Coherent control of macroscopic quantum states in a single-Cooper-pair box

Y. Nakamura*, **Yu. A. Pashkin**† & **J. S. Tsai***

* *NEC Fundamental Research Laboratories, Tsukuba, Ibaraki 305-8051, Japan*
† *CREST, Japan Science and Technology Corporation (JST), Kawaguchi, Saitama 332-0012, Japan*

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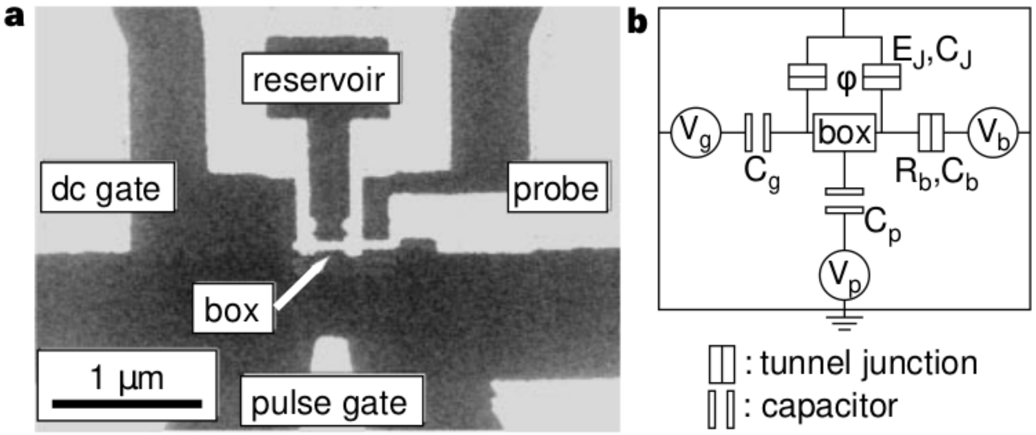

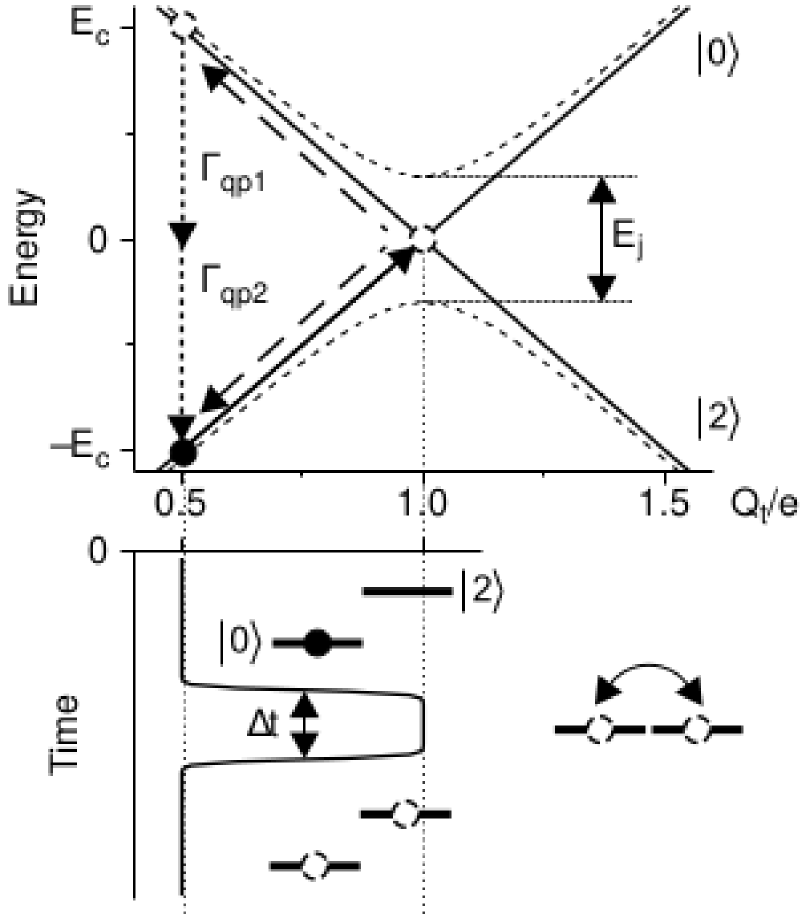

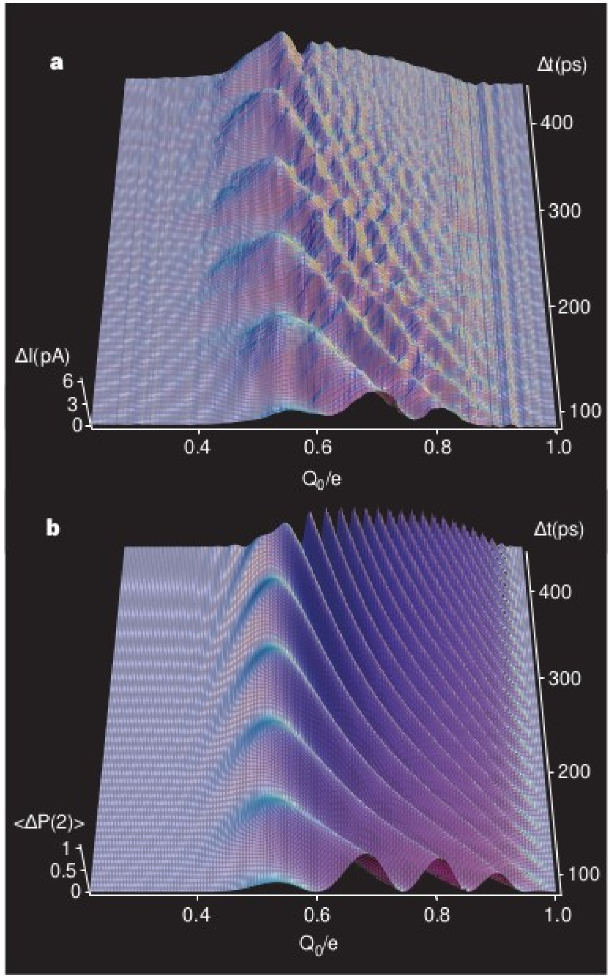

Demonstration of conditional gate operation using superconducting charge qubits

T. Yamamoto[1,2], **Yu. A. Pashkin**[2*], **O. Astafiev**[2], **Y. Nakamura**[1,2] **& J. S. Tsai**[1,2]

[1] *NEC Fundamental Research Laboratories, Tsukuba, Ibaraki 305-8501, Japan*
[2] *The Institute of Physical and Chemical Research (RIKEN), Wako, Saitama 351-0198, Japan*

