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High fidelity quantum gates for ion qubits in optical transitions KIHWAN KIM, MARK RIEBE, MICHAEL CHWALLA, THOMAS MONZ, PHILIPP SCHINDLER, WOLFGANG HAENSEL, PIET SCHMIDT, Institute fuer Experimentalphysik, Universiaet Innsbruck, CHRISTIAN ROOS, HARTMUT HAEFFNER, JAN BENHELM, GERHARD KIRCHMAIR, TIMO KOERBER, RAINER BLATT, Institut fuer Quantenoptik und Quanteninformation, LEANDRO AOLITA, Instituto de Fisica, Universidade Federal do Rio de Janeiro — One of the most important challenges in ion trap quantum computing is the implementation of a high fidelity two–qubit quantum gate. For hyperfine qubits state dependend AC–Stark shifts were used to demonstrate a two qubit gate with a fidelity of 0.97 [1]. Here, we show that similar forces can also be employed for qubits based on optical transitions as for instance the $S_{1/2} \rightarrow D_{5/2}$ transition in Calcium. In contrast to previous work, our proposal can be applied to magnetic–field insensitive transitions. It also allows for negligible spontaneous emission rates and can be implemented with a pair of co–propagating beams. According to simulations with current experimental imperfections, the proposed gate will allow for fidelities exceeding 0.99.

[1] D. Leibfried, *et al.*, Nature **422**, 412 (2003).

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