Possible Observation of Nuclear Superradiant Emission in Quantum Hall System

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The recent interest in possible observation of a cooperative and self-organized radiation from nuclear spin ensemble mediated by the hyperfine coupling with the electron spins, in analogy with Dicke superradiance in quantum optics, has been very stimulating [1-2]. Here we demonstrate that the nuclear spin could exhibit superradiant emission in the quantum Hall regime only when the electronic system produces low energy excitation modes. The nuclear spin dynamic is detected by domain walls formed at the fractional filling factor ν = 2/3 quantum Hall ferromagnet [3]. The interaction between the nuclear- and electron spin could be tuned by altering the electron density via a gate biasing voltage. We show that when the non-equilibrium nuclear spin polarization (dynamically formed by current flow at the ν = 2/3 spin phase transition) was exposed to the filling factor ν = 1.1 quantum Hall states where Skyrmion phases were formed, we observed a sudden intense burst of the hyperfine field on the electron spin (red line curve in Fig. 1b) before finally got relaxed rapidly within 50 seconds. The intense burst was determined by the shift of the transition curve to a lower filling factor and the width was very narrow compared to the filling factor ν = 1.

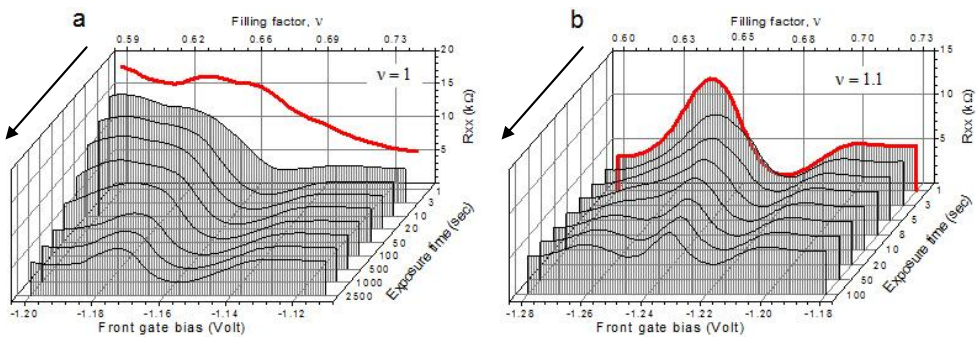

Figure 1: The evolution of spin phase transition curve of the filling factor ν = 2/3 after exposed to (a) the filling factor ν = 1 and (b) ν = 1.1 for a given interval of time. The nuclear spin dynamics was registered in the evolution of the transition curve towards its equilibrium (see the arrow direction). The first exposure transition curve is highlighted by the red line. We have to note that the bias condition changes slightly by thermal cycle.

We observed similar behavior with stronger intensity when the nuclear spin was exposed to a canted antiferromagnetic of the total filling factor ν = 2 bilayer quantum Hall state.

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