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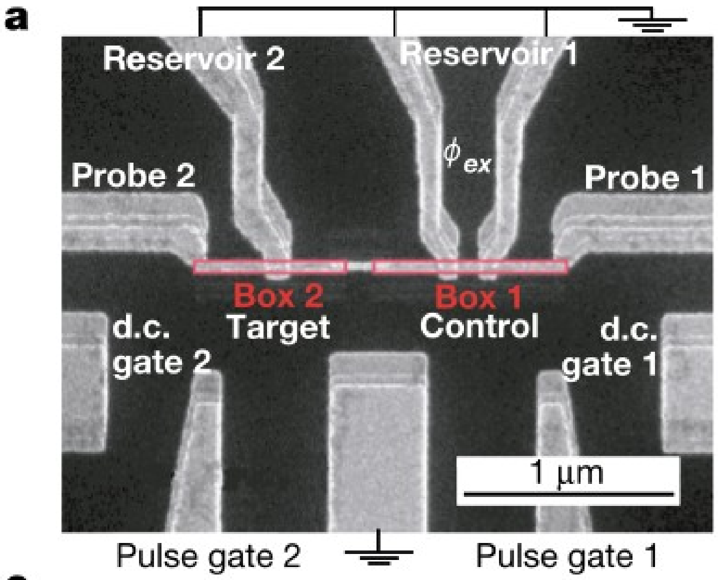

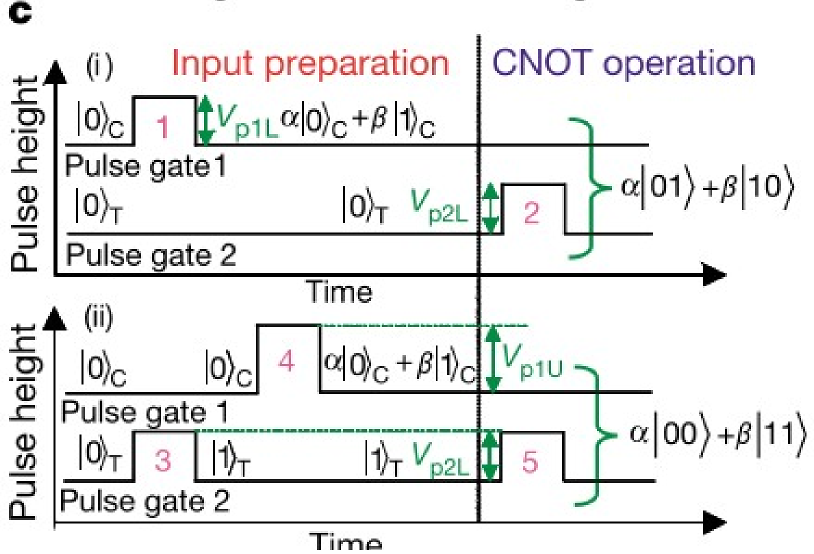

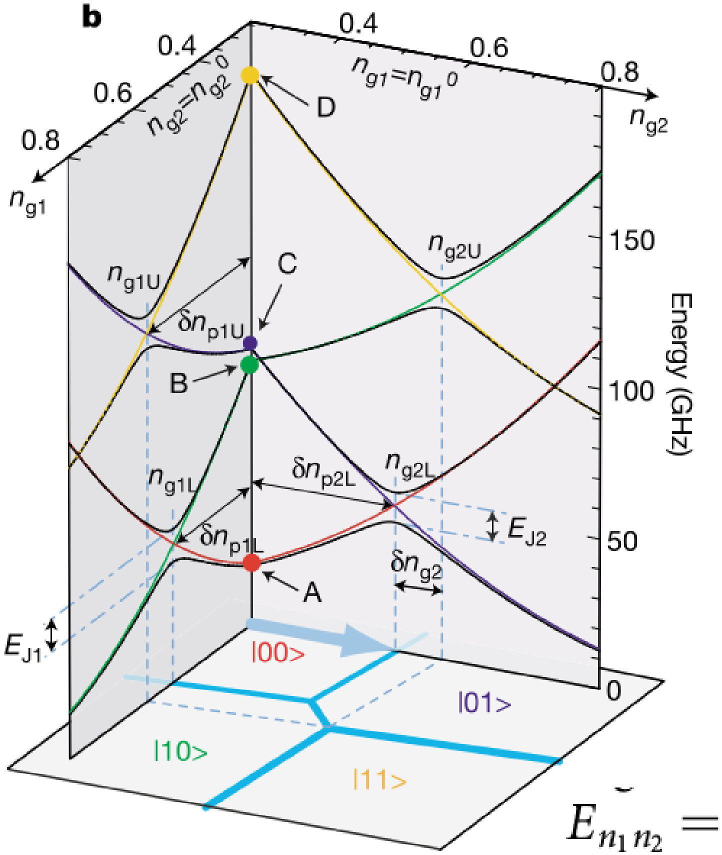

$$H = \sum_{n_1,n_2=0,1} E_{n_1 n_2} |n_1,n_2\rangle\langle n_1,n_2| - \frac{E_{J1}}{2}\sum_{n_2=0,1}(|0\rangle\langle 1| + |1\rangle\langle 0|)\otimes|n_2\rangle\langle n_2| - \frac{E_{J2}}{2}\sum_{n_1=0,1}|n_1\rangle\langle n_1|\otimes(|0\rangle\langle 1|+|1\rangle\langle 0|),$$

$$E_{n_1 n_2} = E_{c1}(n_{g1}-n_1)^2 + E_{c2}(n_{g2}-n_2)^2 + E_{m}(n_{g1}-n_1)(n_{g2}-n_2)$$

