Nuclear Spins in Quantum Dots and Interacting 2DEGs

Daniel Loss

Department of Physics, University of Basel, Klingelbergstr. 82, 4056 Basel. Switzerland

One of the most important decoherence source for spins in GaAs quantum dots are the nuclear spins with which the electron interacts via the contact hyperfine interaction [1] . This problem has been analyzed in great detail over the last few years, and I will present a summary of our current understanding and open problems, and also present recent findings that show that after an initial power law behavior the decoherence crosses over into an exponential (Markovian) decay [2]. There are several strategies which have been proposed to reduce the decoherence effect due to nuclei, such as nuclear state narrowing by transport or optical methods. Another strategy is to fully polarize the nuclear spins, either dynamically or via a thermodynamic phase transition [3] . Mapping the problem onto a Kondo lattice I will show that the nuclear spin system within an interacting two-dimensional electron gas (2DEG) undergoes a ferromagnetic phase transition at finite temperatures. For this it turns out that electron-electron interactions and non-Fermi liquid behavior in the 2DEG are crucial. The nuclear spin Curie temperature can be dramatically enhanced, up into the mK range, by decreasing the electron density of the 2DEG. Depending on the sign of the spin susceptibility change (as function of wave vector) of the 2DEG, the nuclear spins order ferromagnetically or helically [4].

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[4] P. Simon, B. Braunecker, and D. Loss, arXiv :0709.0164.