Measurements of T_{1e} in *n*-GaAs

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Experimental measurements of spin relaxation times are at the heart of interest for basic characterization of the dynamics of any spin system. Even in the well-known n-doped GaAs, the accurate determination of the spin relaxation time for the nuclei directly coupled to the donor - bound electrons was hindered due to the lack of an appropriate technique. Here, a method based on measuring the Hanle effect (depolarization of the photoluminescence by magnetic field) with millisecond time resolution [1,2] is used to study nuclear spin dynamics of nuclei situated in the vicinity of donors. We measure both the rise time of the nuclear spin polarization under pumping and its decay in the dark [3].

There are two time scales characterizing the nuclear spin dynamics in n-type GaAs: the short time of the hyperfine relaxation under the donor orbit (10^{-1} s) and the long time of spin diffusion far from donor centers (10^2 s). Both times are observed in our experiments. To evaluate the long-time spin relaxation, the nuclear spin system is pumped by circularly polarized light during 5 minutes in the longitudinal magnetic fields B_z = + 2mT. The following dynamics is originated after demagnetization in a small transverse field $B_x \approx 0.50.\pm0.05$ mT. It is characterized by a monoexponential decay of the Overhauser field with characteristic times T_{bulk}=90s and T_{bulk}=120s depending on the initial spin temperature sign. To demonstrate the presence of a fast nuclear spin pumping dynamics, we used a time protocol, where the pumping helicity is alternated each 500ms. The Hanle curves are measured within the 50~ms long detection gate gradually scanning over the modulation period. The Hanle curves are measured by scanning B_x field at fixed B_z = +2mT for various delay times Δt, as shown in Fig.1(a). From the analysis of experimental data, we obtain the value of effective nuclear field for each Hanle curve. Fitting dependence on Fig.1(b) gives a characteristic time T_{repump} = 425 ± 50ms.

In summary, two time scales of nuclear build-up and relaxation have been observed. One of them is a slow relaxation of bulk nuclei via spin diffusion from /or to donor centers. The measured time T_{bulk} =10^2 s is typical for the dielectric phase of *n*-GaAs. At the same time, a faster dynamics is observed, characterized by time T_{repump} = 425ms, which is attributed to the spin dynamics of nuclei inside the donor orbit.

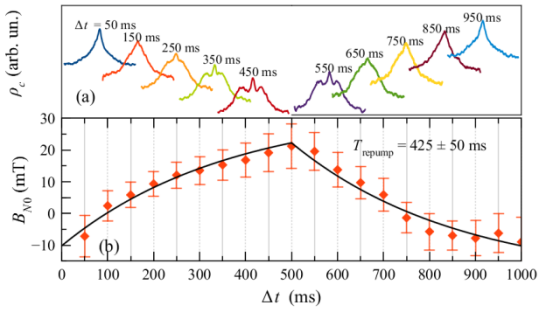

Figure 1: (a) Hanle curves corresponding to the different gated detection in the time intervals. (b) Magnitude of the Overhauser field, B_{N0}, extracted from fitting the Hanle curves (symbols). Solid line is fitting.

References

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