IMPURITY MEDIATED SPLITTING OF CR IN TWO-DIMENSIONAL ELECTRON SYSTEMS

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Introduction

Splitting of the cyclotron resonance (CR) line of two-dimensional (2D) electrons has been reported in AlGaN/GaN [1], AlGaAs/GaAs [2], and Si-MOSFET [3] systems. The splitting, characterized by an anti-level crossing, appears considerably below the energies of all the well-known excitations of the solid such as optical phonons. No convincing explanation has been provided since the first observation of this behavior two decades ago. The only model proposed so far involves the 2D magnetoroton [1] and that has been received with skepticism by theorists who have closely examined the dispersion curve of the 2D carriers [4-6]. Currently, the CR splitting exists as an enigma in the much studied field of excitations in solids.

In its simplest form, the splitting occurs due to the interaction of a second mode with the CR mode of 2D electrons. Although the identity of the second mode remains elusive, we can use experimental tools to highlight the salient features of this unknown excitation. In particular, we wanted to investigate whether momentum k-vector breakdown is critical for coupling the two modes. Violation of k conservation assisting the CR splitting would strongly suggest the second excitation resides away from k=0.

Experimental

A series of AlGaAs/GaAs quantum wells (QW) were designed in which disorder was controlled by systematic doping of the channel with carbon as an impurity. The structures consist of 300 Å wide GaAs channel, flanked on both sides by $Al_{0.33}Ga_{0.67}As$ barriers that are doped with Si about 800A away from the interface. At low temperatures and after illumination with a red LED, the structures show typical 2D density n_{2D} of ~$2x10^{11}$ cm^{-2} while the carrier mobility range between $40x10^3$ and $2x10^6$ cm^2/Vsec. The 2D mobility, μ, varies roughly inversely with the impurity density. We investigated the dependence of the size of the CR splitting, ΔE, on the scattering rates $1/\tau_\mu$ and $1/\tau_q$ associated with the mobility and quantum lifetimes, τ_μ and τ_q, of the 2DES.

Results and Discussion

The CR and the *in-situ* transport measurements show indisputably that ΔE is enhanced by sample disorder. In other words, interaction between the two modes relies critically on the breakdown of k conservation thus suggesting the enigmatic mode is located at a $k \neq 0$. This is a very important finding as it rules out a number of candidates that could otherwise be considered to play the role of the mysterious excitation. Interestingly, the new results bring back the magnetoroton as a possible candidate that may participate in the line splitting.

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