Artist's conception of a chip-based "tractor beam."

S. Wilcox, MIT Research Laboratory of Electronics

DEVICES

Optical Tweezers on an Integrated Chip

New device uses an optical phased array to manipulate particles from a greater distance.

Researchers have developed an integrated "tractor beam" that performs the work of optical tweezers on a photonic chip without a benchtop setup (Nat. Commun., doi: 10.1038/s41467-024-52273-x). The new device allows the manipulation of particles more than 100 times farther from the chip surface than in previous experiments.

Optical trapping of particles has given scientists the opportunity to manipulate individual protein strands and other tiny objects without actually touching them. Standard optical tweezers, however, have required bulky, specialized lasers and other equipment.

In the current work, the team designed an optical phased array (OPA) with a hyperbolic phase distribution that creates a tightly focused radiation pattern some 5 mm above the array, which was patterned on a silicon-on-insulator wafer. The OPA operates at a center wavelength of 1500 nm, but to steer a microparticle or cell, the researchers varied the input wavelength to alter the effective period of the array's tiny antennas, changing their angle of radiation emission.

After calibrating the trapping force of the OPA chip, the researchers practiced moving polystyrene microspheres with the optical tweezers. Finally, the team demonstrated selecting and stretching individual mouse cells, which took a wavelength change of 0.6 nm. —*Patricia Daukantas*

optica-opn.org/news/1224-tweezers

OPTICS

Augmented Reality Comes into Focus

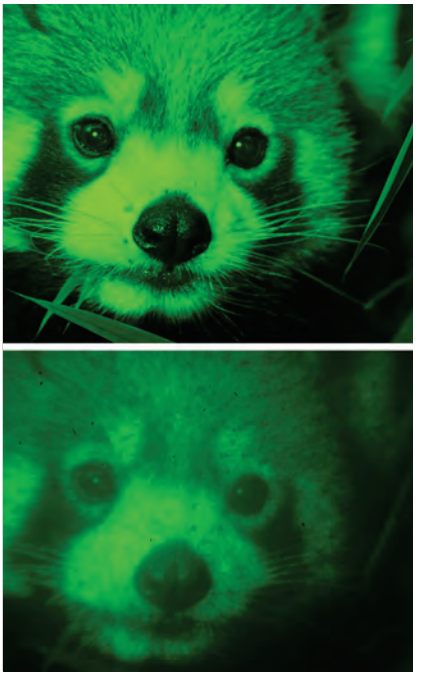
New combination of a metasurface and conventional lenses could allow the technology to be used in glasses.

Although AR is already used for head-up displays in cars, size constraints make the technology less suited to standard glasses. That is because multiple lenses are needed for a reasonable field of view, which increases the length of a device. Now, researchers have shown how to reduce the size of such a system while maintaining a wide field of view and minimal distortion (ACS Photonics, doi: 10.1021/acsphotonics.4c00989).

The team made a device that shines green light from a micro light-emitting diode onto a silicon–nitride metasurface and then through a double-sided aspherical lens made from a synthetic polymer. The metasurface has a diameter of 3.2 mm and feature sizes as small as 100 nm. The whole device is just under 8 mm long.

To test the system, the researchers projected the image it generated onto a white screen and analyzed point-spread functions. The team found it could achieve excellent resolution with minimal aberrations and distortion across a 30° field of view. They then tested the device as if it were inside the arm of a pair of glasses by directing its output at the in-coupling region of an eyepiece doubling up as a waveguide. This yielded an image measuring 28 × 17 mm.

However, meta/refractive hybrid lenses will always exhibit some residual aberration that is brought about by imperfections in the metasurface and aspherical lens, as well as misalignment between the device's various components. To try to minimize the impact of this aberration, they employed a neural network to compare the original and degraded images.



AR display uses a metasurface and an aspherical lens to convert an original image (top) into a projected image.

Adapted from ACS Photonics 2024, DOI: 10.1021/acsphotonics.4c00989

In tests using an image of a raccoon, they found that the corrected image had a significantly higher peak signal-to-noise ratio than the uncorrected one, and it was also a closer fit to the original, with details becoming more visible. —*Edwin Cartlidge*

optica-opn.org/news/1224-hybrid-lens

As of 2021, there were **1.5 billion** AR consumers globally. This number is projected to grow to **4.3 billion** by 2025.

Simon Mahler fits the laser device onto graduate student Yu Xi Huang.

