Quantum Computing

Jonathan A. Jones

A Physical Systems: NMR

1. Estimate the strength of the magnetic field gradient required to make two ^{1}H nuclei in a molecule (assume a separation of about 1 Å) have Larmor frequencies differing by about 100 Hz. Would it be possible to obtain a gradient of this size?

2. Show that a Heisenberg coupling in a two spin system can be approximated by an Ising coupling as long as $|\omega_{12}| \ll |\omega_1 - \omega_2|$.

3. Draw an explicit network of gates to implement a controlled-NOT gate in a two spin system, using only standard single qubit gates and the gate $U(t)$ which corresponds to free evolution under the system's Hamiltonian for a time t. Draw an implementation of a NOT gate that takes the same length of time. (You may find it helpful to look back at section D of the Michaelmas Term problem sheet.)

4. Consider a system of three coupled spins. Write down the Hamiltonian and then design a spin echo sequence such that the average Hamiltonian is reduced to a single coupling term between the second and third spins.

5. Return to a one spin system, and design a spin echo style sequence which will reduce the spin's apparent Larmor frequency to one half of its true value. Is it possible to change the sign of a spin's apparent Larmor frequency? What are the limits on the possible range of scalings? Can coupling strengths be rescaled in the same way?