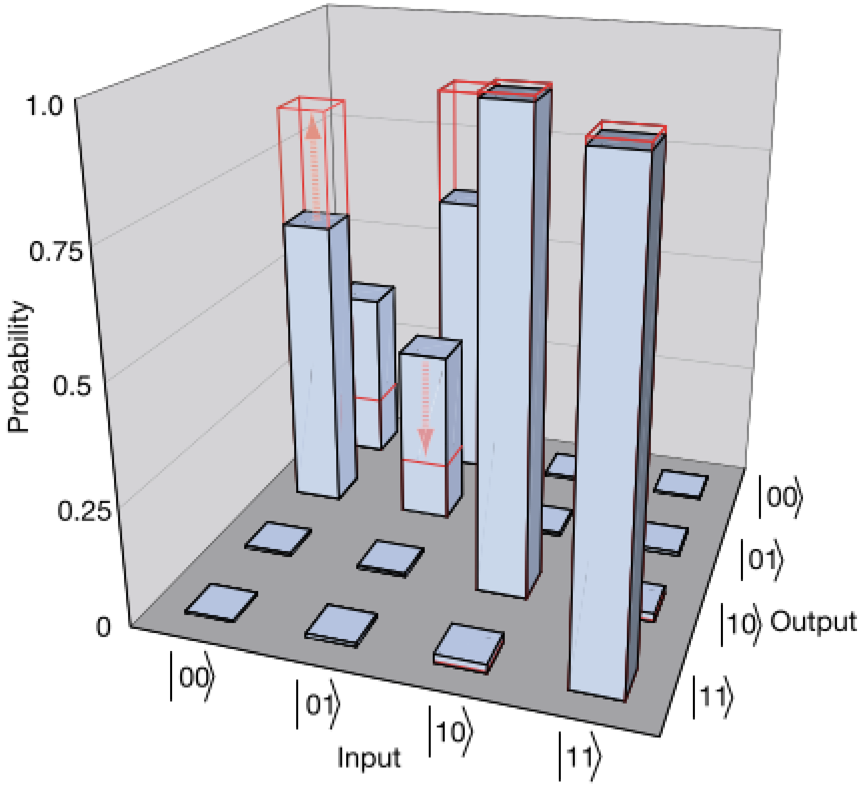

Figure 4 Truth table of the present C-NOT operation estimated by the numerical calculation (solid blue bars). Detailed values of the probabilities are

$$\begin{pmatrix} 0.37 & 0.62 & 0.004 & 0.003 \\ 0.62 & 0.37 & 0.004 & 0.007 \\ 0.004 & 0.004 & 0.97 & 0.018 \\ 0.003 & 0.007 & 0.018 & 0.97 \end{pmatrix}.$$

Ideally, they should be

$$\begin{pmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

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Scalable Quantum Simulation of Molecular Energies

P. J. J. O'Malley,[1,*] R. Babbush,[2,†] I. D. Kivlichan,[3] J. Romero,[3] J. R. McClean,[4] R. Barends,[5] J. Kelly,[5] P. Roushan,[5]
A. Tranter,[6,7] N. Ding,[2] B. Campbell,[1] Y. Chen,[5] Z. Chen,[1] B. Chiaro,[1] A. Dunsworth,[1] A. G. Fowler,[5] E. Jeffrey,[5]
E. Lucero,[5] A. Megrant,[5] J. Y. Mutus,[5] M. Neeley,[5] C. Neill,[1] C. Quintana,[1] D. Sank,[5] A. Vainsencher,[1] J. Wenner,[1]
T. C. White,[5] P. V. Coveney,[7] P. J. Love,[6] H. Neven,[2] A. Aspuru-Guzik,[3] and J. M. Martinis[5,1,‡]

[1]*Department of Physics, University of California, Santa Barbara, California 93106, USA*
[2]*Google Inc., Venice, California 90291, USA*
[3]*Department of Chemistry, Harvard University, Cambridge, Massachusetts 02138, USA*
[4]*Computational Research Division, Lawrence Berkeley National Laboratory,*
Berkeley, California 94720, USA
[5]*Google Inc., Santa Barbara, California 93117, USA*
[6]*Department of Physics, Tufts University, Medford, Massachusetts 02155, USA*
[7]*Center for Computational Science and Department of Chemistry,*
University College London, London WC1H 0AJ, United Kingdom

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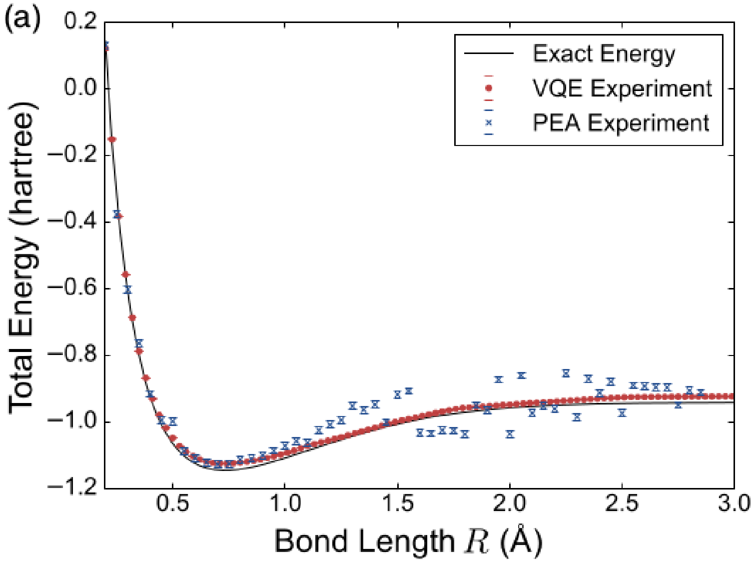


