A quantum gate for optically trapped neutral atoms

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We study theoretically the process of realizing a two-qubit quantum gate based on cold collisions controlled by changing the trapping potential of the system. We calculate the fidelity of gate operation for a time-dependent trap potential where the barrier height between two wells is reduced and then restored again after a short time. We compare our model with that of T. Calarco et al [2]. We also discuss the practical implementation of this gate in our BEC system.

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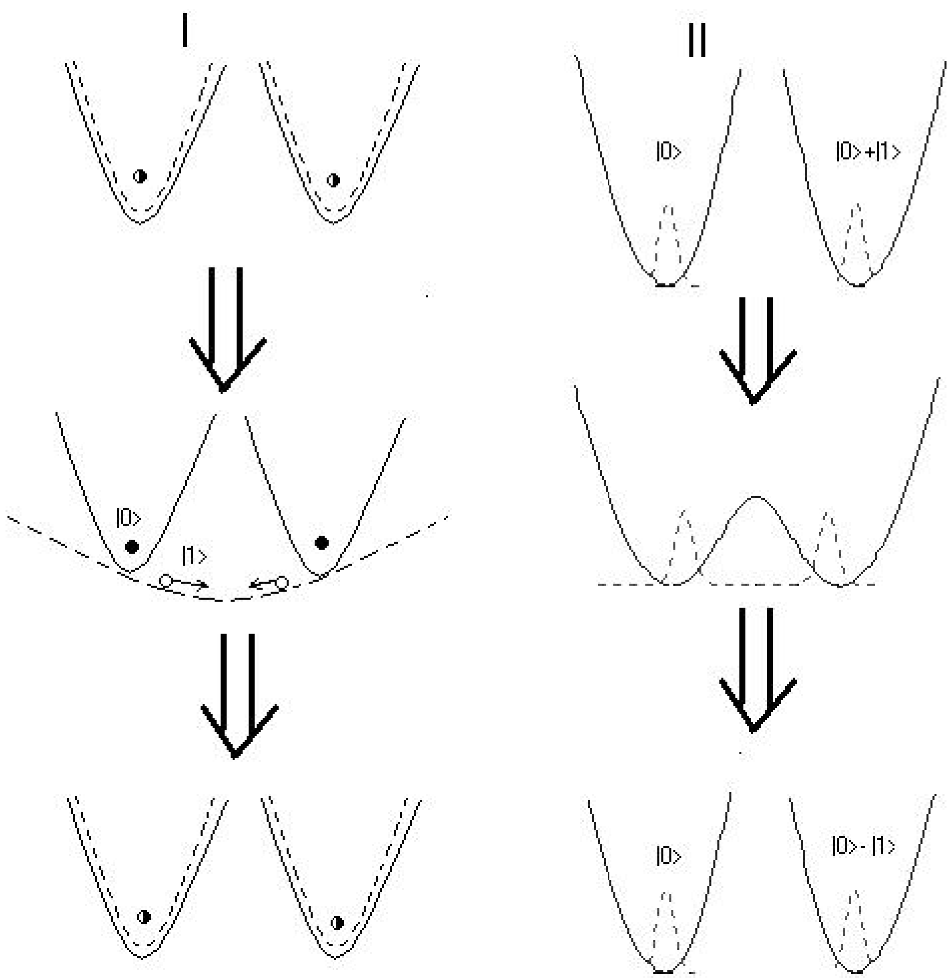

Figure 1: I. The configuration described in T. Calarco's paper. The potential initially has two separated wells. At time $t = 0$ the shape of the trapping potential changes for the particles in state $|1>$, while the potential for state $|0>$ does not change. After interaction time t, the potential is restored to initial shape. II. The initial potential is the same as before. At time $t = 0$ the barrier between two traps is reduced and the wavefunction of both atoms expands to cause a 'collision' (strong interaction). Both internal states $|0>$ and $|1>$ are evolved in the interaction process. After interaction time τ the barrier is restored to its initial value. During the interaction the two internal states accumulate different phase shifts because they have different scattering lengths.