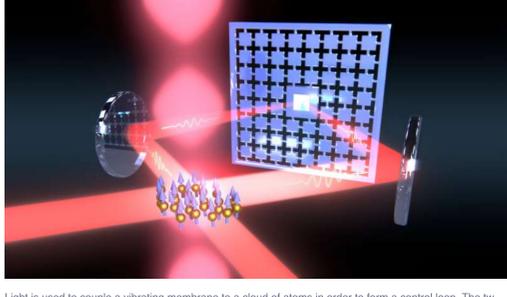


FEBRUARY 2, 2022

Using the principle of coherent feedback to cool a quantum system

by University of Basel



Light is used to couple a vibrating membrane to a cloud of atoms in order to form a control loop. The tw...

We've all experienced the principle of feedback—for example, when we use a thermostat in conjunction with a heating system to regulate indoor temperature. The thermostat measures the current temperature, compares it with the target value and regulates the flow of heat accordingly. Control loops of this kind appear in many areas of everyday life and technology.

← Ads by Google

Send feedback

Why this ad? ▾

They are also useful in the quantum world when it comes to bringing a system into a desired state. For example, it's often necessary to work at very low temperatures—close to absolute zero—in order to observe the sensitive effects of the quantum world and to apply these effects to new technological applications. Classical feedback requires a measurement to be taken within a control loop and only works to

a limited extent in the world of quanta, which differs from the macroscopic world we're familiar with in many respects.

The reason for these limitations is that in quantum systems, the very act of taking a measurement causes a change in the system and therefore leads to uncontrolled backaction. With this in mind, researchers led by Professor Philipp Treutlein from the Department of Physics and the Swiss Nanoscience Institute of the University of Basel have used the principle of coherent feedback to cool a quantum system for the first time—and they have published their results in the journal *Physical Review X*.

Control without measurement

Coherent feedback describes a situation in which two quantum systems interact with one another. As one of the systems acts as a control unit for the other, no measurement is needed. Instead, the control system is configured to bring the target system into a desired state by means of coherent quantum mechanical interaction.

Specifically, the researchers used atoms as a quantum mechanical control system to control the temperature of a macroscopic but very thin vibrating membrane. This process first involves aligning the intrinsic angular momentum (spin) of the atoms in a well-defined direction, which corresponds to a very cold state close to absolute zero. In contrast, the high temperature of the membrane causes it to vibrate strongly. Quantum mechanical interaction allows the atoms and membrane to swap states, causing the membrane to become cold as its energy is transferred to the atoms. Subsequently, however, the atoms can quickly be returned to their initial state using laser light in preparation for another energy transfer from the membrane.

The researchers successfully used this coherent feedback mechanism to reduce the temperature of the oscillating membrane from room temperature to 200 millikelvins (-272.95°C)—that is, a temperature close to absolute zero—within a fraction of a millisecond.

"We use the interaction between the two systems to transfer the membrane into the cold state," explains doctoral student Gian-Luca Schmid, who is first author of the study alongside Chun Tat Ngai, another of Treutlein's doctoral students. "The fascinating thing about these analyses is that we're able to couple a macroscopic system to an atomic quantum system—and control it—over quite a large distance," says Philipp Treutlein.

Delays despite light speed

The relatively large distance between the two quantum systems is an important prerequisite for potential applications in quantum technology, but it also results in tiny delays. Although light travels at light speed, these delays have a clear effect on feedback and make the system more unstable. This results in slightly less cooling of the oscillating membrane than would theoretically be possible in the absence of a delay.

The researchers in Basel are studying phenomena like these at quantum interfaces between atoms and solid-state systems, because hybrid systems of this kind will play an important role in the quantum technology of the future. Potential applications include new types of sensors and quantum networks.

"We're confident that our study will give rise to further practical investigations of coherent feedback in quantum systems," says Treutlein.

