RESISTIVELY DETECTED NMR AT UNITY FILLING FACTOR: A TILTED FIELD STUDY

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Introduction

Resistively detected NMR (RDNMR) is emerging as a powerful new technique to study correlated 2D electron systems [1-3]. In GaAs quantum wells at high field and mK temperatures, the equilibrium nuclear hyperfine field becomes strong enough to produce an observable effect on the longitudinal resistance. In all of the prior RDNMR studies, a “dispersion-like” resistance change is observed just below unity filling factor. At present there is no model to explain the observed suppression and enhancement of the RDNMR response on the low and high field sides of the resonance line. It has been suggested that the anomalous line shape and dramatic RDNMR enhancement near \( \nu = 1 \) involves Skyrmions [1].

Experimental

RDNMR experiments were carried out in an Oxford 18/20T superconducting magnet fitted with a top-loading dilution refrigerator (SCM-1), located in the NHMFL milliKelvin facility. The 30nm wide GaAs quantum well was grown by MBE with \( \text{Al}_{0.3}\text{Ga}_{0.7}\text{As} \) barriers. Remote silicon \( \delta \)-doping yielded a density and mobility of about \( 10^{11} \) cm\(^{-2} \) and \( 10^{11} \) cm\(^2\) V\(^{-1}\) s\(^{-1} \), respectively. The sample was patterned into a Hall bar and mounted onto a rotation stage. The resistance was measured at \( \nu = 1 \) using a Signal Recovery™ Model 7280 lockin. Proper grounding, shielding and power isolation, along with careful optimization of the RF power and current to avoid heating, allowed detection of RDNMR with good signal-to-noise while maintaining 30-40mK temperatures. RDNMR spectra were acquired at 5 different angles. The applied field was set such that \( B_z = B \cos \theta \) and the filling factor remained approximately constant.

Results and Discussion

The key parameter governing the stability of the Skyrmion phase is the ratio of the Zeeman to Coulomb energies, \( \eta \) [4]. According to theory, Skyrmions should disappear at \( \eta \geq 0.22 \). By tilting the field we were able to cover the range \( \eta = 0.13 \rightarrow 0.22 \) (5.1 \( \rightarrow \) 15.6T). The RDNMR line shape was fit to a superposition of two Gaussian functions with negative and positive amplitudes. The negative peak broadens and appears to interfere destructively with the positive peak with increasing field, but the antiphase line shape persisted at fields of up to 15.6 T where Skyrmions should not exist.

Conclusions

The splitting between the two components, as obtained from line-shape fitting, increases linearly with the field, as shown in the figure. Since the Knight shift is proportional to the electron spin polarization, the plot indicates an approximately linear increase in the spin polarization with B over the \( \eta = 0.13 \rightarrow 0.22 \) range.

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References