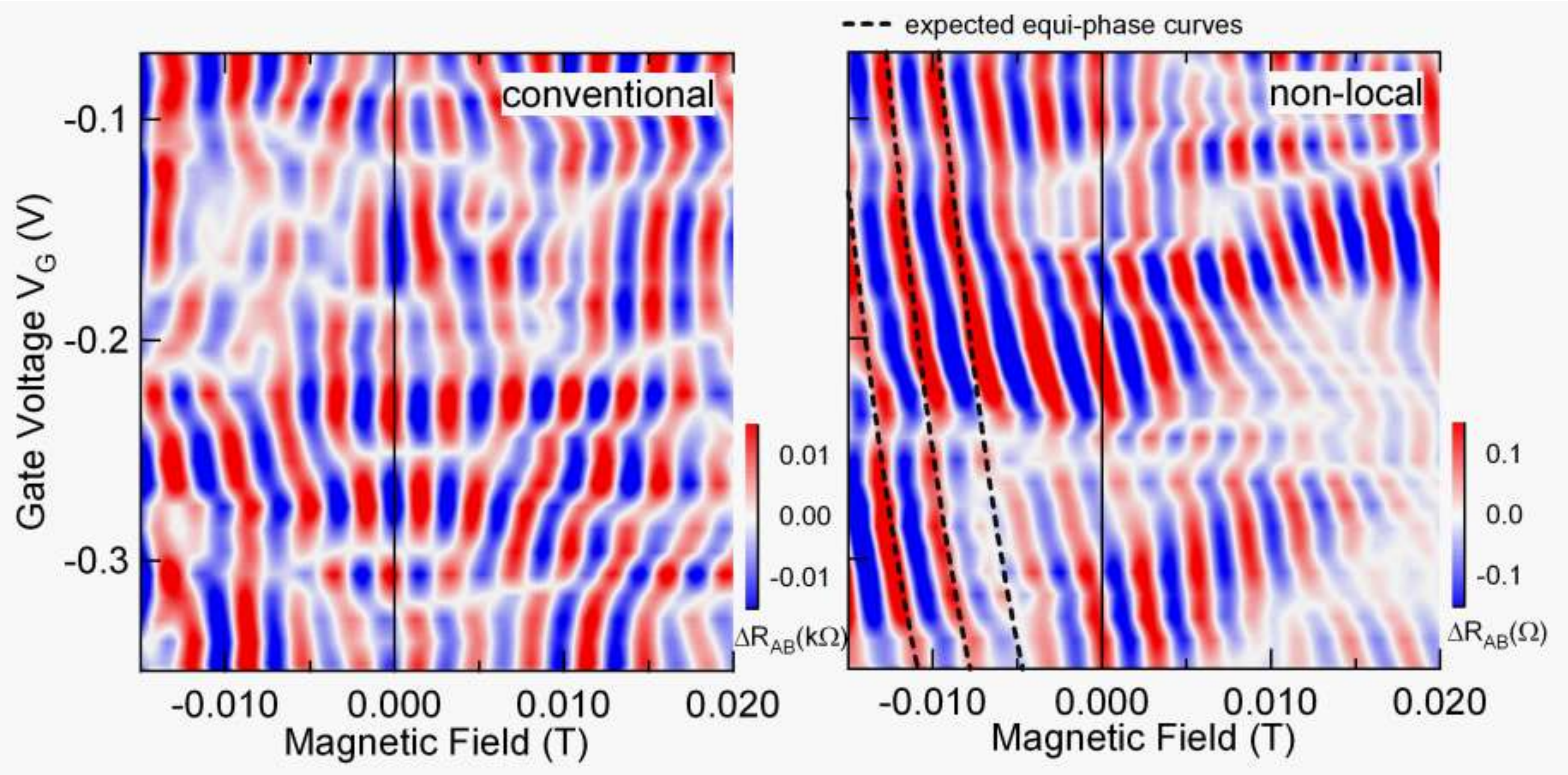
AB効果の非局所測定



２つの端子配置での位相変化



AB位相制御



expected equi-phase curves
conventional
non-local
Gate Voltage V_G (V)
-0.1
-0.2
-0.3
0.01
0.00
-0.01
ΔR_{AB}(kΩ)
0.1
0.0
-0.1
ΔR_{AB}(Ω)
-0.010
0.000
0.010
0.020
Magnetic Field (T)
Magnetic Field (T)

非局所AB効果に対するOnsagerの相反定理