FIG. 3. Computed H_2 energy curve and errors. (a) Energy surface (

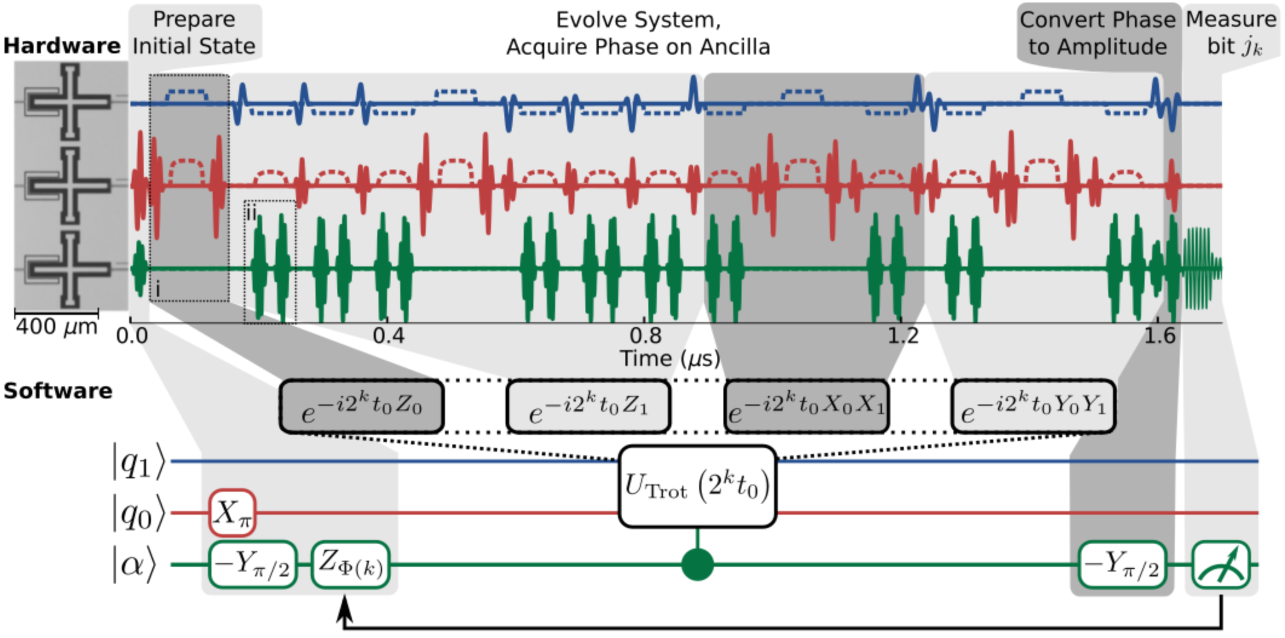


FIG. 4. Hardware and software schematic of the Trotterized phase estimation algorithm. (Hardware) micrograph shows three Xmon transmon qubits and microwave pulse sequences, including (i) the variable amplitude CZ_ϕ (not used in Fig. 1) and (ii) dynamical decoupling pulses not shown in logical circuit. (Software) state preparation includes putting the ancilla in a superposition state and compensating for previously measured bits of the phase using the gate Z_{Φ_k} (see text). The bulk of the circuit is the evolution of the system under a Trotterized Hamiltonian controlled by the ancilla. Bit j_k is determined by a majority vote of the ancilla state over 1000 repetitions.

Quantum supremacy using a programmable superconducting processor

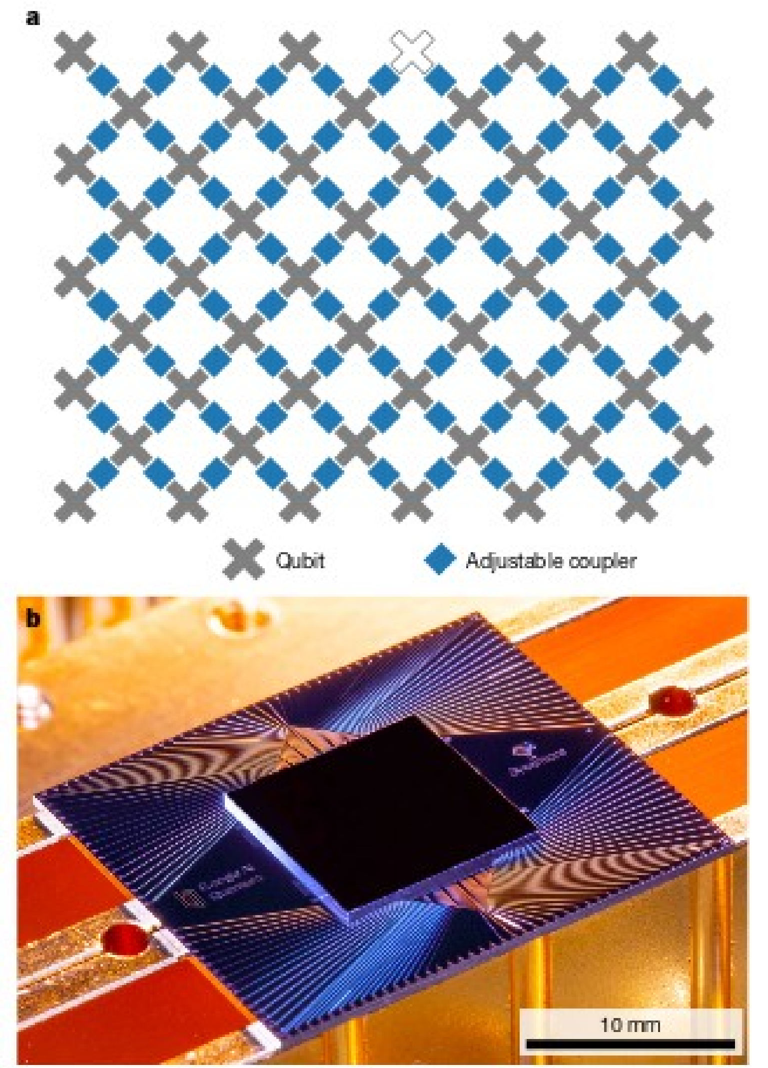


Fig. 1 | The Sycamore processor. a, Layout of processor, showing a rectangular array of 54 qubits (grey), each connected to its four nearest neighbours with couplers (blue). The inoperable qubit is outlined. **b**, Photograph of the Sycamore chip.

Universal Digital Quantum Simulation with Trapped Ions

B. P. Lanyon,[1,2*] C. Hempel,[1,2] D. Nigg,[2] M. Müller,[1,3] R. Gerritsma,[1,2] F. Zähringer,[1,2]
P. Schindler,[2] J. T. Barreiro,[2] M. Rambach,[1,2] G. Kirchmair,[1,2] M. Hennrich,[2] P. Zoller,[1,3]
R. Blatt,[1,2] C. F. Roos[1,2]