Explore further

[Laser loop couples quantum systems over a distance](#)

More information: Gian-Luca Schmid et al, Coherent Feedback Cooling of a Nanomechanical Membrane with Atomic Spins, *Physical Review X* (2022). DOI: 10.1103/PhysRevX.12.011020

Journal information: [Physical Review X](#)

Provided by [University of Basel](#)

15 shares Facebook Twitter Email Feedback to editors

← Ads by Google

Send feedback

Why this ad? ▾



Featured Last Comments Popular

- [IGR J18007-4146 is an intermediate polar, study finds](#)
16 HOURS AGO 0
- [A device based on 3D transistor arrays for collecting intra and inter-cellular recordings](#)
16 HOURS AGO 0
- [Killer whales teach each other how to steal fish from human fisheries](#)
16 HOURS AGO 1
- [Changes measured in prey behavior during loss of apex predators](#)
18 HOURS AGO 0
- [Evidence found for existence of two forms of liquid water](#)
19 HOURS AGO 1

- [Juno and Hubble data reveal electromagnetic 'tug-of-war' lights up Jupiter's upper atmosphere](#)
3 MINUTES AGO
- [Uncrewed Artemis I mission to Moon pushed back](#)
11 HOURS AGO
- [Giant iceberg blocks scientists' study of 'Doomsday Glacier'](#)
11 HOURS AGO
- ['Taste' and 'smell' of coral reefs provide insights into a dynamic ecosystem](#)
11 HOURS AGO
- [Simple, inexpensive, fast and accurate nanosensors pinpoint infectious diseases](#)
11 HOURS AGO
- [Researchers set record by preserving quantum states for more than 5 seconds](#)
11 HOURS AGO
- [New research reveals cadmium's route into chocolate](#)
11 HOURS AGO

Relevant PhysicsForums posts

- [Replacing the Measurement standards \(SI units\)](#)
JAN 30, 2022
- [Is energy an entity?](#)
JAN 30, 2022
- [Tensors and Knots](#)
JAN 30, 2022
- [Can particles in a monatomic material possess/recvie/transmit angular momentum?](#)
JAN 27, 2022
- [Blackbird faster-than-wind vehicle and it's that time to defend basic scientific principles \(again\)](#)
JAN 25, 2022
- [Would a fall from 53 centimeters break the glass from a window?](#)
JAN 24, 2022

[More from Other Physics Topics](#)

Related Stories

- [Laser loop couples quantum systems over a distance](#)
MAY 07, 2020
- [Quantum steering for more precise measurements](#)
APR 23, 2021
- [Researchers find new way of gaining quantum control from loss](#)
JAN 24, 2022
- [How quantum fields could be used to break low-temperature records](#)
JUL 27, 2021
- [Programmable interaction between quantum magnets](#)
NOV 29, 2021
- [Approaching the Heisenberg limit](#)
JUL 14, 2021

Ads by TrendMD

- [Quantum-optical analogies of dimer structures](#)
Jian Wang et al., *Journal of Semiconductors*, 2019
- [Controlling spins in silicon quantum dots](#)
Haibin Li et al., *Journal of Semiconductors*, 2020
- [A simulation-based method to investigate occupant-centric controls](#)
Mohamed M. Ouf et al., *Building Simulation*, 2021
- [Cavity optomechanical system—a powerful platform for investigating quantum effects](#)
Bai et al., *Fundamental Research*, 2021
- [Sequential afatinib and osimertinib in patients with EGFR mutation-positive NSCLC and acquired T790M: A global non-interventional study \(UpSWinG\)](#)
Popat et al., *Lung Cancer*, 2021
- [Silicon carbide based quantum networking](#)
Xu et al., *Fundamental Research*, 2021

I consent to the use of Google Analytics and related cookies across the TrendMD network (widget, website, blog). [Learn more](#)

Yes No

Load comments (0)