Caltech

BIOMEDICINE

Stroke-Risk Test

A head-mounted laser system can reportedly assess a patient's risk of future stroke (Biomed. Opt. Express, doi: 10.1364/BOE.534796). The device, which consists only of a laser diode and a standard camera chip, exploits speckle-contrast optical spectroscopy.

The technique works by shining infrared laser light onto the skull, and then detecting the light after it has traveled through the brain. The loss in light intensity indicates the volume of blood in the brain's vascular system, while the rate of blood flow can be determined from the speckle patterns produced by light scattering from the blood vessels.

To test the system, the researchers measured the blood flow and volume in 50 volunteers of differing stroke risk for three minutes. After the first minute, the participants held their breath to force the body to pump more blood into the brain.

There was a smaller increase in the rate of blood flow when low-risk individuals held their breath, but a larger increase in the volume of blood, indicating that blood vessels had widened. In high-risk patients, the blood vessels are less able to expand and blood must flow more quickly to deliver enough oxygen. —*Susan Curtis*

optica-opn.org/news/1224-stroke

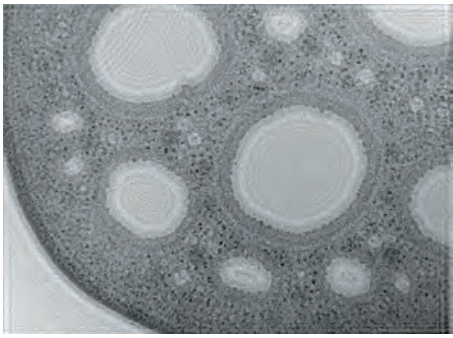
IMAGING

Smartphones Yield 3D Images

A scientist has devised a new way to reconstruct holograms on a smartphone in close to real time using an Android-based application that he designed (Appl. Opt., doi: 10.1364/AO.532972).

The system relies on a separate optical device to record the holograms, containing a semiconductor laser and standard USB camera. Key to the scheme is a simplified form of digital holography better suited to smartphones, which tend to have limited processing and memory capabilities. This "band-limited double-step Fresnel diffraction" involves creating a virtual plane between the hologram and image planes, and then placing that imaginary surface at whatever distance is required to yield a given sampling rate at the image plane.

To test the smartphone-based system, the researcher used it to image a leaf from a pine tree. He showed that it could accurately reproduce both the object's amplitude and phase information, and he found that while holography using convolution-based diffraction yielded about 0.7 frames per second, the double-step method instead reached about 1.9 frames per second.



A hologram of a pine tree leaf created on a smartphone with a simple optical system.

Y. Nagahama

What's more, he also showed it was possible to zoom in on and out of the reconstructed image by pinching the phone's touch screen. He enabled this feature by using what are known as scalable diffraction calculations. —*Edwin Cartlidge*

optica-opn.org/news/1224-pine

In the Spotlight ...

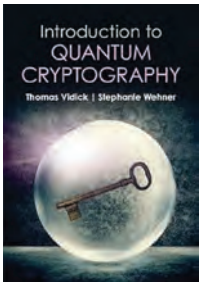
Here is some interesting research recently highlighted in Optica Publishing Group's *Spotlight on Optics*:

Tomas Tyc summarizes a study in JOSA A that examines **the geometric construction of images deformed from relativistic distortion and light ray propagation**.

Shakil Rehmanut covers an *Optics Express* paper demonstrating **depth reconstruction via recording depth data through frequency-modulated continuous-wave illumination of a scene**.

For more on this and other research in the spotlight, visit **opg.optica.org/spotlight.**

Introduction to Quantum Cryptography

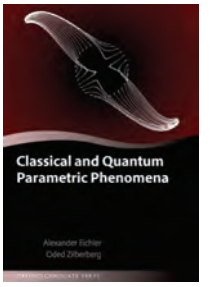


Thomas Vidick and Stephanie Wehner, Cambridge University Press, 2023

This exciting, clearly written and self-contained textbook is derived from an online course (the MOOC "Quantum Cryptography" on edX). It is an ideal way for those interested in quantum cryptography to enter the field with no prior knowledge and emerge with the understanding and the tools to progress. This book also offers readers access to current literature and the opportunity to derive new quantum cryptography protocols. The basic problem covered is how to use quantum phenomena to develop protocols that permit communication of information with various degrees of security. The authors provide the quantum information and the mathematical background for the reader to delve into. Furthermore, quantum key distribution protocols are clearly explained and illustrated, and the pedagogical features of the book are outstanding. Each chapter contains a clear exposition, illustrations, worked examples, quizzes, homework exercises with answers, cheat sheets that summarize important mathematical results, chapter notes with suggested reading and online videos and exercises. Following my perusal of this book, I highly recommend it to others.