SCIENCE VOL 334 7 OCTOBER 2011

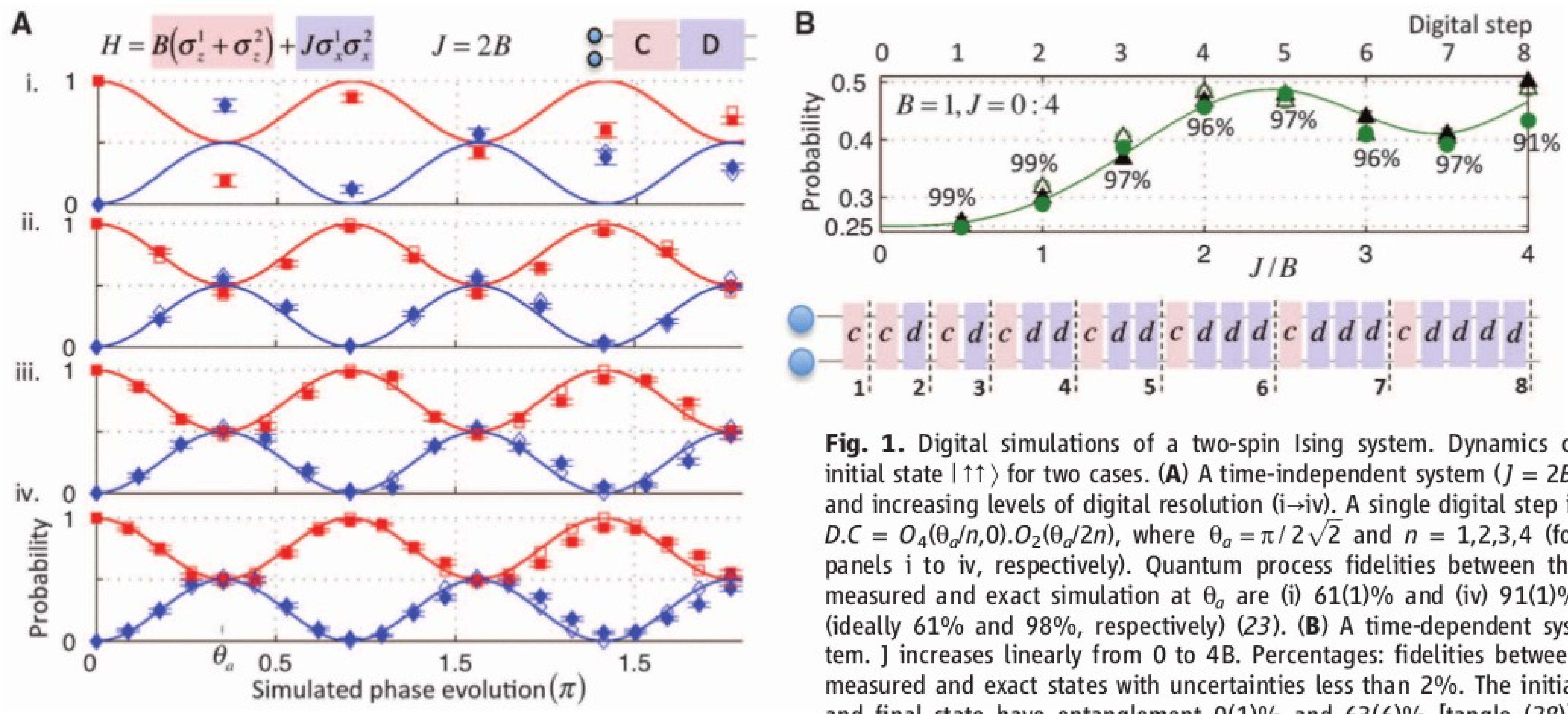


Fig. 1. Digital simulations of a two-spin Ising system. Dynamics of initial state $|\uparrow\uparrow\rangle$ for two cases. (**A**) A time-independent system ($J = 2B$) and increasing levels of digital resolution (i→iv). A single digital step is $D.C = O_4(\theta_a/n,0).O_2(\theta_a/2n)$, where $\theta_a = \pi/2\sqrt{2}$ and n = 1,2,3,4 (for panels i to iv, respectively). Quantum process fidelities between the measured and exact simulation at θ_a are (i) 61(1)% and (iv) 91(1)% (ideally 61% and 98%, respectively) (*23*). (**B**) A time-dependent system. J increases linearly from 0 to 4B. Percentages: fidelities between measured and exact states with uncertainties less than 2%. The initial and final state have entanglement 0(1)% and 63(6)% [tangle (*28*)], respectively. The digitized linear ramp is shown at the bottom: $c = O_2(\pi/16)$, $d = O_4(\pi/16,0)$. For more details, see (*23*). Lines; exact dynamics. Unfilled shapes: ideal digitized; filled shapes: data (■ $\uparrow\uparrow$ ◆ $\downarrow\downarrow$ ● $\rightarrow\rightarrow_x$ ▲ $\leftarrow\leftarrow_x$).

