optics.org
the business of photonics

SPRING 2024

QUANTUM FOCUS

Your gateway to the latest advances in Quantum technology

China-Europe group creates customizable waveguide arrays to drive photonic systems

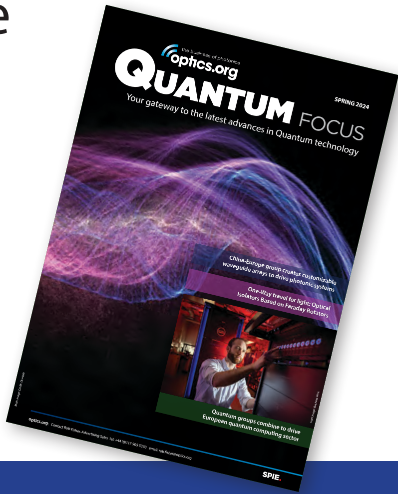
One-way travel for optical isolators based on Faraday rotators

Quantum groups combine to drive European quantum computing sector

Main image: Credit: Devrimb


IN THE ART OF
MAKING LASERS
For Quantum
Cobolt Qu-T.
Compact Tunable Lasers.
C-WAVE.
Widely Tunable Lasers.
Ampheia.
High Power, Ultra Low noise Lasers.
Cobolt.
High-Speed Modulated Lasers.
High performance – concretely speaking
CW to fs lasers for advanced imaging, detection and analysis.
HÜBNER Photonics offers a full range of high performance lasers including single and multi-line Cobolt lasers (including the Cobolt Qu-T compact tunable laser), tunable C-WAVE lasers, C-FLEX laser combiners, VALO femtosecond fiber lasers along with the Ampheia fiber amplifiers.
HÜBNER Photonics
hubner-photonics.com
HÜBNER
ENESTEDT.SE

Quantum groups worldwide collaborate to drive this new tech sector forward



This issue's handpicked selection of quantum sector application and research news reflects a strong sense of cooperation between international groups experiencing the benefits of working together to progress quantum-related developments. For example, in the European quantum computing sector, ORCA Computing, Pixel Photonics, Sparrow Quantum, and the Niels Bohr Institute have announced the new Eurostars project "SupremeQ". The initiative is bringing together quantum experts with the shared goal of commercializing of photonic quantum computing technologies (page 5). In the same vein a new China-Europe group has co-developed customizable waveguide arrays to drive photonic systems. Their work has implications from mode lasing, to data transmission, and quantum optics ***(page 4)*****.**

In this issue

Optical isolators are quietly playing a pivotal role in minimizing the effects of back-reflected light on the stability of a laser system. Toptica Photonics explains how these devices transmit light in one direction while preventing transmission in the reverse direction: this component is a key part of photonic infrastructure for noise-sensitive quantum applications *(page 6)*.

Max-Planck progresses UV spectroscopy with high-resolution dual-comb method; scientists in the group of Nathalie Picqué at the Max-Planck Institute of Quantum Optics, Garching, Germany, say they have made a significant leap in the field of ultraviolet spectroscopy by successfully implementing high-resolution linear-absorption dual-comb spectroscopy in the UV spectral range *(page 8)*.

The University of Twente, Netherlands, is coordinating a project called 'QU-PIC' project, which is intended to accelerate the development of quantum computing systems. They say the aim is to "establish European sovereignty with a toolbox of PIC quantum building blocks" *(page 11)*.

Quintessent has landed $11.5 million to advance optical interconnects; the spin-out from John Bowers' photonics research group at the University of California, Santa Barbara, has closed an oversubscribed funding round. The investment will support its development of high-speed optical interconnects incorporating heterogeneous silicon photonics and quantum dot lasers *(page 12)*.

And Quantum Computing Inc., based in Hoboken, NJ, a developer of quantum optics and nanophotonics technology, has won a $200,000 order for its quantum lidar prototype from Johns Hopkins University *(page 11)*.

In research news, ICFO has developed QUIONE, a quantum simulator that observes individual atoms. The scientists, based in Barcelona, Spain, have built their own quantum-gas microscope, named QUIONE after the Greek goddess of snow. The group explains how their microscope is "the only one able to image individual atoms of strontium quantum gases in the world" *(page 14)*.

