Ballistic Phonon Interactions with the Fractional Quantum Hall Liquid

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The excitations of quantum liquids give important insights as to their nature. The low lying excitations of the fractional quantum Hall liquids are believed to have a finite energy gap at low wavevectors and a minimum of energy, known as the magnetoroton (MR) minimum at a finite wavevector. Girvin, MacDonald and Platzman [1] derived the form of the excitation curve for simple fractions such as Landau level filling factors, ν = 1/3 and 1/5. Jain and co-workers [2] have derived expressions for ν = 2/5 using the composite fermion picture. Ballistic phonons have convenient energy and wavevectors that allow interactions to take place between the ballistic phonons and the excitations at finite in-plane wavevectors close to the magnetoroton minimum.

In this paper we describe the first ballistic phonon experiments to probe the FQHE excitations over known ranges of finite wavevectors. This builds on earlier work in which we determined the temperature dependence of the heat capacity of a two-dimensional electron system (2DES) [3]. The experiments were carried out on a 2mm thick GaAs wafer with fixed heaters on the side of the wafer opposite to the 2DES. The resistance of the 2DES was measured with a time resolution of 30nS at ν=1/3. This allowed the identification of both TA and LA phonon interactions. The results on a 2DES with a mobility of 1×10^{6} $cm^{2}V^{-1}s^{-1}$ and density of 1.4×10^{11} cm^{-2} are in good agreement with theoretical prediction at ν=2/5 whilst there is approximately a factor of 2 difference at ν=1/3. The results are compared to those of Raman scattering [4] and possible reasons for the apparent discrepancy are discussed.

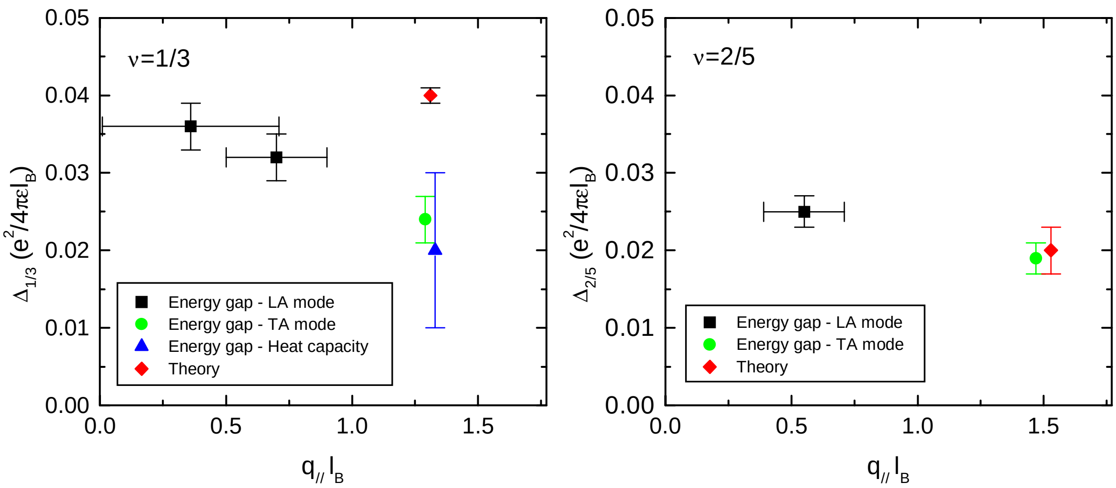

Figure 1: Experimentally determined dispersion of FQH excitations at ν=1/3 and 2/5 compared to theory. The experimental results are determined by the temperature dependence of the heat capacity and relative absorption of energy from ballistic phonons as the energy distribution of the phonons is altered. Theory results are from refs 1 and 2 respectively.

1. SM Girvin, AH Macdonald, PM Platzman, *Phys. Rev*. B**33** (1986) 2481.
2. VW Scarola, K Park and JK Jain, *Phys. Rev*. B**61** (2000) 13064.
3. U Zeitler, AM Devitt, JE Digby, et al, *Phys. Rev. Lett*. **82** (1999) 5333.
4. M Kang, A Pinczuk, BS Dennis, et al, *Phys. Rev. Lett*. **84** (2000) 546.