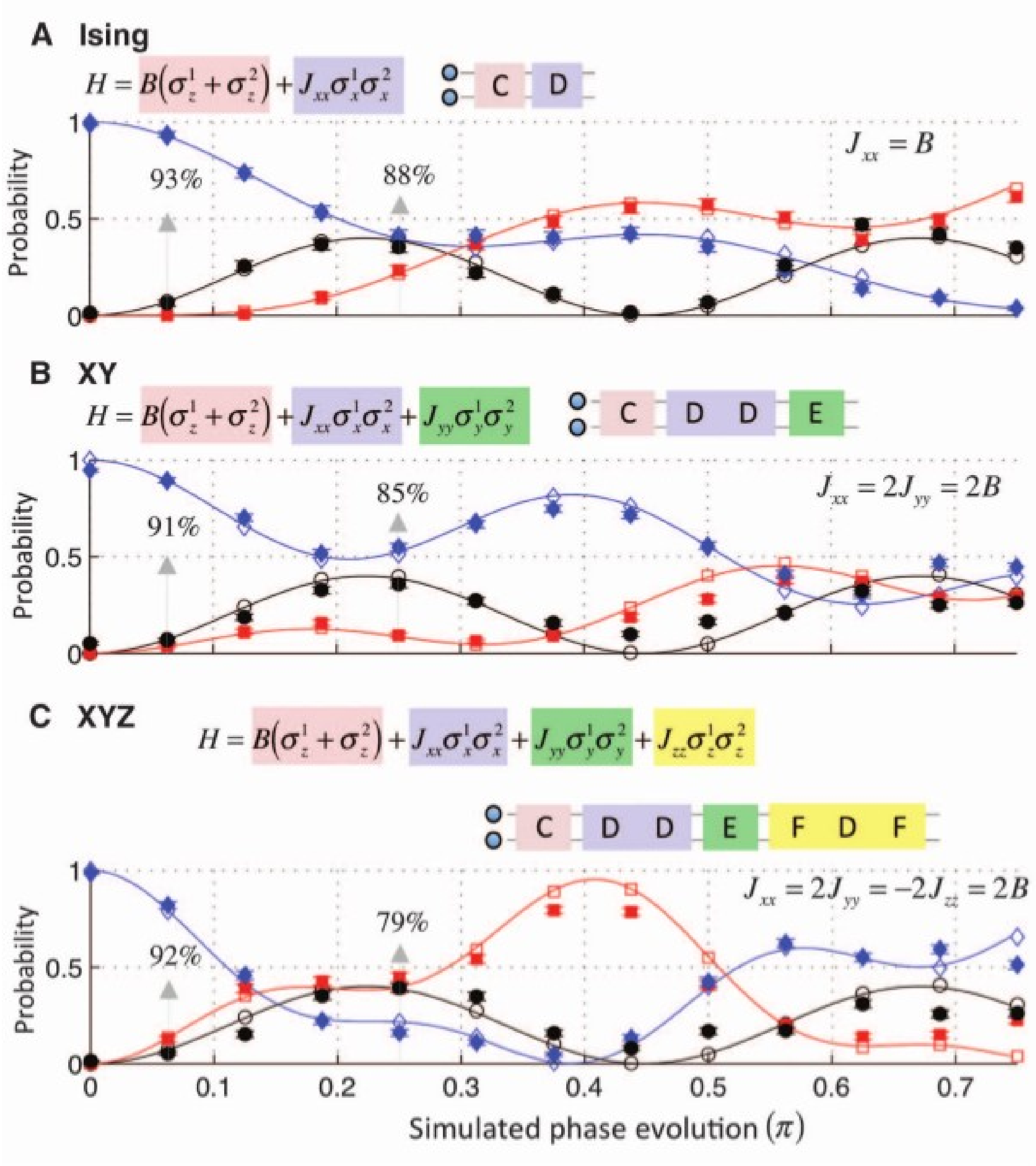
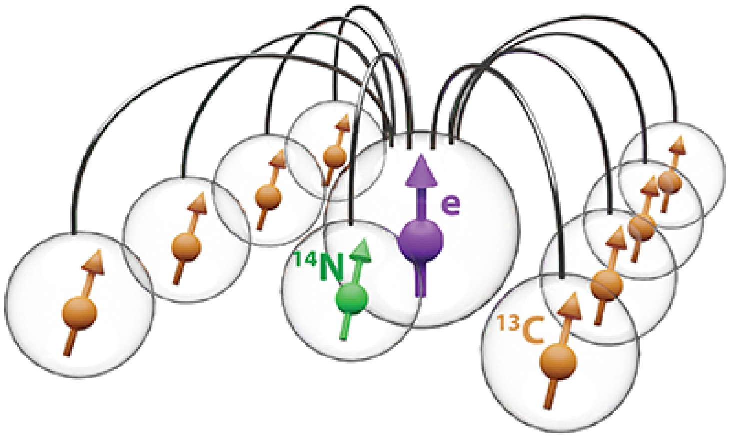


Fig. 2. (**A** to **C**) Digital simulations of increasingly complex two-spin systems. Dynamics of the initial state $|\rightarrow\leftarrow\rangle_x$ with a fixed digital resolution of π/16. The graphic in each panel shows how a single digital step is built: $C = O_2(\pi/16)$, $D = O_4(\pi/16,0)$, $E = O_4(\pi/16,\pi)$, $F = O_3(\pi/4,0)$. Quantum process fidelities between the measured and exact simulation after one and four digital steps are shown with gray arrows [uncertainties ≤ 1% (*23*)]. Lines; exact dynamics. Unfilled shapes: ideal digitized; filled shapes: data (♦ $\rightarrow\leftarrow_x$ ■ $\leftarrow\rightarrow_x$ ● $\leftarrow\leftarrow_x$ or $\rightarrow\rightarrow_x$).

Synopsis: Diamond Qubits Take the Stage

September 11, 2019

A ten-qubit system based on spins in impure diamond achieves coherence times of over a minute.



C. E. Bradley/Delft University of Technology

In the global race to build a quantum computer, it's still unclear what material will make the best qubit. Companies have bet on a variety of architectures based on trapped ions, neutral atoms, superconducting circuits, and more. Now, Tim Taminiau of Delft University of Technology, Netherlands, and colleagues have demonstrated that they can manipulate magnetic spins inside diamond into the robust quantum states

Print

A Ten-Qubit Solid-State Spin Register with Quantum Memory up to One Minute

C. E. Bradley, J. Randall, M. H. Abobeih, R. C. Berrevoets, M. J. Degen, M. A. Bakker, M. Markham, D. J. Twitchen, and T. H. Taminiau

Phys. Rev. X 9, 031045 (2019)

Published September 11, 2019

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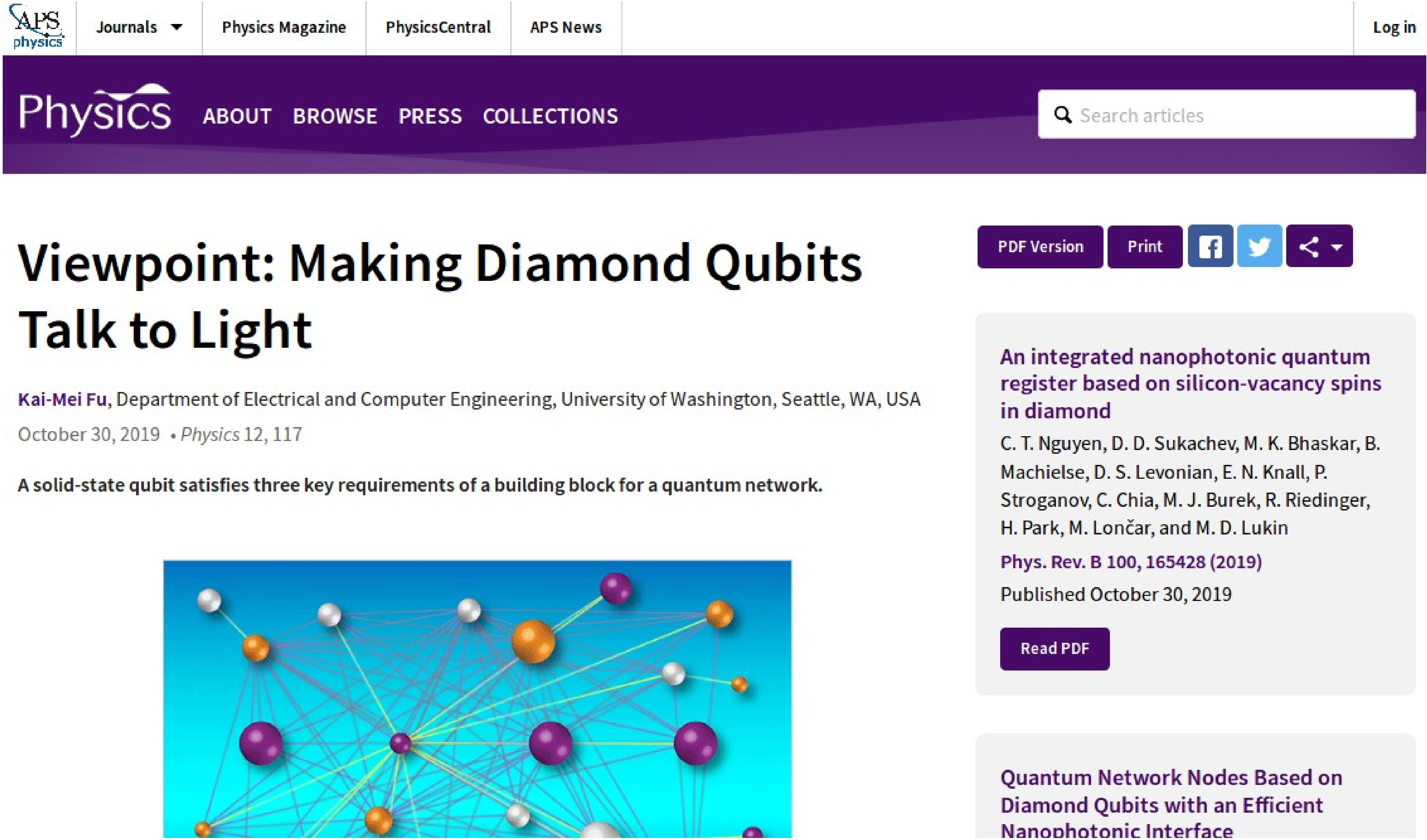
Opinion: Time to Act Like It's a Climate Emergency

