Dr. John J.L. Morton
(St. John's College, Oxford)

Spin NOON states and quantum memory - from molecular systems to donors in silicon

Nuclear spins are attractive systems in which to test quantum coherent phenomena. They have hosted the most complex quantum algorithm to date and we have recently shown how a Schrödinger cat state of 10-spin spins might be used for enhanced sensing of magnetic fields [1]. However, the weak thermal polarisation of nuclear spins poses a barrier to scaling and advcoates a shift to an electron spin degree of freedom.
For electron spin qubits, nuclear spins are often found to be sources of decoherence, in systems as diverse as GaAs quantum dots and molecular magnets. However, if the interaction between the two is suitably engineered, the nuclear spin can provide a resource for the electron spin, and vice versa, optimising the strengths of the different degrees of freedom available. Electron spins may be used to drive ultrafast operations on the nuclear spins [2], or nuclear spins used for storage as quantum memory elements. The latter requires the coherent transfer of a superposition state in an electron spin *processing* qubit to a nuclear spin *memory* qubit, which we have performed using a combination of microwave and radiofrequency pulses applied to 31P donors in an isotopically pure 28Si crystal with fidelities of up to 97%. The coherence lifetime of the quantum memory element is studied as a function of donor concentration, temperature and under dynamic decoupling, and is found to exceed two seconds at 5.5K [3]. We have extended these methods to other systems such as endohedral fullerene spins and N-defects in diamond.

[1] Magnetic field sensing beyond the standard quantum limit using 10-spin NOON states. J.A. Jones, S.D, Karlen, J. Fitzsimons, A. Ardavan, S.C. Benjamin, G.A.D Briggs and J.J.L. Morton Science in press (2008); arxiv.org/0811.4350

[2] Bang-bang control of fullerene qubits using ultra-fast phase gates, J.J.L. Morton, A.M. Tyryshkin, A. Ardavan, S.C. Benjamin, K. Porfyrakis, S.A. Lyon and G.A.D. Briggs, Nature Physics 2 40 (2006)

[3] Solid state quantum memory using the 31P nuclear spin. J.J.L. Morton, A.M. Tyryshkin, R.M. Brown, S. Shankar, B.W. Lovett, A. Ardavan, T. Schenkel, E.E. Haller, J.W. Ager and S.A. Lyon, Nature 455 1085 (2008)

15. Mai 2009, 14:00 Uhr

Universität Stuttgart, NWZII, Raum 2.136
Pfaffenwaldring 57, 70569 Stuttgart