Dynamic nuclear polarisation in GaAs/AlGaAs dots
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In this note, nuclear spin effects are studied in individual quantum dots pumped by circularly polarised excitation using an attoCFM I. Spin is transferred from optically generated electrons to the system of about 10.000 nuclear spins. The effect of nuclear spin polarisation on the electron spin can be described in terms of effective nuclear magnetic field (also referred to as Overhauser field). Optically generated Overhauser fields of the order of several Tesla are observed localised in a single quantum dot of 4 x 20 x 20 nm^3 in size (see figure 1).
Optically pumped nuclear polarisation has striking dynamic properties: for example in electron-charged InP/GaInP dots a high nuclear spin polarisation can be excited in a few ms, but survives after the light has been switched off for hundreds of seconds with some background polarisation observed after two hours.
Obviously, such measurements require exceptional set-up stability, since for each point in the decay curve (see figure 3) a single dot is excited and probed by an individual pump-probe pulse pair. To remove uncertainty introduced by the noise in the CCD detectors, the whole decay curve has to be measured several times in the same conditions. Hence, the experiment is run for up to 25 hours, during which time the sample drift is considerably less than the 400 nm aperture size in the metallic shadow film through which the dot is optically excited.
Additional measurements of nuclear spin effects in charged and neutral quantum dots have been carried out with the setup (see [2]).

The following advantages of the attoCFM I setup seem to be crucial for these experiments:
- free space access conserving polarisation of light;
- exceptional mechanical stability both at zero and high magnetic fields;
- very small sample drift when scanning the field (<< 400 nm up to 2.5 T).

The data has been generously provided by E. Chekhovich, M. Makhonin, and A. Tartakovskii from the Department of Physics, Sheffield University, UK.

[1] D. Gammon, *et al.*, Science **277**, 85 (1997)
[2] E. Chekhovich, *et al.*, submitted

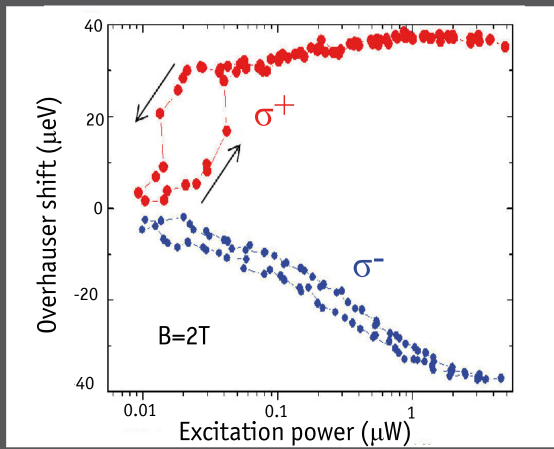

Fig. 1: Nuclear spin polarisation in interface GaAs quantum dots. Very detailed power scans (1-2 hour scans) have been taken.

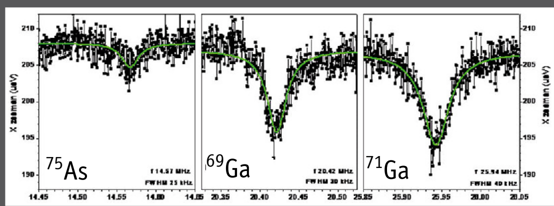

Fig. 2: Optically detected NMR (ODNMR) spectra. This allows insight into the local material composition on the nano-scale. This has been demonstrated only once before in 1997 by Gammon and co-workers [1]. The quality of data is considerably higher thanks to the stability of the attoCFM I.

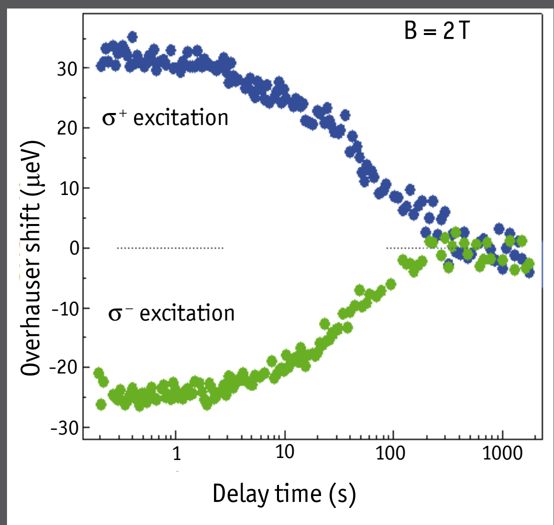

Fig. 3: Nuclear polarisation decay measurements in GaAs dots. A very smooth decay curve is observed, with the nuclear spin decay most probably caused by the nuclear spin diffusion in the semiconductor matrix surrounding the dot (see A.E. Nikolaenko, et al., PRB 79 1(R), 2009).