Fundamental physics of nuclear polarization clarified by using the simplest quantum Hall ferromagnet at ν = 2

ν = 2 量子ホール強磁性における核スピン偏極の基礎物性の解明

Extremely large g-factor of InSb allows us a crossing of down spin of ground Landau-level (LL) and up spin of the first LL at ν = 2 in a tilted magnetic field, resulting in a formation of the quantum Hall ferromagnet (QHF) at ν = 2 with spin domain structures. This is the simplest QHF providing us a chance to study the fundamental feature of dynamic nuclear polarization in QHF.

The theoretical study [1] demonstrates that the energy needed to flip one electron spin in a domain wall becomes comparable to the energy needed to flip the nuclear spin. The orthogonality of orbital electronic states is overcome by the many-electron character of the domain. The simulation demonstrates a flip-flop dynamic nuclear polarization keeping both energy and angular momentum conservation rules. It is also clarified that nuclear polarization occurs both sides, but not the center, of the domain wall.

Experimentally, we fabricated both Corbino and Hall-bar structures based on InSb 2D system. It is well-known that the Hall-bar has chiral edge channel running one-direction; however, there is no edge channel for Corbino disk. As shown in Fig. 1, RDNMR (resistively-detected NMR) signal is symmetric for current flow direction and disappears even at 2 K for the Corbino disk. On the other hand, RDNMR signal is asymmetric for current flow direction and remains up to 6 K for Hall-bar structure. This results clearly indicate an important role of the chiral edge channel for dynamic nuclear polarization. When we set the Hall-bar structure at 3 K, where bulk (edge) dominated nuclear polarization disappears (remains), we confirm clear reciprocity reflecting the characteristics of the chiral edge channel in the RDNMR signal [2].

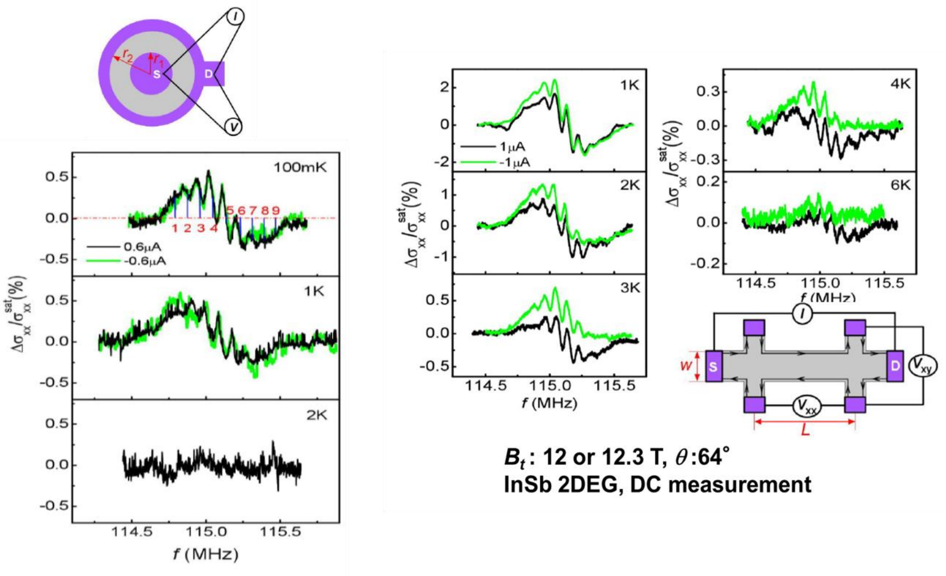

Fig.1 Side-by-side RDNMR experiments for both Corbino and Hall bar structures. The RDNMR experiments were carried out at the ν = 2 QHF at Landau level crossing point under a tilted magnetic field.

Representative publications:

1. M. Korkusinski, P. Hawrylak, H. W. Liu, and Y. Hirayama, Scientific Reports, 7, 43553 (2017).

2. K. Yang, K. Nagase, Y. Hirayama, T. D. Mishima, M. B. Santos, and H. Liu, Nature Comm. 8: 15084, doi: 10.1038/ncomms15084 (2017).