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Locking electron spins into resonance by electron-nuclear feedback[1]

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All basic building blocks for spin-based quantum information processing using electron spins in GaAs quantum dots have recently been realized. Recent experiments have shown single-shot read-out of an individual spin [1], the implementation of the SWAP gate [2] and (magnetically induced) coherent single electron spin rotations [3]. However, the main drawback of using electron spins in a GaAs environment is the short spin coherence time, which is measured to be in the nanosecond range [2,4]. The source of this fast decoherence is the hyperfine interaction of the localized electron spin with the randomly fluctuating nuclear spins of the host lattice. The fluctuations of the nuclear spins have to be reduced to extend the electron spin coherence time. We therefore study the electron-nuclear spin interaction and use magnetically driven spin resonance to control the electron spin and indirectly manipulate the nuclear spins. We apply continuous microwave excitation to the electron spin and observe strong electron-nuclear feedback. One experimental signature of this feedback is the locking of the electron spin system into resonance with the microwaves. Once the electron spin is locked into resonance, this resonance condition remains fullfilled even when the external magnetic field or the microwave frequency is changed. This is due to dynamically build up nuclear polarizations (up to 500 mT) which generally counteract the external magnetic field. Locking of the electron spin system into resonance might indicate that the nuclear polarization exhibits stable configurations where fluctuations of the nuclear distribution are reduced [5].

References

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