Our actions as physicists matter in the public eye, and we should use that prominence to stand up for the climate emergency.

Open Mic for Vietnamese Physicists

Physics asked a number of scientists from Vietnam about their thoughts on physics in their home country.

Postcard: Physics in Vietnam



Viewpoint: Making Diamond Qubits Talk to Light

Kai-Mei Fu, Department of Electrical and Computer Engineering, University of Washington, Seattle, WA, USA

October 30, 2019 • *Physics* 12, 117

A solid-state qubit satisfies three key requirements of a building block for a quantum network.

An integrated nanophotonic quantum register based on silicon-vacancy spins in diamond

C. T. Nguyen, D. D. Sukachev, M. K. Bhaskar, B. Machielse, D. S. Levonian, E. N. Knall, P. Stroganov, C. Chia, M. J. Burek, R. Riedinger, H. Park, M. Lončar, and M. D. Lukin

Phys. Rev. B 100, 165428 (2019)

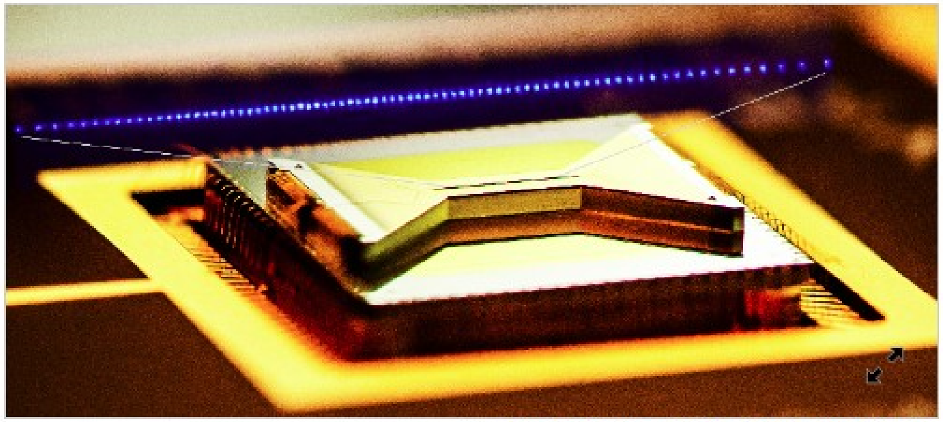
Published October 30, 2019

Quantum Network Nodes Based on Diamond Qubits with an Efficient Nanophotonic Interface

Waiting for the Quantum Simulation Revolution

October 21, 2019 • *Physics* 12, 112

Quantum computers still need lots of development before they can compete with conventional computers in chemistry, drug development, and materials science, but they are making progress.



K. Hudek & E. Edwards/Univ. of Maryland/IonQ, Inc./JQI

Using a linear array of trapped ions similar to the one shown here, ionQ scientists calculated the ground-state energy of a water molecule. (The above composite combines an image of the ions with a photo of the chip containing them.)

Quantum computers are hot. The US Congress has authorized up to $1.2 billion of research funding for

Features

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Our actions as physicists matter in the public eye, and we should use that prominence to stand up for the climate emergency.

Open Mic for Vietnamese Physicists

Physics asked a number of scientists from Vietnam about their thoughts on physics in their home country.

Postcard: Physics in Vietnam

After emerging from difficult times, Vietnam is now ready to make its scientific potential known.

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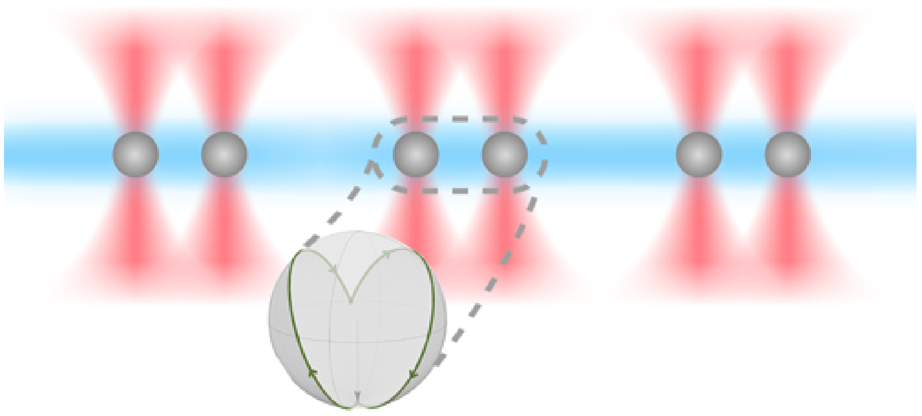
Announcements

Collection: Battery Research and Applications

Synopsis: Neutral-Atom Quantum Computers Are Back in the Race

October 22, 2019

Fidelity in multiqubit gates made from trapped rubidium atoms is now competitive with other approaches and can be maintained as the device is scaled up.



