Origin of the anomalous spin resonance in a strongly correlated electron system

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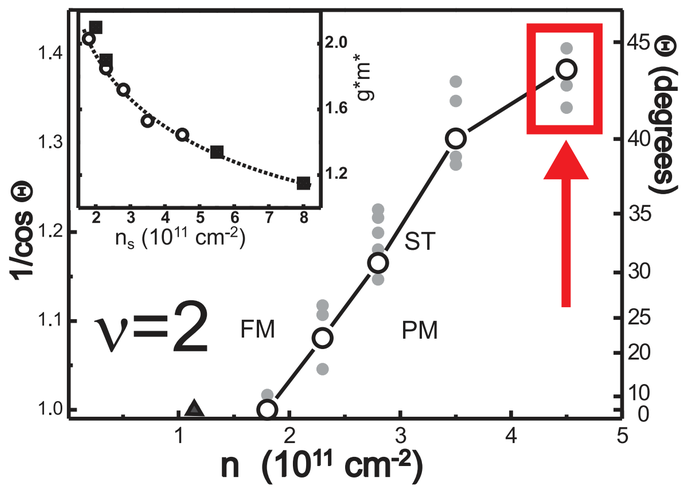
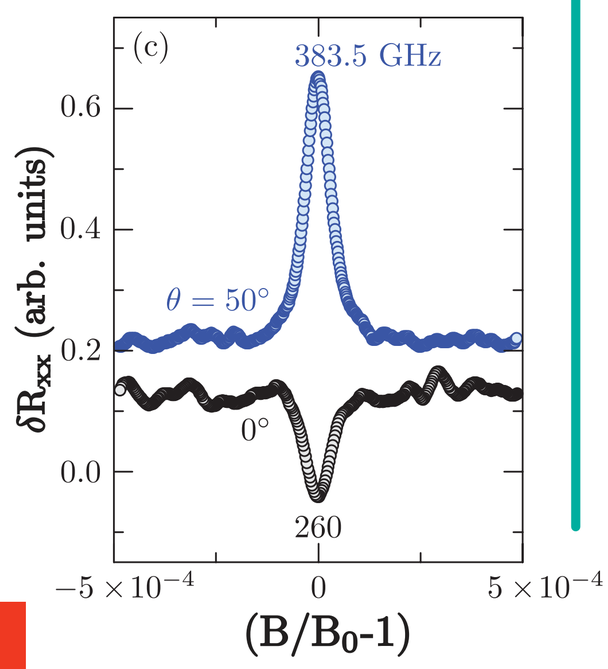
Intro

Phase diagram of Paramagnetic (PM) - Ferromagnetic (FM) transition at v = 2

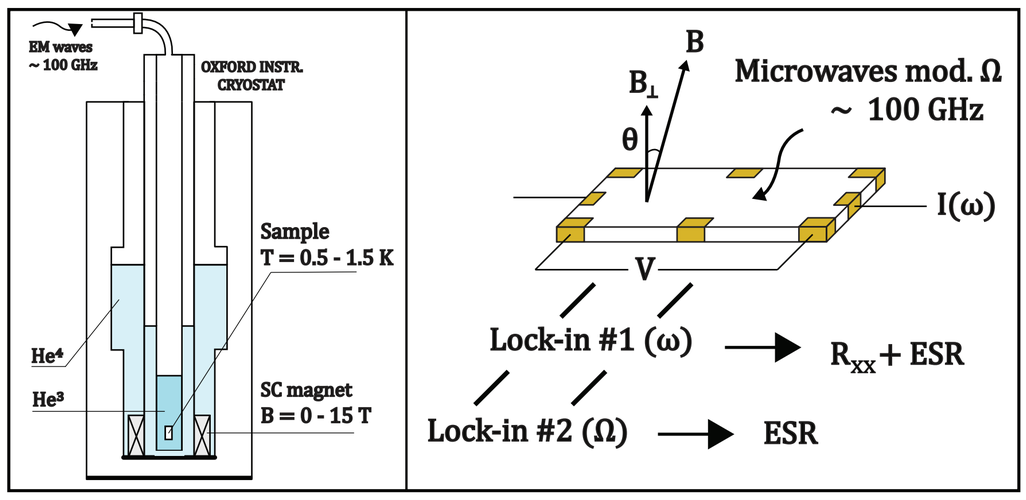
Van'Kov, A. B., B. D. Kaysin, and I. V. Kukushkin. Physical Review B 96.23 (2017): 235401.



Typical ESR peaks: normal (blue) and anomalous (black)