Review by Barry R. Masters, Fellow of AAAS, Optica and SPIE.

Classical and Quantum Parametric Phenomena



Alexander Eichler and Oded Zilberberg, Oxford University Press, 2023

This book is primarily aimed at physicists at the graduate level who are interested in phenomena that arise when parametric pumping is applied to oscillators (parametric amplification, noise squeezing, spontaneous symmetry breaking, activated switching, cat states and Ising spin lattices). For this purpose, the authors rely on nonlinear and stochastic dynamics, mode coupling and quantum mechanics. The book contains a cogent discussion of the different subjects in the context of exercises based on numerical Python codes; this will be especially useful for self-teaching.

Review by Christian Brosseau, Optica Fellow and professor of physics, Université de Bretagne Occidentale, Brest, France.

The opinions expressed in the book review section are those of the reviewer and do not necessarily reflect those of OPN or its publisher, Optica. Read the full reviews at ***optica-opn.org/books****.*

ACQUISITION

Synopsys Sells OSG

Synopsys, a Silicon Valley–based electronic design automation software specialist, announced on 19 September a definitive agreement to sell its Optical Solutions Group (OSG) to Keysight Technologies, USA. According to a Synopsys press release, the sale was "determined to be a necessary step" toward regulatory approval of its proposed acquisition of Ansys, USA.

Once completed, the Ansys acquisition is expected to increase Synopsys' total addressable market by 50%, to about US$28 billion. The Keysight sale is subject to customary closing conditions, including review by regulatory authorities and the successful closing of Synopsys' acquisition of Ansys, which is expected in the first half of 2025.

Keysight provides electronic design and test solutions for the commercial communications, aerospace, defense and government, and electronic industrial markets. The firm says it expects the addition of OSG, which it calls a "complementary business," to broaden its existing software portfolio and build on core expertise.

optica-opn.org/news/1224-osg

Courtesy of Synopsys

FUNDING

New Luminate Winners

Business accelerator Luminate NY has named the winners in its Round Seven competition. Taking top honors as "Company of the Year" was Nicslab, an early-stage firm focused on novel approaches to compact photonic/electronic integration on semiconductor chips.

As the winner of this year's competition, Nicslab will rake in US$1 million in funding from the state of New York, through the state's Finger Lakes Forward Upstate Revitalization Initiative. The program also will sprinkle an additional US$1 million on five other companies honored at the 2024 Luminate Finals on 26 September. To receive the funding, all winners must commit to establishing operations in the region surrounding Rochester, NY, for a minimum of the next 18 months.

Now administered by the technology incubator NextCorps, Luminate NY launched in 2017, and since then has annually tapped 10 promising startups at the beginning of each year. The companies each receive an initial investment of US$100,000, and come to Rochester for a six-month intensive boot camp aimed at bringing their ideas closer to commercialization. At the end of the process, the participants give a pitch to sell their ideas to industry and venture-capital judges for the chance to receive more funding.

Having completed its seventh round, Luminate now has 70 companies in its portfolio, into which it has invested a total of US$18.6 million. And the finalists in the competition each year offer a revealing glimpse at what's hot or top-of-mind in the optics and photonics community.

Nicslab cofounders Anggi Utami (left) and Andri Mahendra at the Luminate Finals.

Luminate NY

For example, Nicslab is a "fabless" semiconductor firm focused on integrated photonic and electronic circuits, for markets including "artificial intelligence (AI), data centers, autonomous vehicle, space, and semiconductor applications," according to a Luminate press release. The company's products, Luminate says, combine power supply, signal processing, sensing and electronic control systems into a compact, chip-scale solution with "unparalleled accuracy, up to 1,000 more channels, and at 3x the cost efficiency."

Interestingly, Nicslab, in contrast to some other startups supported by Luminate, has reportedly already gained some traction in the industry, garnering sizable orders from existing semiconductor foundries and several government contracts. According to its founder and CEO Andri Mahendra, the company plans to use the new US$1 million in Luminate funding to scale up and drive manufacturing and development of its products.

