2006 Vol.46 No.2 pp.297-302 DOI:

Motional Quantum-State Engineering and Implementation of a Quantum Phase-Gate for Multiple Trapped Ions

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(Received: 2005-11-1; Revised:)

Abstract: We propose a scheme to generate a superposition of motional coherent states with arbitrary coefficients on a line in phase space and implement a quantum controlled phase-gate for multiple trapped ions with a single standing-wave laser pulse whose carrier frequency is tuned to the ions transition. In the scheme each ion does not need to be exactly positioned at the node of the standing wave, which is very important from viewpoint of experiment. Furthermore, our scheme may allow the generation of a superposition of coherent states with large mean phonon number for a large number of trapped ions in a fast way by choosing suitable laser intensity. We show that it can also be used to generate maximally entangled states of multiple trapped ions.

PACS: 42.50.Dv, 42.50.Vk, 03.67.Lx

Key words: quantum-state engineering, quantum computation, trapped ions