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Xanadu announces programmable photonic quantum chip able to execute multiple algorithms

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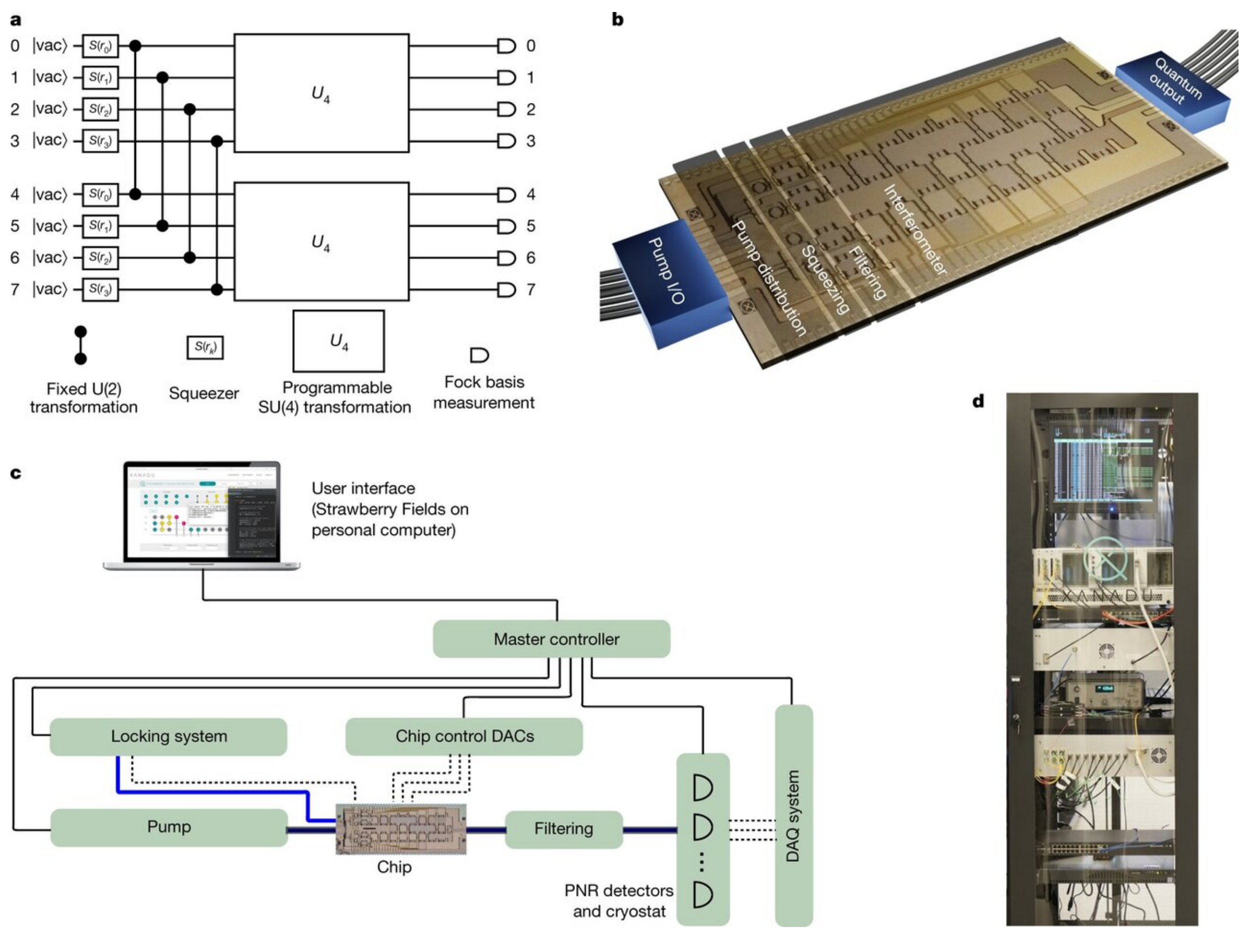

Overview of apparatus. a, Equivalent quantum circuit diagram illustrating the functionality of the photonic hardware. Up to eight modes initialized as vacuum are squeezed with squeezing parameters rk and entangled (via the fixed two-mode unitary transformation U(2) equivalent to a 50/50 beam splitter with the relative input phase set to produce two-mode squeezing at the output) to form two-mode squeezed vacuum states. Programmable four-mode rotation gates (SU(4) transformation, represented by the large boxes labelled U4) are applied to each four-mode subspace. All eight modes are individually read out by measurements in the Fock basis. b, Rendering of the chip (based on a micrograph of the actual device) showing fibre optical inputs and outputs, and on-chip modules for coherent pump power distribution, squeezing, pump filtering and programmable linear optical transformations. c, Schematic of full apparatus and control system. Solid (dashed) black lines indicate digital (analogue) electronic signals; blue lines indicate optical signals. DAC, digital-to-analogue converter; DAQ, data acquisition; PNR, photon number resolving. d, Photograph of entire system (except for photon-number-resolving detector hardware), which has been fitted into a standard server rack. Credit: *Nature* (2021). DOI: 10.1038/s41586-021-03202-1

A team of researchers and engineers at Canadian company Xanadu Quantum Technologies Inc., working with the National Institute of Standards and Technology in the U.S., has developed a programmable, scalable photonic quantum chip that can execute multiple algorithms. In their paper published in the journal *Nature*, the group describes how they made their chip, its characteristics and how it can be used. Ulrik Andersen with the Technical University of Denmark has published a News & Views piece in the same journal issue outlining current research on quantum computers and the work by the team in Canada.

Scientists around the world are working to build a truly useful quantum computer that can perform calculations that would take traditional computers millions of years to carry out. To date, most such efforts have been focused on two main architectures—those based on superconducting electrical circuits and those based on trapped-ion technology. Both have their advantages and disadvantages, and both must operate in a supercooled environment, making them difficult to scale up.

Receiving less attention is work using a photonics-based approach to building a quantum computer. Such an approach has been seen as less feasible because of the problems inherent in generating quantum states and also of transforming such states on demand. One big advantage photonics-based systems would have over the other two architectures is that they would not have to be chilled—they could work at room temperature.

In this new effort, the group at Xanadu has overcome some of the problems associated with photonics-based systems and created a working programmable photonic quantum chip that can execute multiple algorithms and can also be scaled up. They have named it the X8 photonic quantum processing unit. During operation, the chip is connected to what the team at Xanadu describe as a "squeezed light" source—infrared laser pulses working with microscopic resonators. This is because the new system performs continuous variable quantum computing rather than using single-photon generators.

As part of its announcement, Xanadu reps noted that their new system is the first photonic quantum computing platform to be made available to the public. Those wishing to run applications on it can opt for systems running 8 or 12 qubits over Xanadu's quantum cloud.

More information: J. M. Arrazola et al. Quantum circuits with many photons on a programmable nanophotonic chip, *Nature* (2021). DOI: 10.1038/s41586-021-03202-1