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Entangling Ions through Multiple Transverse Modes on an Ion-Chain[1] KUAN ZHANG, YAO LU, SHUAINING ZHANG, YANGCHAO SHEN, WENTAO CHEN, JING-NING ZHANG, KIHWAN KIM, Center for Quantum Information, IIIS, Tsinghua University, Beijing, P. R. China — A Greenberger-Horne-Zeilinger (GHZ) state of up to 14 ions has been created by applying a single operation of Mølmer-Sørensen (MS) gate [1,2]. In their gate, it is essential to use only the center-mass (CM) mode along the axial direction, therefore, requiring well isolation of the mode from all the other motional modes. However, it is difficult to maintain the requirement when the number of ions further increases in a linear ion-chain with reasonable trap frequencies. Here, we present a scalable multi-qubit gate, which entangles ions by using multiple transverse modes instead of a single CM mode. Our gate considers the influence of all the motional modes, and creates entanglement among arbitrary number of selected ions in the ion-chain by simultaneously applying laser beams to them. Our multi-qubit gate provides an efficient and scalable solution for trapped-ion quantum computation and simulation. [1] Anders Sørensen and Klaus Mølmer. Phys. Rev. Lett. 62, 022311 (2000). [2] Thomas Monz, et al., Phys. Rev. Lett. 106, 130506 (2011).

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