DAMOP10-2010-020113

Abstract for an Invited Paper
for the DAMOP10 Meeting of
the American Physical Society

Quantum Information Processing with Ions and Photons[1]

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Quantum information research is driven by the prospect of using the features of quantum physics to tackle otherwise intractable computational problems. Systems of trapped atomic ions have proven to be one of the most promising candidates for the realization of quantum computation due to their long trapping times, excellent coherence properties, and exquisite control of the internal atomic states. Integrating ions (quantum memory) with photons (distance link) offers a unique path to large-scale quantum computation and long-distance quantum communication. I present the implementation of a heralded photon-mediated quantum gate between remote ions, and the employment this gate to perform a teleportation protocol between two ions separated by a distance of about one meter. A quantum bit stored in the hyperfine levels of a single ytterbium ion (Yb^+) is teleported to a second Yb^+ atom with an average fidelity of 90% over a replete set of states. The method demonstrated here avoids many of the issues associated with previously demonstrated motional gates, while presenting a new set of challenges and possibilities for integration to larger systems.

[1]Research performed at the University of Michigan and the University of Maryland under the supervision of Christopher Monroe.