Office of Naval Research Science & Technology

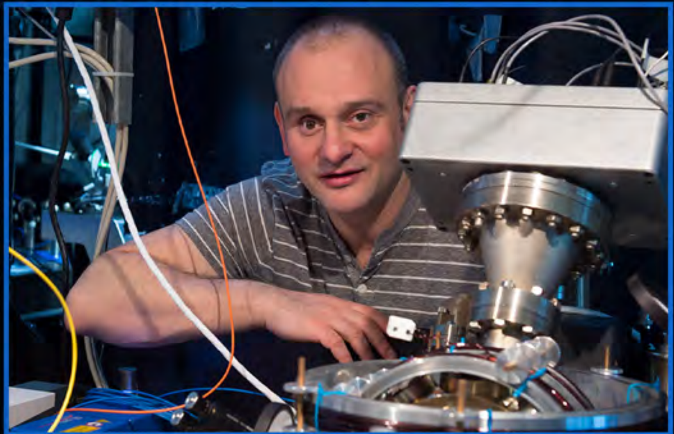
Distinguished Lecture Series

DEVELOPING A MODULAR MICROWAVE TRAPPED-ION QUANTUM COMPUTER

Presented by:

Winfried K. Hensinger, Ph.D.
Director, Sussex Centre for Quantum Technologies
Department of Physics and Astronomy
University of Sussex, United Kingdom

JULY 9
2019
11 A.M.
IN THE JUNKER CENTER



Office of Naval Research
875 N. Randolph St., Arlington, Va.
Bobby Junker Executive Conference Center, 14th Floor

Developing a Modular Microwave Trapped-Ion Quantum Computer

Trapped ions are arguably the most mature technology capable of constructing practical large-scale quantum computers. We are now moving away from fundamental physics studies toward tackling the required engineering tasks in order build such machines.

By inventing a new method where voltages applied to a quantum computer microchip are used to implement entanglement operations, we have managed to remove one of the biggest barriers traditionally faced to build a large-scale quantum computer using trapped ions, namely having to precisely align billions of lasers to execute quantum gate operations. This new approach, quantum computing with global radiation fields, is based on the use of well-developed microwave technology [1].

In order to be able to build large-scale device, a quantum computer needs to be modular. One approach features modules that are connected via photonic interconnect; however, only very small connection speeds between modules demonstrated have been demonstrated so far. We have invented an alternative method where modules are connected via electric fields, allowing ions to be transported from one module to another giving rise to much faster connection speeds [2].

Incorporating these two inventions, we recently unveiled the first industrial blueprint on how to build a large-scale quantum computer which I will discuss in this talk [2]. I will show progress in constructing a quantum computer prototype at the University of Sussex featuring this technology, and I will discuss a new method we have demonstrated recently in order to make quantum gates with trapped ions more resilient to sources of decoherence such as motional heating, stray magnetic fields and noise in electrical components [3].

References

[1] Trapped-ion quantum logic with global radiation fields, S. Weidt, J. Randall, S. C. Webster, K. Lake, A. E. Webb, I. Cohen, T. Navickas, B. Lekitsch, A. Retzker, and W. K. Hensinger, Phys. Rev. Lett. 117, 220501 (2016)

[2] Blueprint for a microwave trapped ion quantum computer, B. Lekitsch, S. Weidt, A.G. Fowler, K. Mølmer, S.J. Devitt, Ch. Wunderlich, and W.K. Hensinger, Science Advances 3, e1601540 (2017)

[3] Resilient entangling gates for trapped ions, A. E. Webb, S. C. Webster, S. Collingbourne, D. Bretaud, A. M. Lawrence, S. Weidt, F. Mintert and W. K. Hensinger, Phys. Rev. Lett. 121, 180501 (2018)

ABOUT

Winfried K. Hensinger, Ph.D.

Prof. Winfried Hensinger heads the Sussex Ion Quantum Technology Group and is the director of the Sussex Centre for Quantum Technologies. Hensinger's group works on constructing a practical trapped-ion quantum computer as well developing portable quantum sensors. Hensinger produced the first ion trap microchip in the world and more recently, his group developed a new generation of quantum microchips featuring world-record specifications. In 2016, Hensinger and his group invented a new approach to quantum computing with trapped ions where voltages applied to a quantum computer microchip can replace billions of laser beams which would have been required in previous proposals on how to build a quantum computer. In 2017, Hensinger announced the first practical blueprint for building a quantum computer in a paper published in the journal Science Advances, giving rise to the assertion that is now possible to construct a large-scale quantum computer. Hensinger obtained his PhD at the University of Queensland, demonstrating new and strange quantum effects with ultra-cold atoms. During his PhD research, he spent an extended period at NIST in Gaithersburg, Maryland in the group of Nobel laureate William Phillips, where he accomplished the first demonstration of a highly counterintuitive quantum phenomenon where individual cold atoms move in two opposite directions simultaneously – dynamical tunnelling. He then spent three years at the University of Michigan, in the group of Chris Monroe, developing ways to scale ion trap quantum computing before taking up a faculty position at the University of Sussex in 2005.