Numerical Simulation of Quantum Computation on Quantum Dots

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September 4, 2001

We propose an implementation of quantum controlled-NOT gate on the basis of dipole-dipole interacting asymmetric quantum dots. This implementation does not require application of an external electric field unlike that proposed originally by Deutsch. We consider two single-electron quantum dots separated by a distance R. Both ground state and one of the excited states of each dot form computational basis states. The schematic of the potential profile of the dot is given in Fig.1. Due to the asymmetry of the potential profile of the

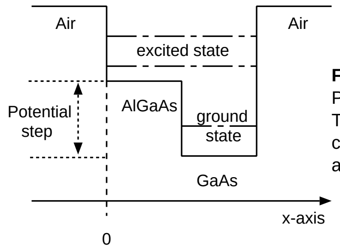

Fig.1.
Potential profile of the quantum dot along x-axis.
The step height of the potential profile and its position can be tuned by a proper choice of materials and growth conditions.

quantum dot, the charge distribution in the ground state and the exicited states of each dot is uneven even in the absence of an external field and can also be tuned and shifted in any direction by a proper modification of the potential profile like in Fig.2. The high dipole moments and sufficient intersubband energy separations of

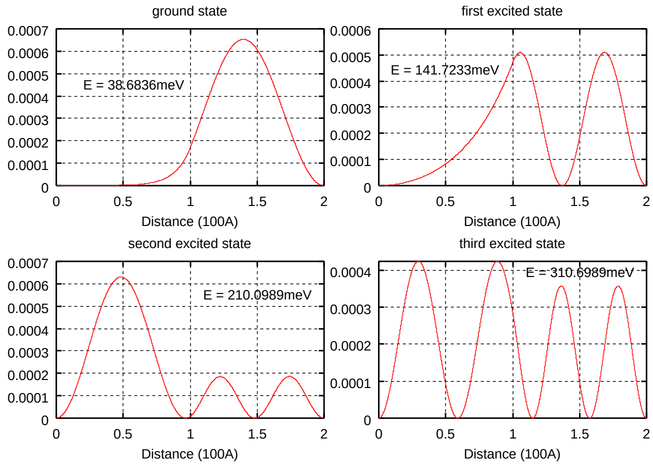

Fig.2
Charge density distribution for the first four confined states. Results are presented for a quantum dot of width 200A and 150meV high step.The legends on top of each figure give the confined energy.

the confined levels in the 200A wide dot make them attractive for the use as computational basis states. Since dipole-dipole interaction between ground state and first excited state is so small,we use second excited state as the basis state $|1>$ and ground state as the basis $|0>$ and solve time independent Schrodinger Equation in asymmetric dots with a 10A separation between two dots. Because the defference of ω_1 and ω_2 which is resonance frequency between state $|1>|1>$ and $|1>0>$ and that between state $|0>|1>$ and $|0>0>$ is not at all large, it may not be possible that both of case resonant. But if these problem are overcomed by changing devise architecture, the implementation of quantum controled NOT gate will be actualized. In this presentation we study condition of quantum dots with strong dipole-dipole interaction and present simple and feasible quantum algorithm for that quantum dots.

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