Photo-induced Faraday rotation in n-GaAs microcavities

D. Scalbert[1], R. Giri[1], S. Cronenberger[1], M. Vladimirova[1], K.V. Kavokin[1,2], M. Glazov[2], A. Lemaître[3], and J. Bloch[3]

[1] *Laboratoire Charles Coulomb, CNRS-Université Montpellier 2, France*
[2] *A.F. Ioffe Physico-Technical Institute, St-Petersburg, Russia*
[3] *Laboratoire de Photonique et Nanostructures, CNRS, Marcoussis, France*

It is well established that nuclear spins in semiconductors can be efficiently manipulated and detected optically. This is made possible by hyperfine interaction between conduction band electrons and nuclei. However, the presence of the photo-created carriers required until now for such experiments does affect the behavior of the nuclear spins. Here we demonstrate that nuclear spin polarization can be detected in the "darkness", that is long after photo-induced spin polarization has been lost. The idea of such experiment has been proposed in 80s [1]: nuclear spins are cooled well below lattice temperature by circularly polarized pumping (dynamic nuclear polarization technique), then the pump beam is switched off and the resulting spin polarization in the longitudinal magnetic field is monitored via Faraday rotation of the probe beam. This rotation results mainly from the conduction band splitting in the Overhauser field generated by spin polarized nuclei.

For practical realization of such measurements a high-Q microcavity was designed and grown in order to provide sufficient interaction length between the light and n-GaAs active layer. The n-doping close to metal to insulator transition ($n_e \approx 2\times10^{16}\ cm^{-3}$) ensures stronger polarization of the electron gas via optical orientation and thus in this system we also achieve up to 19° Faraday rotation due to electron spin polarization in the absence of the external magnetic field. On the other hand, this allows investigating nuclear spin dynamics in the presence of degenerate electron gas. Such configuration is potentially interesting since slow relaxation of nuclei is expected, but only few experimental data are available.

Our first results allowed for the quantitative determination of the Faraday rotation efficiency due to nuclear and electron magnetization and comparison with the model. On the other hand the dynamics of nuclear spins in n-GaAs appeared to be quite complex and unexpected.

(i) We observed that spin relaxation of nuclei in the darkness depends strongly on the magnetic field. Even at strong field (B~200 G) nuclear spin relaxation is faster than predicted by Korringa mechanism (~10 minutes), and at low field it appears to be much faster (1 min). (ii) Faraday rotation signal resulting from nuclear magnetization has two components. In addition to conventional slowly decaying signal, we observe a rapidly decaying rotation (10 s) with the opposite sign. Tentative explanation in terms of polarization of nuclei by holes localized on acceptor sites is proposed.

[1] E.S. Artemova and I.A. Merkulov, Sov. Phys. Solid State **27**, 941 (1985)