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Study of decoherence and dynamical decoupling in an optical lattice S. MANESHI, J.F. KANEM, C. ZHUANG, M. PARTLOW, A.M. STEINBERG, CQIQC, IOS and Department of Physics, University of Toronto — Optimizing quantum error correction protocols in the presence of real-world experimental constraints is a major problem along the path to quantum-information implementations. We present work on this problem in the context of an optical-lattice system. Cold ^{85}Rb atoms are held in shallow optical lattices supporting only 1-3 bound states. We create superposition of vibrational states, and observe decoherence in the form of decay of oscillations. Quantum Process Tomography (QPT) is used to characterize decoherence and to study various pulses used to preserve the atomic coherence. These control pulses are limited to manipulations of the lattice potential itself. We optimize simple and compound pulses, and use QPT to quantitatively compare loss of coherence and loss of atoms due to each pulse. A Gaussian shaped pulse is found to be superior to hard pulses in both parameters. We then apply a series of optimized pulses, and observe second and third order echo signals. By confining atoms in a 3D lattice, we study the effect of transverse motion of atoms on the coherence time of the system and compare it to a 1D lattice. The 3D lattice makes it possible to characterize decoherence due to tunneling as a homogeneous or inhomogeneous broadening effect. With our methods, we are able to characterize decoherence processes, implement dynamical decoupling schemes, and study the role of tunneling on decoherence.

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