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Alkaline-earth atoms as few-qubit quantum registers ALEXEY GORSHKOV, Physics Department, Harvard University, Cambridge, Massachusetts 02138, USA, ANA MARIA REY, JILA, National Institute of Standards and Technology and University of Colorado, Boulder, CO 80309-0440, USA, ANDREW DALEY, Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information, A-6020 Innsbruck, Austria , MARTIN BOYD, JUN YE, JILA, National Institute of Standards and Technology and University of Colorado, Boulder, CO 80309-0440, USA, PETER ZOLLER, Institute for Theoretical Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information, A-6020 Innsbruck, Austria, MIKHAIL LUKIN, Physics Department, Harvard University, Cambridge, Massachusetts 02138, USA —
We propose and analyze a novel approach to quantum information processing, in which multiple qubits can be encoded and manipulated using electronic and nuclear degrees of freedom associated with individual alkaline-earth atoms trapped in an optical lattice. Specifically, we describe how the qubits within each register can be individually manipulated and measured with sub-wavelength optical resolution. We also show how such few-qubit registers can be coupled to each other in optical superlattices via conditional tunneling to form a scalable quantum network. Finally, potential applications to quantum computation and precision measurements are discussed.

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