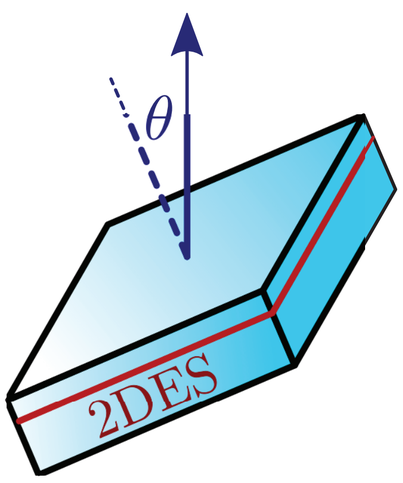
Sample and experimental technique



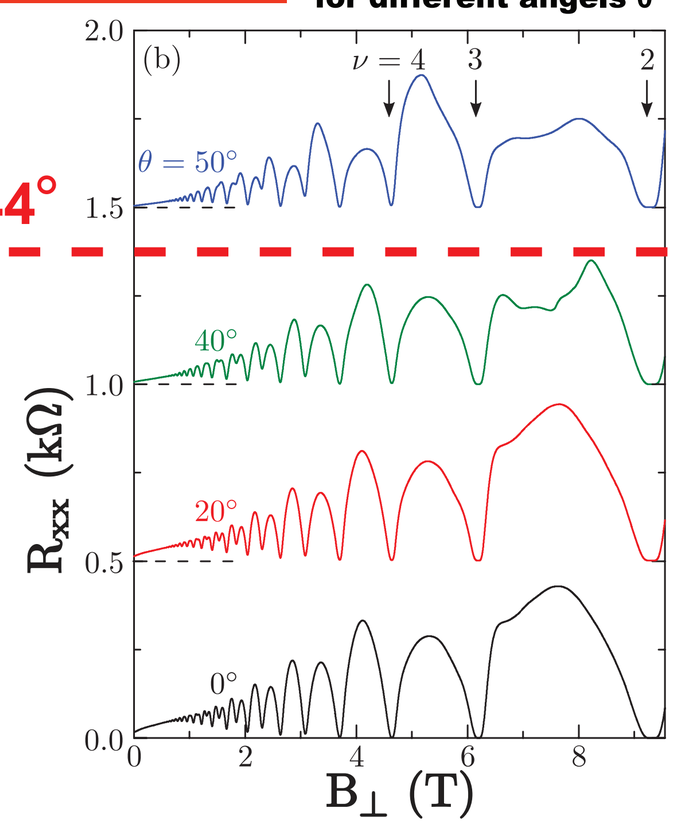
- Single lock-in and double lock-in amplifier techniques
- ZnO/MgZnO heterojunction; was grown by MBE
- Density $n_s = 4.5 \cdot 10^{11}$ cm^{-2}, mobility $\mu = 250 \cdot 10^3$ cm^2/Vs
- The ESR was detected by monitoring R_{xx}
- Angle between the normal to the 2DES and the external magnetic field θ = 0°, 20°, 40°and 50°

Results

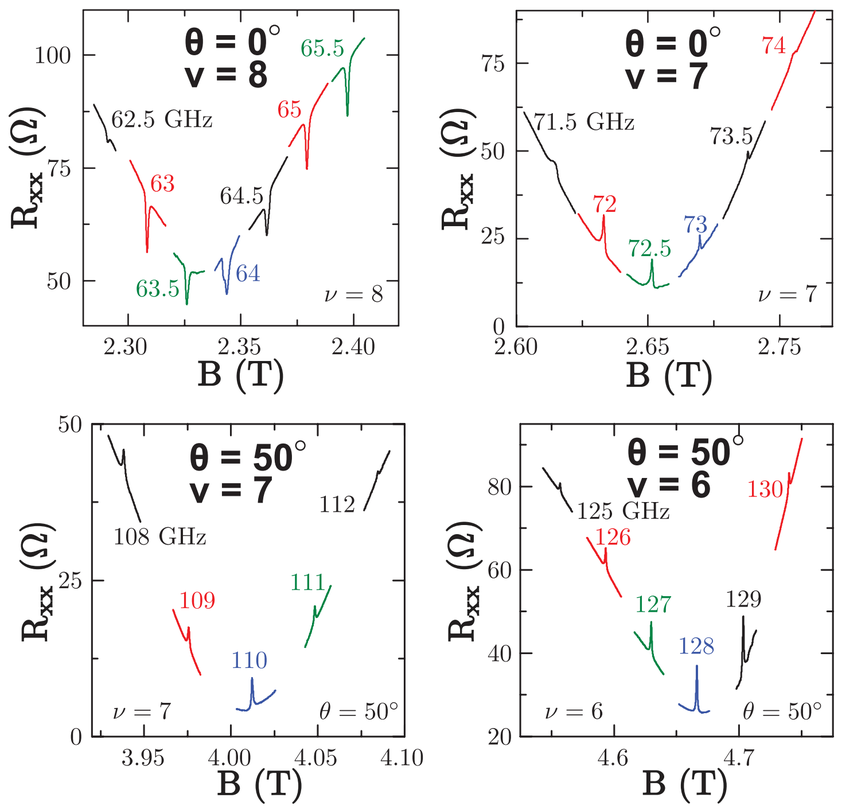
Ferromagnetic phase transition θ = 44°



Quantum Hall Effect for different angels θ



ESR lines measured using a single lock-in amplifier



ESR in PM phase (before phase transition):
- Even fillings: anomalous
- Odd fillings: normal

ESR in FM phase (after phase transition):
- Even fillings: normal
- Odd fillings: normal

Origin of the anomalous ESR

Temperature dependence of the ESR amplitude at v = 4. Circles — ESR amplitude, solid lines — $\delta R_{xx}/\delta T$ (heat sensitive 2DES)

- δRxx/δT were derived from the independently measured temperature dependencies of sample resistance
- Negative amplitude values mark an anomalous ESR, in this case values of δRxx/δT were multiplied by −1
- ESR amplitude was normalized to match the δRxx/δT dependence
- 2DES behaves during an anomalous spin resonance as if it cools due to intense absorption of electromagnetic radiation
- During the transition to the ferromagnetic state on even QHE filling factors, the ESR returned to its usual “heating” behavior.
- Approaching phase transition suppresses ESR signal at even fillings

(a) Schematic representation of the cyclotron spin-flip excitations (CSFE)

(b) The possible spin-flip transitions between the partially empty LL_0 and partially occupied LL_1 in the presence of the lowest \CSFE mode.

(c) The schematic representation of the two lowest branches CSFE dispersion.

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