Invited speaker

Prof. Christopher Monroe

Joint Quantum Institute and University of Maryland

Affiliation／Joint Quantum Institute, Department of Physics, University of Maryland, College Park, MD 20742 USA

e-mail／monroe@umd.edu

Quantum Networks with Atoms and Photons

Abstract

Laser-cooled and trapped atomic ions are standards for quantum information science, acting as qubits with unsurpassed levels of quantum coherence while also allowing near-perfect measurement [1]. When qubit state-dependent optical forces are applied to a collection of atomic ions, their Coulomb interaction is modulated in a way that allows the entanglement of the qubits through quantum gates that can form the basis of a quantum computer [2]. Similar forces allow the simulation of quantum magnetic interactions, and recent experiments have implemented tunable long-range interacting spin models with up to 20 trapped ions, the largest collection of interacting qubits yet demonstrated [3]. Scaling to even larger numbers can be accomplished by coupling trapped ion qubits to optical photons, where entanglement can be formed over remote distances for applications in quantum communication, quantum teleportation, and distributed quantum computation [4]. By employing such a modular and reconfigurable architecture, it should be possible to scale up ion trap quantum networks to useful dimensions [5], for future applications in quantum computing and quantum communication that are impossible using classical processors.

References

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About the Author

Christopher Monroe earned his PhD in Physics in 1992, under Carl Wieman and Eric Cornell at the University of Colorado. From 1992-2000 he was a postdoc then staff physicist at the National Institute of Standards and Technology, in the group of David Wineland. With Wineland, Monroe led the team that demonstrated the first quantum logic gate in 1995, and exploited the use of trapped atoms for the first controllable qubit demonstrations. In 2000, Monroe became Professor of Physics and Electrical Engineering at the University of Michigan, where he pioneered the use of single photons to couple quantum information between atoms and also demonstrated the first electromagnetic atom trap integrated on a semiconductor chip. From 2006-2007 was the Director of the National Science Foundation Ultrafast Optics Center at the University of Michigan. In 2007 he became the Bice Zorn Professor of Physics at the University of Maryland and a Fellow of the Joint Quantum Institute. In 2008, Monroe's group succeeded in producing quantum entanglement between two widely separated atoms and for the first time teleported quantum information between matter separated by a large distance. Since 2009 his group has investigated the use of ultrafast laser pulses for speedy quantum entanglement operations, pioneered the use of trapped ions for quantum simulations of many-body models related to quantum magnetism, and has proposed and made the first steps toward a scalable, reconfigurable, and modular quantum computer.