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Electron-nuclear spin coupling in nano-scale devices: self-sustaining resistance oscillations and controlled multiple quantum coherences

GO YUSA, NTT Basic Research Labs. NTT

Author: G Yusa, K. Muraki, K. Takashina (NTT BRL), K. Hashimoto (SORST-JST), and Y. Hirayama (NTT BRL and SORST-JST). We studied electron-nuclear spin coupled systems implemented in microscopic fractional quantum Hall devices and found that in a constant voltage measurement, the longitudinal resistance of such devices oscillates self-sustainingly with a period of about 200 sec. Such behavior suggests that the average nuclear spin polarization self-sustainingly oscillates between randomized and polarized states. When the resistance is measured in constant current mode, on the other hand, nuclear spins are polarized and reach a steady state in about 200 sec. Using the polarized state as an initial state, quantum mechanical superpositional states between four nuclear spin states (multiple quantum coherence) are controlled by pulsed radio frequency radiation resonant with nuclear spin transitions (nuclear magnetic resonance, NMR). Any arbitrary multiple quantum coherent state can be detected as change in the longitudinal resistance. Our findings represent a big step closer to practical all-electrical solid state nuclear spin quantum computing and quantum memory devices.