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**A double well lattice for dynamically manipulating pairs of cold atoms<sup>1</sup>**

JENNIFER SEBBY-STRABLEY, NIST

We describe the design and implementation of a 2D optical lattice of double wells suitable for isolating and manipulating an array of individual pairs of atoms in an optical lattice. Atoms in the square lattice can be placed in a double well with any of their four nearest neighbors. The properties of the double well (the barrier height and the energy offset of the paired sites) can be dynamically controlled. We demonstrate the dynamic control of the lattice by showing the coherent splitting of atoms from single wells into double wells and observing the resulting double-slit atom diffraction pattern. We also demonstrate efficient transfer of atoms between adjacent sites of the lattice as well as between different energy bands. This lattice can be used to test controlled neutral atom motion among lattice sites and should allow for testing controlled two-qubit gates. We propose a scheme and present progress towards performing a two-qubit gate.

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