H. Levine/Harvard University

In the race to build the first, useful, large-scale quantum computer, researchers are exploring many different routes, each with their own strengths and limitations. Approaches that use neutral atoms offer a scalable system, but the consistency of atom interactions—their quantum fidelity—lags behind that of other

Print

Parallel Implementation of High-Fidelity Multiqubit Gates with Neutral Atoms

Harry Levine, Alexander Keesling, Giulia Semeghini, Ahmed Omran, Tout T. Wang, Sepehr Ebadi, Hannes Bernien, Markus Greiner, Vladan Vuletić, Hannes Pichler, and Mikhail D. Lukin

Phys. Rev. Lett. 123, 170503 (2019)

Published October 22, 2019

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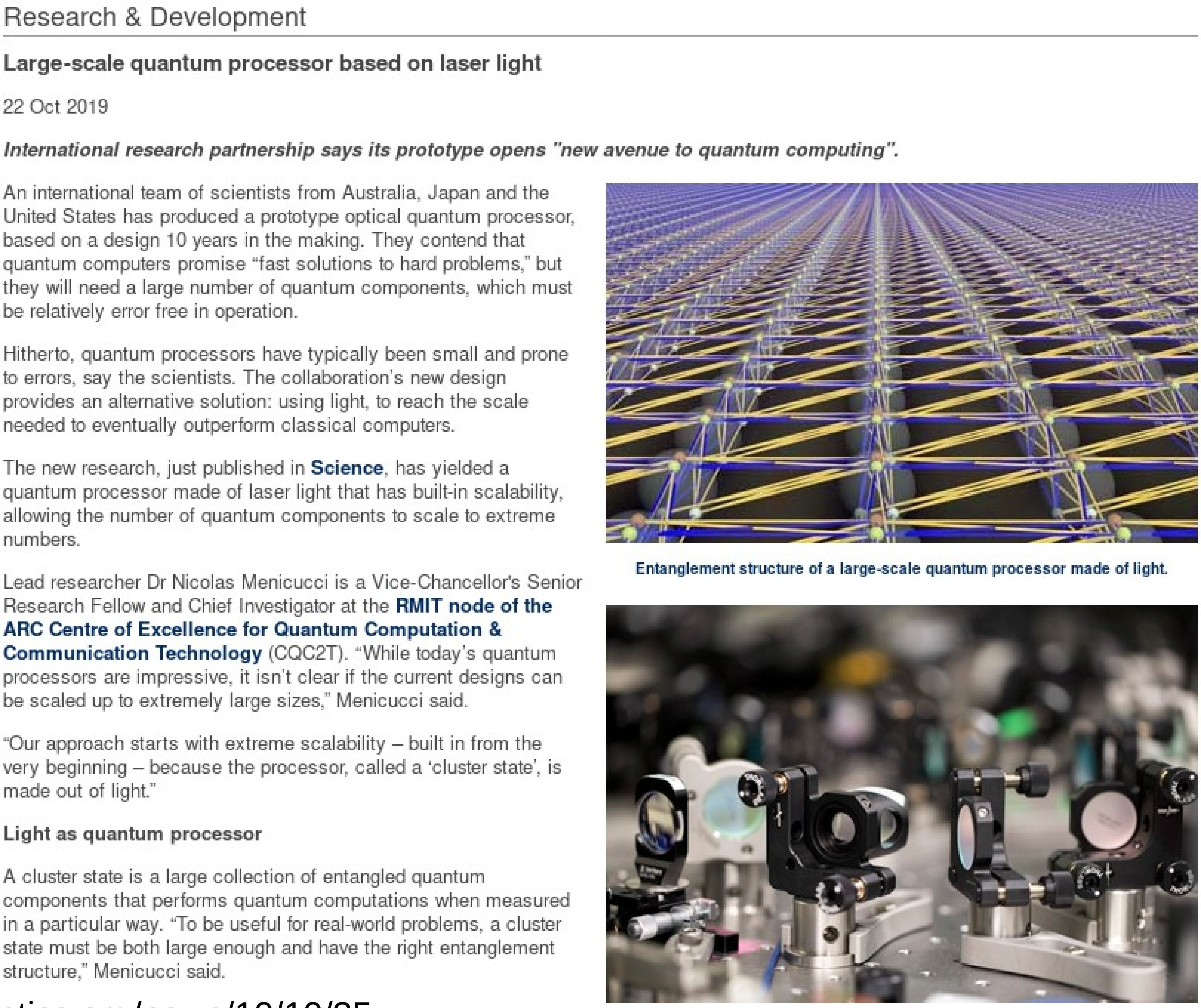

Research & Development

Large-scale quantum processor based on laser light

22 Oct 2019

International research partnership says its prototype opens "new avenue to quantum computing".

An international team of scientists from Australia, Japan and the United States has produced a prototype optical quantum processor, based on a design 10 years in the making. They contend that quantum computers promise “fast solutions to hard problems,” but they will need a large number of quantum components, which must be relatively error free in operation.

Hitherto, quantum processors have typically been small and prone to errors, say the scientists. The collaboration’s new design provides an alternative solution: using light, to reach the scale needed to eventually outperform classical computers.

The new research, just published in **Science**, has yielded a quantum processor made of laser light that has built-in scalability, allowing the number of quantum components to scale to extreme numbers.

Lead researcher Dr Nicolas Menicucci is a Vice-Chancellor's Senior Research Fellow and Chief Investigator at the **RMIT node of the ARC Centre of Excellence for Quantum Computation & Communication Technology** (CQC2T). “While today’s quantum processors are impressive, it isn’t clear if the current designs can be scaled up to extremely large sizes,” Menicucci said.

“Our approach starts with extreme scalability – built in from the very beginning – because the processor, called a ‘cluster state’, is made out of light.”

Light as quantum processor

A cluster state is a large collection of entangled quantum components that performs quantum computations when measured in a particular way. “To be useful for real-world problems, a cluster state must be both large enough and have the right entanglement structure,” Menicucci said.

Entanglement structure of a large-scale quantum processor made of light.

https://optics.org/news/10/10/35