Electron spin/ nuclear spin interactions at v=2/3 and dynamic nuclear polarization
v=2/3 における電子スピン/核スピンの相互作用と動的核スピン偏極

The interaction between electron and nuclear spins occurs in the fractional quantum Hall regime in case that two different spin states have degeneracy. The interaction has been evidenced by slow and gradual resistance enhancement observed at the certain condition. The involvement of the nuclear spin polarization in this resistance enhancement has been confirmed by nuclear magnetic resonance (NMR) experiments under a radio frequency irradiation and a long-term memory effect after a complete depletion of the 2DEG.

We also found that the spin phase transition (SPT) from spin-polarized to spin unpolarized v=2/3 gives us a very sensitive measure of the background nuclear polarization. The less than 1% nuclear polarization can be detected as a shift of the SPT peak. In the case of dynamic nuclear polarization by the current flow at v=2/3 SPT, nuclear polarization occurs spatially inhomogeneous manner, resulting in the SPT peak with an enhanced amplitude and a large half-width.

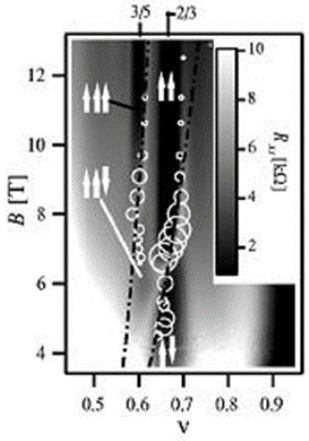

Fig.1 A grey-scale plot of R_{xx} at T = 80 mK as a function of magnetic field and electron filling factor. This plot was measured by scanning the electron density at the normal speed with a small current where dynamic nuclear polarization was negligible. The transition from spin-polarized to spin unpolarized v=2/3 is clear and we can see the degenerate states between them. When we measured R_{xx} using a slow scanning rate with a larger current, R_{xx} enhancements appear at the points of the white circles which size corresponds to the value of the R_{xx} enhancement. The R_{xx} enhancements clearly occur along the transition point between spin-polarized and unpolarized v=2/3 states by the dynamic nuclear spin polarization.

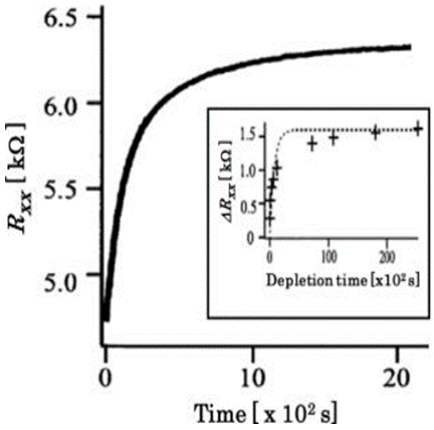

Fig.2 The gradual polarization of nuclear spins results in the slow R_{xx} increase as a function of time when we set the sample to the v=2/3 degenerate point. The gradual R_{xx} increase also means that we can measure the degree of nuclear spin polarization by using the R_{xx} value. To confirm this point further, we completely deplete 2DEG after nuclear spin polarization, in other words R_{xx} saturation, for certain time duration and measure how R_{xx} enhancement relax during this duration. The resistance relaxation, ΔR_{xx}, is approximately fit the exponential decay with a time constant of about 1000s. This result suggests unique and important feature of the interaction at the v =2/3 degenerate situation; approximately linear relation between R_{xx} value and total longitudinal magnetization, M_z, coming from nuclear spin polarization.

Representative publications:

1. K. Hashimoto, K. Muraki, T. Saku and Y. Hirayama, Phys. Rev. Lett. 88 176601 (2002)
2. K. Hashimoto, T. Saku and Y. Hirayama, Phys. Rev. B 69 153306 (2004)
3. M. H. Fauzi, S. Watanabe, and Y. Hirayama, J. Korean Phys. Soc. 60,1676 (2012).
4. M. H. Fauzi, S. Watanabe, and Y. Hirayama. App. Phys. Lett. 101, 162105 (2012).