title	Investigation of the polarization dependence of atom trapping potentials for quantum computing
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additional	
department	Physics
proj_desc	Many physics research groups are currently investigating ways to create a quantum computer. A quantum computer exploits quantum mechanical processes to perform certain tasks that would take more than the age of the universe to do on a conventional computer. So far no quantum computer has been realized. One physical system that has been suggested as the basis for a quantum computer is neutral atoms trapped in light patterns. In my previous work I have discovered (computationally) an atom trapping light pattern that is well-suited for quantum computing [1], and I would like to further investigate the properties of this pattern. In particular, the trapping potential will differ for atoms in different internal states, depending on the polarization of the light at the trapping locations. This could be exploited in order to make 2-qubit quantum gates, currently the missing step for implementing a quantum computer with neutral atoms. The honors student will modify an existing Mathematica code to include the polarization dependence of the trapping potential and will calculate the potentials seen by atoms in certain internal states. The outcome may reveal a new way of enabling the performance of 2-qubit gates. Helpful skills/knowledge: Previous experience with Mathematica and a basic knowledge of electromagnetic waves and quantum mechanics is desirable. The student will receive all the necessary training in atom trapping, atomic physics and quantum computing as part of the project. Support: The student will be supported as student assistant during Winter and Spring quarters, with an expected involvement of 4-5 hours per week. Based on the performance of the student and the progress of the project (and subject to availability of other funds), work may continue during the summer. Reference: (Please note: Christandl is my maiden name.) [1] “One- and two-dimensional optical lattices on a chip for quantum computing,” Katharina Christandl, Gregory P. Lafyatis, Seung-Cheol Lee, Jin-Fa Lee, 2004, Physical Review A 70, 032302.
inter_desc	The proposed project combines atomic physics and optics with information theory and computer science. The honors student will gain an understanding of * how storing information in a quantum bit (“qubit”) is different than storing information in a classical bit, thus introducing the student to quantum information theory * how two internal states of an atom can be used to encode a qubit of information *

	why quantum operations can be exponentially more efficient than classical gates that are familiar from classical computer science * how quantum gates are performed by controllably making atoms interact using techniques from atomic physics * how an array of atomic qubits is created by trapping atoms in a light pattern, as derived from optical physics * how the light pattern can be modified to allow quantum operations between atoms, as needed for a quantum computer
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