Nonlinear growth in the microwave reflection signal from the GaAs/AlGaAs 2DES in the regime of radiation-induced magnetoresistance oscillations

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Microwave induced magnetoresistance oscillations (MIMOs) in the high mobility two dimensional electron system (2DES)[1, 2] have now been studied for more than a decade, using a variety of experimental methods. And, a number of theories including the displacement model, the inelastic model, the radiation-driven electron orbit model, and the non parabolicity model have been proposed to explain the observed phenomena. In order to better understand the physical contributions, we have studied microwave reflection from the high mobility 2DES and the correlation between microwave reflection and the observed MIMOs in transport .

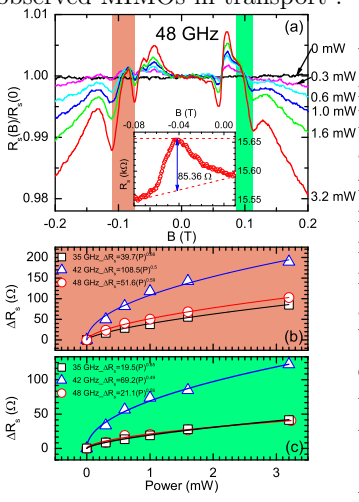

Figure 1: (a)Normalized R_s as a function of B for different microwave powers at 48 GHz and 1.5 K. The inset shows the determination of the amplitude of the R_s oscillation. (b) Amplitude of R_s oscillation on left dark region in (a) as a function of microwave power at different frequencies. (c) Amplitude of R_s oscillation on right dark region in (a) as a function of microwave power.

Microwave reflection was measured by a resistive bolometric sensor that lies right above the high mobility GaAs/AlGaAs heterostructure specimen. At liquid helium temperature both the diagonal resistance (R_{xx}) and bolometric resistance (R_s) that indicates microwave reflection were measured by four terminal lock-in technique in a ramped perpendicular magnetic field. With microwave illumination, R_{xx} exhibit MIMOs and, remarkably, R_s also exhibits oscillations in the same regime as MIMOs. Experiment indicates that the amplitude of both MIMOs and R_s oscillations increases with the microwave power, P. To highlight the oscillatory effects, the R_s with different microwave powers were normalized to zero magnetic field as in Figure 1(a). Figure 1(b) and (c) show that, as microwave power increases from 0 mW to 3.2 mW, the amplitude of the R_s oscillations increases nonlinearly with P. A fit of the growth of the R_s amplitude with P indicates a power law relation between the R_s amplitude and microwave power. From Fig. 1(b) and 1(c) it is apparent that the non-linear growth of the R_s amplitude is similar to observed growth of the MIMOs amplitude with P.[3] Both R_s oscillations and MIMOs amplitude appear to follow a power law as $A = A_0(P)^\alpha$, where A is the amplitude, A_0 is a constant, P is incident microwave power and α is the power law exponent. For both R_s oscillations and MIMOs, α is approximately 0.5. The results suggest that the remote sensor is able to sense the photo-excited state of the 2DES.

[1] R. G. Mani et al., Nature. **420**, 646 (2002).
[2] M. A. Zudov et al., Phys. Rev. Lett. 90, 046807 (2003).
[3] R. G. Mani et al., Phys. Rev. B **81**, 125320 (2010).