Electric field mediated nuclear spin resonance
電界による核スピン共鳴

A nuclear spin resonance using a radio frequency (rf) electric field instead of a magnetic field, named nuclear electronic resonance (NER), is important to realize a high spatial resolution, especially combined with scanning nanoscale gate. We have demonstrated two types of NER.

One uses a domain structure with spin-polarized and -unpolarized electron states at $\nu = 2/3$ spin phase transition. In this NER, oscillating electric field induces a domain wall (DW) oscillation. Because the DW has a finite in-plane hyperfine component, nuclear magnetic resonance is induced when DW goes back and forth on the polarized nuclear spin site and nuclear spins effectively feel oscillating in-plane magnetic field with resonant frequency. The effective oscillating magnetic field produced by a domain wall oscillation has not sinusoidal but pulse-like shape; therefore, the NER signal appears not only around f_L but also around $f_L/2$, $f_L/3$ and $f_L/4$ differently from conventional NMR, where f_L is Larmor frequency (see Fig. 1).

Another type of NER is induced by electric quadrupolar interaction. This type of NER appears in the wider range of filling factors because we do not need a domain structure in this mechanism. For example, the NER signal appears for $\nu = 2$ (spin unpolarized state) as shown in Fig. 2. As a peculiar characteristics of this mechanism, the center line of the three quadrupolar split lines is missing and the signal appears at $2f_L$. Reflecting a screening effect of the electric field, the NER signal is enhanced in the regime where electron states are incompresible and R_{xx} is close to zero.

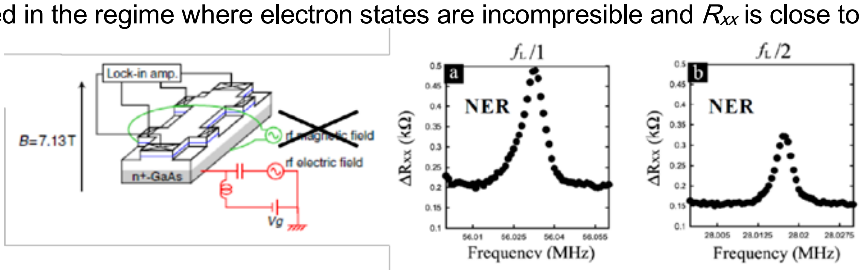

Fig. 1 In the NER experiment, a sinusoidal rf voltage is applied to the backgate through a bias-tee after dynamic nuclear spin polarization. (a) and (b) show the NER signal at f_L and $f_L/2$. The NER was carried out at $\nu = 2/3$ spin phase transition. The dynamic nuclear polarization and detection were also done by using $\nu = 2/3$ spin phase transition.

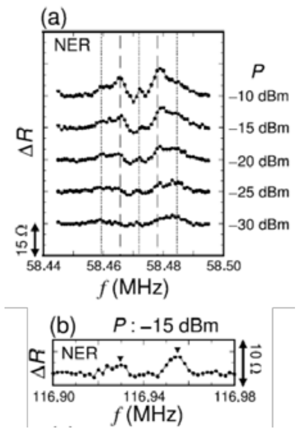

Fig. 2 (a) RF power (P) dependence of NER spectra taken near ^{75}As f_L. (b) NER spectra at $2f_L$ for P = −15 dBm. The NER signal was taken at $\nu = 2$. The dynamic nuclear polarization and detection were carrued out by using $\nu = 1$ quantum Hall breakdown.

Representative publications:

1. N. Kumada, T. Kamada, S. Miyashita, Y. Hirayama, and T. Fujisawa, Phys. Rev. Lett. 101 137602 (2008).
2. S. Watanabe, G. Igarashi, K. Hashimoto, N. Kumada, and Y. Hirayama, Physica E42, 999 (2010).
3. T. Tomimatsu, S. Shirai, K. Hashimoto, K. Sato, and Y. Hirayama, AIP Advanced 5, 087156-1-6 (2015).