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Mechanisms of relaxation and spin decoherence in nanomagnets

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Relaxation in spin systems is of great interest with respect to various possible applications like quantum information processing and storage, spintronics, and dynamic nuclear polarization (DNP). The implementation of high frequencies and fields is crucial in the study of systems with large zero-field splitting or large interactions, as for example molecular magnets and low dimensional magnetic materials. Here we will focus on the implementation of pulsed Electron Paramagnetic Resonance (ERP) at multiple frequencies of 10, 95, 120, 240, and 336 GHz, and the relaxation and decoherence processes as a function of magnetic field and temperature. Firstly, at higher frequencies the direct single-phonon spin-lattice relaxation (SLR) is considerably enhanced, and will more often than not be the dominant relaxation mechanism at low temperatures, and can be much faster than at lower fields and frequencies. In principle the measurement of the SLR rates as a function of the frequency provides a means to map the phonon density of states. Secondly, the high electron spin polarization at high fields has a strong influence on the spin fluctuations in relatively concentrated spin systems, and the contribution of the electron-electron dipolar interactions to the coherence rate can be partially quenched at low temperatures[1]. This not only allows the study of relatively concentrated spin systems by pulsed EPR (as for example magnetic nanoparticles and molecular magnets), it enables the separation of the contribution of the fluctuations of the electron spin system from other decoherence mechanisms. Besides choice of temperature and field, several strategies in sample design, pulse sequences, or clock transitions can be employed to extend the coherence time in nanomagnets. A review will be given of the decoherence mechanisms with an attempt at a quantitative comparison of experimental rates with theory. [1] Takahashi, S.; Hanson, R.; van Tol, J.; Sherwin, M.S. and Awschalom, D.D. *Phys. Rev. Lett.,* 101, 047601 (2008)