ABSTRACT

ELECTRON/NUCLEAR SPIN APPROACHES TO QIP

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Nuclear spins are appealing qubits for quantum information processing given their long coherence times. However to use nuclear spins we still require an efficient means of initial state preparation, faster conditional logic, and a more sensitive state measurement. All of these can be provided by a localized electron spin coupled to the nuclear spins via the hyperfine interaction. Since the strength of the hyperfine interaction varies between atoms in a crystal, it has been used as the basis for conditional gates. For example, Mehring has combined microwave irradiation, radio-frequency irradiation and a resolved hyperfine splitting to obtain universal control in a number of small spin systems1. Here we wish to avoid the necessity of using radio-frequency irradiation to nutate the nuclear spins. When the hyperfine interaction between electron and nuclear spins has an anisotropic coupling, we show that universal control over the combined subsystems can be attained by addressing only the electron spin transitions. Building on the GRAPE2 method for quantum control, we propose a method for modulating solely the electron spin, which allows for faster, more robust quantum operations over the nuclear spins than would be had by addressing the nuclear spins directly. We experimentally demonstrate these ideas in a test bed system of one S=1/2 electron spin and one I=1/2 nuclear spin and show that a universal set of gates can be achieved on this system. We will discuss approaches to more complex spin systems.

1. M. Mehring and J. Meade, Phys. Rev. A 73, 052303 (2006)
2. N. Khaneja et al., J. Magn. Reson. 172, 296 (2005)