Linear polarization rotation study of the microwave radiation-induced magnetoresistance oscillations in the GaAs/AlGaAs system

A. N. Ramanayaka [1], Tianyu Ye [1], H-C. Liu [1], R. G. Mani [1], and W. Wegscheider [2]

[1] *Dept. of Physics & Astronomy, Georgia State University, Atlanta, GA 30303*
[2] *ETH-Zurich, 8093 Zurich, Switzerland*

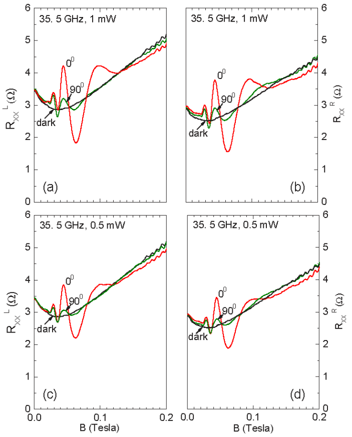

Fig. 1) Microwave-induced magneto resistance oscillations in R_{xx} at 1.5K are shown at f = 35.5 GHz for P = 1 mW in panels (a) and (b), and for P = 0.5 mW in panels (c) and (d). The R_{xx} measured on the left (right) side of the Hall bar is shown as R_{xx}^{L} (R_{xx}^{R}). Each panel shows a dark curve (black), a curve (red) obtained at $\theta = 0°$, and a trace (green) obtained at $\theta = 90°$.

Microwave-induced zero-resistance states appear when the associated B^{-1}-periodic magnetoresistance oscillations grow in amplitude and become comparable to the dark resistance of the 2DES.[1] Existing theories, such as the displacement model, the inelastic model, the nonparabolicity model, and radiation-driven electron orbit model, have made differing predictions regarding the influence of the microwave polarization in the microwave radiation-induced oscillatory transport. For example, the inelastic model suggests polarization insensitivity.[see ref. 2 and refs. therein] We have investigated the effect of rotating, in-situ, the polarization of linearly polarized microwaves relative to long-axis of Hall bars. The results indicate that the amplitude of the magneto-resistance oscillations is remarkably responsive to the relative orientation between the linearly polarized microwave electric field and the current-axis in the specimen. [2]

For this experiment, we invented a new setup where circular symmetry allows the rotation of the antenna and the linear polarization with respect to the stationary sample. Figure 1 exhibits the R_{xx} vs. B at f = 35.5 GHz with a high mobility GaAs/AlGaAs Hall bar sample in the setup. Fig. 1(a) and (b) show the results obtained at a source-power P = 1 mW, while Fig. 1(c) and (d) show the same obtained at P = 0.5 mW. Here, a comparison of the red ($\theta = 0^0$) and green ($\theta = 90^0$) traces within any single panel of Fig. 2 indicates that the amplitude of the radiation-induced magneto-resistance oscillations is reduced at $\theta = 90^0$.[2]

We have also examined the detailed polarization angle, θ, dependence of the magnetoresistance oscillations at the oscillatory extrema by fixing the magnetic field and rotating θ at particular frequencies.[2] We found that the angular response of the extrema can be fit with $R_{xx}(\theta) = A \pm C \cos^2(\theta - \theta_0)$, where the + sign corresponds to the maxima and the – sign corresponds to the minima. Here, the fit extracted θ_0 differ substantially from zero, well beyond experimental uncertainty. Indeed, the data suggest that the θ_0 depends upon the extremum in question or B, and sgn(B). Such a large difference in θ_0 due to B-reversal was wholly unexpected.[2]

[1] R. G. Mani et al., Nature 420, 646 (2002); M. A. Zudov et al., Phys. Rev. Lett. 90, 046807 (2003).

[2] R. G. Mani, A. N. Ramanayaka, and W. Wegscheider, Phys. Rev. B 84, 085308 (2011); A. N. Ramanayaka, R. G. Mani, J. Inarrea, and W. Wegscheider, Phys. Rev. B. 85, 205315 (2012).