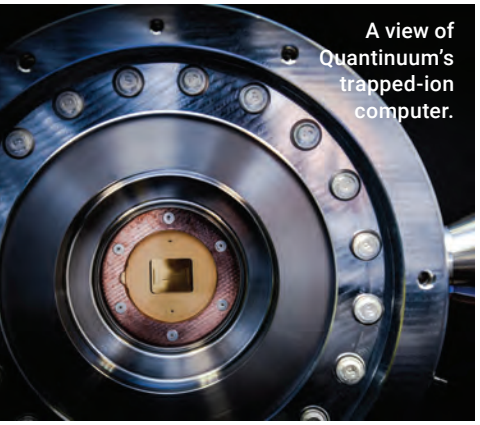
optica-opn.org/news/1224-luminate

TECHNOLOGY

Quantum Teleportation of a Logical Qubit

A team at the quantum computing company Quantinuum has reportedly achieved the high-fidelity, fault-tolerant teleportation of a quantum state encoded in a so-called logical qubit (Science, doi: 10.1126/science.adp6016). The researchers argue that their feat constitutes "the state of the art" in quantum error correction and an important step on the road toward scaling up trapped-ion platforms into universal, fault-tolerant quantum computers.

Previous teleportation demonstrations have involved individual physical qubits, and the fragile nature of quantum information means that the process is highly prone to error. One way to get around such errors would be to encode the quantum state not in a physical qubit such as a photon, atom or ion, but in a logical qubit. Such a qubit is essentially an ensemble of multiple physical qubits whose collective state mimics that of one qubit—but on which quantum error correction (QEC) codes can be run on the fly to keep it as stable and fault-tolerant as possible.



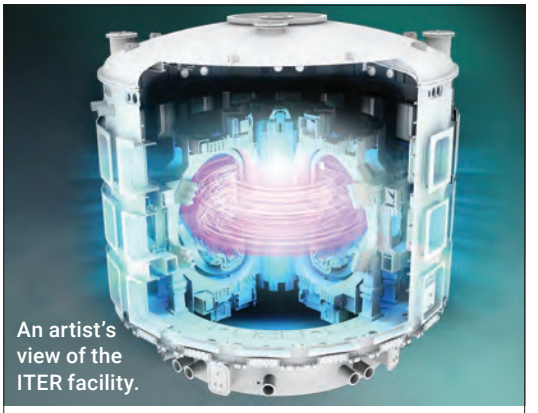
A view of Quantinuum's trapped-ion computer.

Quantinuum

The Quantinuum team now says it has demonstrated one version of such an enabling result. In a blog post, the firm calls it "the first time that an arbitrary quantum state has been teleported at the logical level," and "the first demonstration of a fully fault-tolerant version of the state teleportation circuit using real-time quantum error correction."

The new experiments involved using Quantinuum's 30-qubit H2 trapped-ion processor to create and teleport logical qubits with error correction, under two separate schemes. One scheme, using so-called transversal circuits, involved the inclusion of error-checking "QEC gadgets" as part of the circuit, to enable errors to be caught and corrected in real time. The other scheme, "lattice surgery," is a simpler setup relying on 2D nearest-neighbor interactions that is logically equivalent to transversal circuits but uses fewer resources. The company maintains that the ability to test these two different circuit types testifies to the flexibility of the Quantinuum processor's "quantum charge-coupled device" architecture.

optica-opn.org/news/1224-quantinuum



An artist's view of the ITER facility.

©European Joint Undertaking for ITER and the Development of Fusion Energy

MARKETS

Photonics21 Study on Fusion Energy

European public–private partnership Photonics21 has released a report highlighting the role of photonics in the development of fusion energy.

The study is forthright about the obstacles still ahead on the path toward cost-effective, workable fusion power, including the materials used to surround and contain the fusion reaction, which would degrade and weaken structures built using industry-scale materials available today. The report also points to difficulties in practical extraction and use of heat from fusion reactions, the challenge of industrial scale-up of what are currently demonstration projects, and the scarcity of the tritium needed for fuel.

From the point of view of opportunities for the photonics business, the new report suggests that these practical industrial challenges may be a feature, not a bug. The authors write that lasers and photonics-based systems will be required in a range of areas to scale up nuclear fusion, including high-precision laser-based manufacturing and photonics-based instrumentation and control systems.

optica-opn.org/news/1224-fusion

Edwin Cartlidge, Susan Curtis, Patricia Daukantas, Meeri Kim and Stewart Wills are freelance science writers. Alessia Kirkland, Hannah Lanford and Rachel Sender are OPN staff contributors.