Coexistence of two different mechanism of dynamic nuclear polarization in a transition region between integer quantum Hall states

R. Moriya [1]**, S. Umezawa** [1]**, S. Masubuchi** [1,2]**, Y. Hashimoto** [3]**, S. Katsumoto** [2,3]
and T. Machida [1,2]

[1] *Institute of Industrial Science, University of Tokyo, Tokyo 153-8505, Japan*
[2] *INQIE, University of Tokyo, Tokyo 153-8505, Japan*
[3] *The Institute for Solid State Physics, University of Tokyo, Chiba 277-8581, Japan*

In the quantum Hall states (QHS) of semiconductor two-dimensional electron gas, the hyperfine coupling between electron spin and nuclear spin has been utilized for polarizing and detecting the nuclear spins. Up to now, there have been two different processes to polarize nuclear spin; these are edge channel (EC) and bulk states (BS) of QHE. These two processes had been treated as independent method to control nuclear spins. However, since the nature of QHE, these two contributions can not be completely separated and could be coexisting depending on device geometry. We compared current induced dynamic nuclear polarization (DNP) in Hall bar device in longitudinal resistance (LR) and non-local resistance (NLR) configuration and revealed coexisting of EC and BS contribution.

The 2-dimensional electron gas (2DEG) in GaAs/AlGaAs is patterned into the Hall bar device. At the filling factor $\nu = 1.7$ of the QHS, the differential NRL R_{NL} and LR R_{xx} is measured under dc-current bias I_{SD} as shown in top panel of Fig. 1 and 2, respectively. We observed clear hysteresys between up and down sweep due to the polarization of nuclear spins. We determined the magnitude of DNP using pump-probe measurements where we pumped nuclear system with various I_{SD} for 200 second and probed the nuclear spin states at $I_{SD}=0$. The difference of R_{xx} at $I_{SD}=0$ before and after the pumping is derived as ΔR and obtained I_{SD} dependence of ΔR is plotted on the bottom panel of Fig. 1 and 2, respectively. The ΔR vs. I_{SD} can be viewed as a superposition of symmetric and asymmetric dependence on I_{SD}. We compared ΔR_{xx} and ΔR_{NL} with various contact configuration and external field direction. Results indicate that these asymmetric and symmetric contributions can be explained by the DNP induced by the EC and BS, respectively. And these two contributions coexist in Hall bar device.
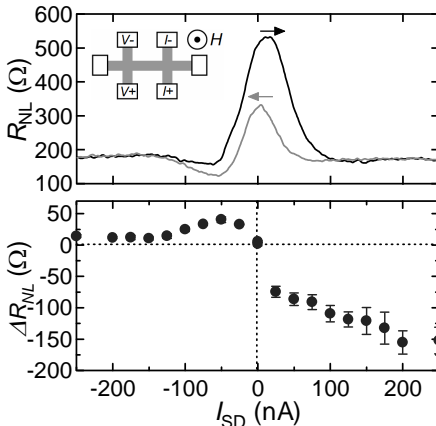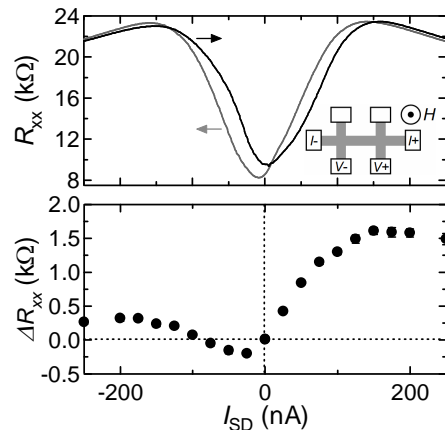

Fig. 1: I_{SD} dependence of R_{NL} and ΔR_{NL}.

Fig. 2: I_{SD} dependence of R_{xx} and ΔR_{xx}.