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Anyonic Interferometry and Protected Memories in Atomic Spin Lattices LIANG JIANG, Physics Department, Harvard University, GAVIN BRENNEN, Institute for Theoretical Physics, University of Innsbruck, ALEXEY GORSHKOV, Physics Department, Harvard University, KLEMENS HAMMERER, Institute for Theoretical Physics, University of Innsbruck, MOHAMMAD HAFEZI, EUGENE DEMLER, MIKHAIL LUKIN, Physics Department, Harvard University, PETER ZOLLER, Institute for Theoretical Physics, University of Innsbruck —
Systems with topological order can exhibit remarkable phenomena such as quasiparticles with anyonic statistics and might be used for naturally error-free quantum computation. Here we describe how to unambiguously detect and characterize such states in recently proposed spin lattice realizations using ultra-cold atoms or molecules trapped in an optical lattice. We propose an experimentally feasible technique to access non-local degrees of freedom by performing global operations on trapped spins mediated by an optical cavity mode. We show how to reliably read and write topologically protected quantum memory using an atomic or photonic qubit. Furthermore, our technique can be used to probe statistics and dynamics of anyonic excitations.

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