The acoustoelectric response of double layer 2D hole systems

R.B. Dunford, M.R. Gates, C.J. Mellor, V.W. Rampton, J.S. Chauhan, J.R. Middleton and M.Henini

School of Physics and Astronomy, University of Nottingham
University Park, Nottingham NG7 2RD, UK.

Surface acoustic wave (SAW) techniques have played an important role in establishing the composite fermion theory of the quantum Hall effect in 2D electron systems [1]. The action of the SAW electric field perturbs the density of mobile carriers and generates an acoustoelectric drag current within the 2D system. Previously, we found that this acoustoelectric effect is extremely sensitive to the composite fermion behaviour close to filling factor $\nu=1/2$ in single layer 2D electron and hole systems [2,3]. In this paper we report the first measurements of the acoustoelectric effect in double layer AlGaAs/GaAs 2D hole systems (2DHS).

The double layer 2D hole system consists of two GaAs quantum wells (thickness 10nm) separated by an AlAs barrier (thickness 10nm). The height of the barrier and the high effective mass of the holes results in very low tunneling between the wells, with a predicted energy splitting between the symmetric and anti-symmetric states of ~80mK [4]. Conventional magnetotransport measurements have shown that the odd integer $\nu=3,5,7\ldots$ quantum Hall effect states are absent due to this weak tunneling [4]. At a total filling factor of $\nu=1$ (i.e. $\nu=1/2$ in each well) magnetotransport [4,5] and magnetothermopower [6] measurements have provided evidence for a finite temperature phase transition. Insulating behaviour has been observed for $\nu<1$, which provides strong evidence for the existence of a double layer correlated Wigner solid state [4,5].

Previously, we studied the temperature and frequency dependence of the SAW velocity shift and observed maxima in SAW velocity shift at $\nu=1$, 2, 4, 6 and 8 [7]. A hysteretic feature at $\nu=2$ was observed in both conventional magnetotransport and SAW velocity shift measurements, which was attributed to slight parallel conduction at the lower interface.

The longitudinal (E_x) and transverse acoustoelectric field (E_y) have been measured for 0.6-1.2GHz over the temperature range of 0.34-4.2K. At integer filling factors $\nu=1,2,4,6$ and 8, where the longitudinal conductivity goes through a minimum, E_x exhibits a double peak structure. The asymmetry of these peaks suggests that the sample is inhomogeneous. The measured E_x and E_y values agree qualitatively with the values predicted by conventional magnetotransport measurements. E_x and E_y obey a tensor relation ($E_y = \alpha B\, dE_x/dB$, where α is a sample dependent constant). The $\nu<1$ insulating phase has also been investigated.

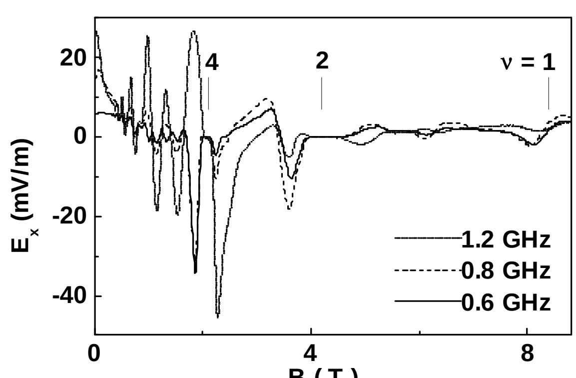

Fig. 1. Frequency dependence of the transverse acoustoelectric field at 0.3K for a double layer sample with total $n=2\times10^{11}cm^{-2}$ and $\mu=1.5\times10^5\ cm^2/Vs$.

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