Trapped Ion Quantum Computation with Transverse Phonon Modes

M.-S. Chang, K. Kim, S. Korenblit, K. R. Islam, L.-M. Duan[†], and C. Monroe
JQI and Department of Physics, University of Maryland, College Park, MD 20742
[†]Department of Physics, University of Michigan, Ann Arbor, MI 48109

Trapped ion systems remain as one of the most promising candidates [1] for practical quantum information processing (QIP). Recent theoretical studies suggested that using transverse collective motion as the quantum bus [2] has several potential advantages over longitudinal normal modes adopted in previous demonstrations. First, the transverse modes are more tightly bound than axial modes for any number of ions and are hence less sensitive to motional decoherence. Second, the closely-spaced spectrum of the transverse modes allows ions to couple through multiple modes simultaneously. This opens up an avenue to tailor the many-body ion coupling strengths for exploring nontrivial spin Hamiltonians [3], and enables entangling gates with arbitrary speed by applying composite laser pulses. We will report the recent experimental progress of this scheme with trapped Ytterbium ions in a linear Paul trap, and its application for quantum simulations of Heisenberg-like spin Hamiltonians. We will also discuss the scalability of this approach for trapped ion QIP.

This work is supported by the DARPA OLE Program under ARO Award W911NF-07-1-0576, IARPA under ARO contract W911NF-08-1-0355, and the NSF PIF Program under grant PHY-0601255.

[1] J. I. Cirac and P. Zoller, Phys. Rev. Lett. 74, 4091 (1995); Wineland, D. J. et al., J. Res. Natl Inst. Stand. Technol. 103, 259-328 (1998); Blatt R., Wineland D., Nature 453, 1008-1015 (2008).
[2] S.-L. Zhu, C. Monroe, and L.-M. Duan, Phys. Rev. Lett. 97, 050505 (2006).
[3] D. Porras and J. I. Cirac, Phys. Rev. Lett. 92, 207901 (2004)