More news stories

- [Juno and Hubble data reveal electromagnetic 'tug-of-war' lights up Jupiter's upper atmosphere](#)
New Leicester space research has revealed, for the first time, a complex 'tug-of-war' lights up aurorae in Jupiter's upper atmosphere, using a combination of data from NASA's Juno probe and the Hubble Space Telescope.
PLANETARY SCIENCES 3 MINUTES AGO 0 0
- [Scientists engineer new material that can absorb and release enormous amounts of energy](#)
A team of researchers from the University of Massachusetts Amherst recently announced in the Proceedings of the National Academy of Sciences that they had engineered a new rubber-like solid substance that has surprising qualities. ...
MATERIALS SCIENCE 15 HOURS AGO 8 1189
- [A device based on 3D transistor arrays for collecting intra and inter-cellular recordings](#)
Animal cells can use elements or ions to generate electrical impulses. These impulses are then conveyed from one cell to another, traveling across cellular networks.
NANOPHYSICS 16 HOURS AGO 0 44
- [Researchers set record by preserving quantum states for more than 5 seconds](#)
Quantum science holds promise for many technological applications, such as building hackerproof communication networks or quantum computers that could accelerate new drug discovery. These applications require a quantum version ...
QUANTUM PHYSICS 11 HOURS AGO 0 203
- [Shocked zircon find a 'one-off gift' from Mars](#)
Curtin University researchers studying a Martian meteorite have found the first evidence of high-intensity damage caused by asteroid impact, in findings that have implications for understanding when conditions suitable for ...
PLANETARY SCIENCES 14 HOURS AGO 0 90
- [Two-dimensional polymer helps create a new lightweight material that is stronger than steel](#)
Using a novel polymerization process, MIT chemical engineers have created a new material that is stronger than steel and as light as plastic, and can be easily manufactured in large quantities.
MATERIALS SCIENCE 17 HOURS AGO 2 1273
- [Novel method simulates tens of thousands of bubbles in foamy flows](#)
Bubbles aren't just for bath time. Bubbles, specifically bubbles in foamy flows, are critical for many industrial processes, including the production of food and cosmetics and drug development and delivery. But the behavior ...
GENERAL PHYSICS 14 HOURS AGO 0 80
- ['Quantum friction' slows water flow through carbon nanotubes, resolving long-standing fluid dynamics mystery](#)
For 15 years, scientists have been baffled by the mysterious way water flows through the tiny passages of carbon nanotubes—pipes with walls that can be just one atom thick. The streams have confounded all theories of fluid ...
NANOPHYSICS 17 HOURS AGO 0 507

Unsere aktuellen Angebote
EURONICS Bühler

- [IGR J18007-4146 is an intermediate polar, study finds](#)
Using ESA's XMM-Newton and NASA's NuSTAR spacecraft, astronomers have observed a galactic neutron star and NASA's IGR J18007-4146. The observational campaign has found that this source is an intermediate polar. The finding is ...
ASTRONOMY 16 HOURS AGO 0 76
- [Astronomers offer theory about mysterious location of massive stars](#)
Astronomers from Georgia State University have found an explanation for the strange occurrence of massive stars located far from their birthplace in the disk of our Milky Way Galaxy.
ASTRONOMY 11 HOURS AGO 3 289
- [Uncrewed Artemis I mission to Moon pushed back](#)
The first mission in NASA's program to take humans back to the Moon has been delayed until spring at the earliest, the US space agency said Wednesday, saying it needed more time to complete safety checks.
SPACE EXPLORATION 11 HOURS AGO 2 111
- [New research reveals cadmium's route into chocolate](#)
Commited chocoholics, be warned. A health-robbing heavy metal, cadmium, lurks in the velvety recesses of your favorite indulgence.
ECOLOGY 11 HOURS AGO 1 181
- [Giant iceberg blocks scientists' study of 'Doomsday Glacier'](#)
Antarctica's so-called Doomsday Glacier, nicknamed because it is huge and coming apart, is mostly thwarting an international effort to figure out how dangerously vulnerable it is.
ENVIRONMENT 11 HOURS AGO 1 24
- [Scientists develop 'exceptional' surface to explore exotic physics](#)
By demonstrating exceptional control of an open optical system, an international research team has provided a path to experimentally measure and test exotic phenomena and gain insights into new physics with exquisite sensitivity.
OPTICS & PHOTONICS 11 HOURS AGO 0 99
- [Simple, inexpensive, fast and accurate nanosensors pinpoint infectious diseases](#)
In recent years, deadly infectious diseases, including Ebola and COVID-19, have emerged to cause widespread human devastation. Although researchers have developed a range of sophisticated methods to detect such infections, ...
BIO & MEDICINE 11 HOURS AGO 0 74
- ['Taste' and 'smell' of coral reefs provide insights into a dynamic ecosystem](#)
Coral reefs are hotspots of biodiversity and are amazingly productive, with a vast number of organisms interacting simultaneously. Hundreds of molecules that are made by important members of the coral reef community were ...
PLANTS & ANIMALS 11 HOURS AGO 0 82

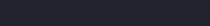
Entdecken Sie unsere Angebote
EURONICS Bühler

- [Medical Xpress](#)
Medical research advances and health news
- [Tech Xplore](#)
The latest engineering, electronics and technical advances
- [Science X](#)
The most comprehensive sci-tech news coverage on the web

Newsletters

Email

Follow us



Science X Daily and the Weekly Email Newsletter are free features that allow you to receive your favorite sci-tech news updates in your email inbox

- Top
- Home
- Search
- Mobile version
- Help
- FAQ
- About
- Contact
- Science X Account
- Sponsored Account
- Archive
- News wire
- Android app
- iOS app
- RSS feeds
- Push notification