Abstract Submitted
for the MAR06 Meeting of
The American Physical Society

Nuclear Spin of Phosphorus Donors in Silicon: Spin Relaxation Times and Environmental Decoupling[1] ALEXEI TYRYSHKIN, STEPHEN LYON, Princeton University, JOHN MORTON, ARZHANG ARDAVAN, Oxford University — All shallow donors in silicon (and their various isotopes) have non-zero nuclear spins and thus, both the electron and nuclear spins of neutral donors have been proposed for coding, manipulating and storing quantum information. We have recently demonstrated that the spin of electrons bound to donors have extremely long coherence times of at least T_{2e}= 60ms at liquid helium temperatures which permits 10^6 single-qubit operations before the electron spin decoheres [1]. Here we extend this work and demonstrate that spin states of both the electron and nucleus of a ^{31}P donor can be accurately controlled using resonant microwave and RF pulses in pulsed electron nuclear double resonance (ENDOR) experiments. We measure the spin relaxation times of the ^{31}P nuclear spin and observe long longitudinal relaxation times T_{1n}= 70s at 6K, limited by hyperfine interaction with the electron spin residing on the donor. We implement a recently proposed bang-bang strategy which decouples the nuclear spin from a decohering environment, through repeated manipulation of the coupled electron spin [2]. This highlights the potential benefits of physical qubit systems beyond the simple 2-level structure. [1] A. M. Tyryshkin et al. PRB, 68, 193207 (2003); [2] J. J. L. Morton et al. Nature Physics in press (2005)

[1]Supported in part by the ARO and ARDA

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Date submitted: 30 Nov 2005 Electronic form version 1.4