Microwave irradiated two-dimensional electron gas in magnetic fields

M. Potemski*
Grenoble High Magnetic Field Laboratory, MPI/FKF and CNRS/LCMI
BP 166, 38042 Grenoble, Cedex 9, France

The physics that results from subjecting a high mobility two-dimensional electron gas (2DEG) to magnetic fields continues to provide new and fascinating phenomena. Among them is the recently reported observation [1] of oscillations in the longitudinal magneto-resistance (ρ_{xx}) of a 2DEG irradiated by microwaves with frequencies in the range of $\omega = 5 - 100$ GHz. These oscillations are observed in high mobility samples, at moderately low temperatures $T \sim 1$ K, and relatively low magnetic fields ($\hbar\omega_C \leq \hbar\omega$). The periodicity of these oscillations is determined by the ratio of $\hbar\omega/\hbar\omega_C$, in contrast to the well established case of Shubnikov-de Haas (SdH) oscillations which are determined by the ratio $E_F/\hbar\omega_C$. Here, as usual $\hbar\omega_C = \hbar eB/m^*$ is the electron cyclotron energy, with m^* standing for the electron effective mass and E_F denotes the Fermi energy. Under strong microwave irradiation and with samples that have a sufficiently high mobility, the minima of ρ_{xx} become transformed into "zero resistance states" [2]. This observation has stimulated a flow of new theoretical papers [3], revisiting of previously reported concepts [4], as well as further experimental work [5]

The experimental results concerning microwave induced resistance oscillations (MIROs) will be reviewed and discussed in terms of the existing theoretical models. New experimental work, which address the unresolved issues in this field, will also be presented. In particular, it will be shown that MIROs are not only present in the longitudinal resistance but can also be observed in the transverse component of the magneto-resistance. Form factors which describe the effects of damping of MIROs at low fields and high temperatures will be analysed in reference to simultaneous measurements of SdH oscillations. Experiments performed in the limit of high microwave frequencies (up to 2THz) will be discussed, as well as attempts to search for signatures of cyclotron resonance harmonics in absorption-type and microwave-modulated luminescence measurements.

*Work performed in collaboration with
S.A. Studenikin, P.T. Coleridge, A.S. Sachrajda, Z.R. Wasilewski, M. Hilke, L.N. Pfeifer, K.W. West, S. Moreau, M. Byszewski, M.L. Sadowski, and D.K. Maude.

1. M.A. Zudov *et al*., Phys. Rev. B **64**, 201311 (2001).
2. R.G. Mani *et al*., Nature (London) **420**, 646 (2002) ; M.A. Zudov *et al*., Phys. Rev. Lett. **90**, 46807 (2003)
3. see, for example, A.C. Durst *et al*., Phys. Rev. Lett. **91**, 86803 (2003), A.V. Andreev *et al*., Phys. Rev. Lett. **91**, 56803 (2003); I.A. Dmitriev *et al*., Phys. Rev. Lett. **91,** 212303 (2003).
4. V.I. Ryzhii, Sov. Phys. Solid State **11**, 2078 (1970).
5. S.I. Dorozhkin, JETP Lett. **77**, 577 (2003) ; S. Studenikin *et at.,*.Solid State Commun.**129**, 341 (2004).