

RDNMR in GaAs quantum point contacts (QPCs) GaAs 量子ポイントコンタクト (QPC) における RDNMR

We observed resistively-detected NMR (RDNMR) also for GaAs quantum point contact (QPC) [1]. Thanks to the triple-gate-structure [see also “*Various studies on quantum point contacts (QPCs)*”], we can enjoy a good controllability of the channel shape. In our QPC RDNMR experiments, we set the bulk two-dimensional electron gas (2DEG) at $\nu_b = 2$ and tune the QPC filling factor to the vicinity of $\nu_{\text{QPC}} = 1$. As shown in Fig. 1, RDNMR line shape is dispersive near $\nu_{\text{QPC}} = 1$ but it changes to conventional dip for $\nu_{\text{QPC}} < 1$. This previously unobserved line shape in a QPC points to a simultaneous occurrence of two hyperfine-mediated spin flip-flop processes within the QPC; one is inside of constriction where electron spins are polarized ($\nu_{\text{QPC}} = 1$) and another is near QPC but out of the constriction where electron spins are unpolarized ($\nu_b = 2$). Nuclear diffusion to the center of the QPC might play an important role. For $\nu_{\text{QPC}} > 1$, we can see the similar tendency but the RDNMR spectrum gets inverted. As shown in the lower left inset in Fig. 1(a), the Overhauser field from the polarized nuclei affects oppositely for up- and down-spin transmission, resulting in the signal inversion. The dispersive line shape was also reported for two-dimensional systems and our experiments provide a hint to consider origin of the dispersive line shape. The phenomenological study using Landauer-Buttiker approach was also reported for RDNMR in the QPC [2].

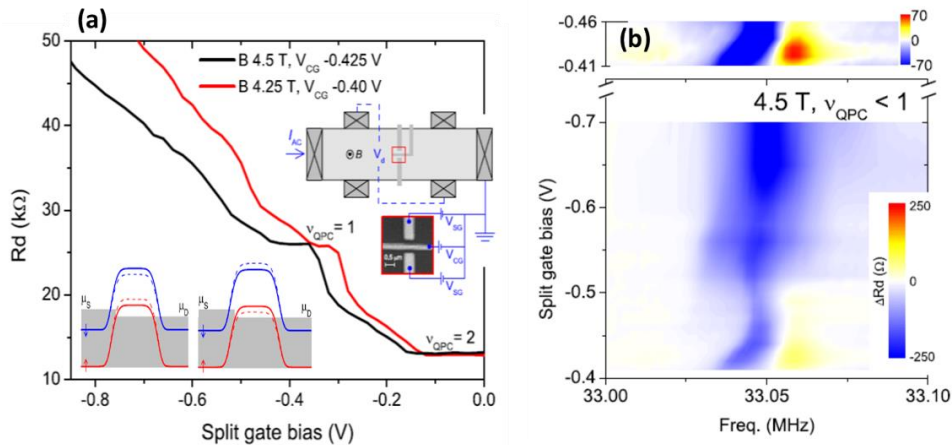


Fig. 1 (a) Differential diagonal resistance $R_d \equiv dV_d/dI_{AC}$ curve versus split gate bias voltage (V_{SG}) at a field of 4.5 (black) and 4.25 T (red). The left and right split gates are biased equally. The center gate voltage V_{CG} is fixed to -0.425 and -0.4 V, respectively. The upper right inset displays a schematic drawing of the device. The lower left inset shows schematic of potential barrier seen by up- and down-spin electrons without (solid line) and with (dashed line) the presence of positive (left) and negative (right) nuclear polarization. (b) The lower plot shows a 2D colormap of ^{75}As -RDNMR traces at the upper flank of the $\nu_{\text{QPC}} = 1$ plateau, $-0.70 < V_{SG} < -0.41$ V, measured at 4.5 T. The background resistance was subtracted from the spectrum. The upper plot shows the blown-up spectra in between $-0.46 < V_{SG} < -0.41$ V to accentuate the dispersive structure.

Representative publications:

1. M. H. Fauzi, A. Singha, M. F. Sahdan, M. Takahashi, K. Sato, K. Nagase, B. Muralidharan, and Y. Hirayama, “Resistively detected NMR line shapes in a quasi-one-dimensional electron system”, *Phys. Rev. B* **95** (RC), 241404-1-5 (2017).
2. A. Singha, M. H. Fauzi, Y. Hirayama, and B. Muralidharan, “Landauer-Buttiker approach for hyperfine mediated electronic transport in the integer quantum Hall regime”, *Phys. Rev. B* **95**, 115416-1-17 (2017).