Matthew Peach, Editor in Chief
matthew.peach@optics.org

This Issue

plus the latest product launches from within the industry

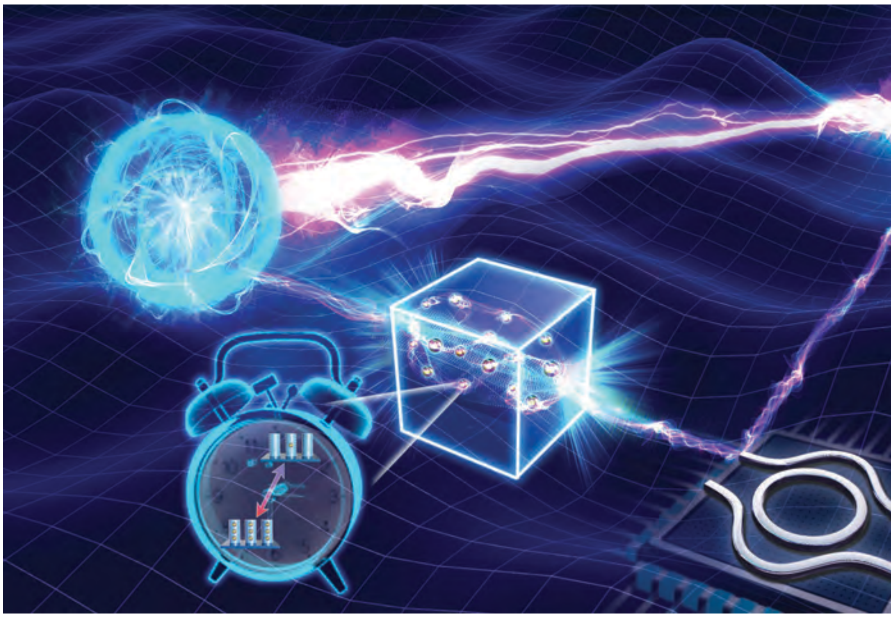


Photo credit: The group of Prof. Xiao-Song Ma, Nanjing Univ.

Researchers moving toward networked quantum devices

Networking is everything. To realize their full potential, quantum devices must be networked, and in principle this can be done using the fiber optic networks employed for classical telecommunications.

See article page 11.

China-Europe group creates customizable waveguide arrays to drive photonic systems

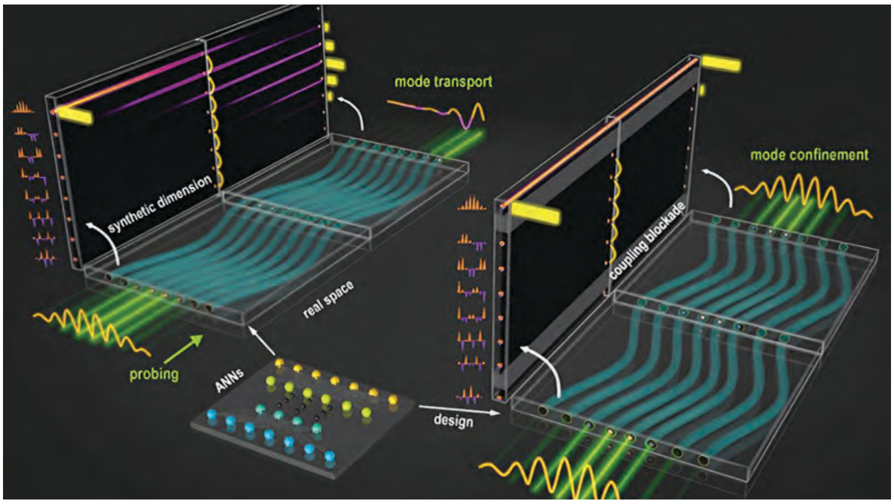
With implications ranging from mode lasing, to data transmission, and quantum optics.

In the realm of physics, synthetic dimensions (SDs) have emerged as one of the frontiers of active research, offering a pathway to explore phenomena in higher-dimensional spaces, beyond the conventional 3D geometrical space. The concept has gained significant attention, especially in topological photonics, due to its potential to unlock rich physics inaccessible in traditional dimensions.

Researchers have proposed various theoretical frameworks to study and implement SDs, aiming at harnessing phenomena like synthetic gauge fields, quantum Hall physics, discrete solitons, and topological phase transitions in four dimensions or higher. Those proposals could lead to new fundamental understandings in physics.

One of the primary challenges in conventional 3D space is the experimental realization of complex lattice structures with specific couplings. SDs offer a solution, by providing a more accessible platform for creating intricate networks of resonators with anisotropic, long-range, or dissipative couplings. This capability has already led to groundbreaking demonstrations of non-Hermitian topological winding, parity-time symmetry, and other phenomena.

A variety of parameters or degrees of freedom within a system, such as frequency modes, spatial modes, and orbital angular momenta, can be used to construct SDs, promising for applications in diverse fields ranging from optical communications to topological insulator lasers.



Credit: Advanced Photonics (2024). DOI: 10.1117/1.AP.6.2.026005

Deep learning empowers light manipulation in a synthetic dimension.

A key goal in this field is the construction of a "utopian" network of resonators where any pair of modes can be coupled in a controlled manner. Achieving this goal necessitates precise mode manipulation within photonic systems, offering avenues for enhancing data transmission, energy harvesting efficiency, and laser array radiance.

Customizable arrays

Now, as reported in Advanced Photonics, an international team of researchers has created customizable arrays of waveguides to establish synthetic modal dimensions.

This advance allows for effective control of light in a photonic system, without the need for complicated extra features like nonlinearity or non-Hermiticity. Professor Zhigang Chen of Nankai University commented, "The ability to adjust different modes of light within the system brings us a step closer to achieving utopian networks, where all parameters of an experiment are perfectly controllable."

In their work, the researchers modulate perturbations (described as "wiggling frequencies") for propagations that match the differences between different modes of light. To do so, they employ artificial neural networks (ANNs) to design waveguide arrays in real space. The ANNs are trained to create waveguide setups that have exactly the desired mode patterns. These tests help reveal how light propagates and gets confined within the arrays.

Finally, the researchers demonstrate the use of ANNs to design a special type of photonic lattice structure called a Su-Schrieffer-Heeger (SSH) lattice. This lattice has a specific feature enabling topological control of light throughout the system. This allows them to change the bulk mode in which light travels, showcasing the unique properties of their synthetic dimensions.

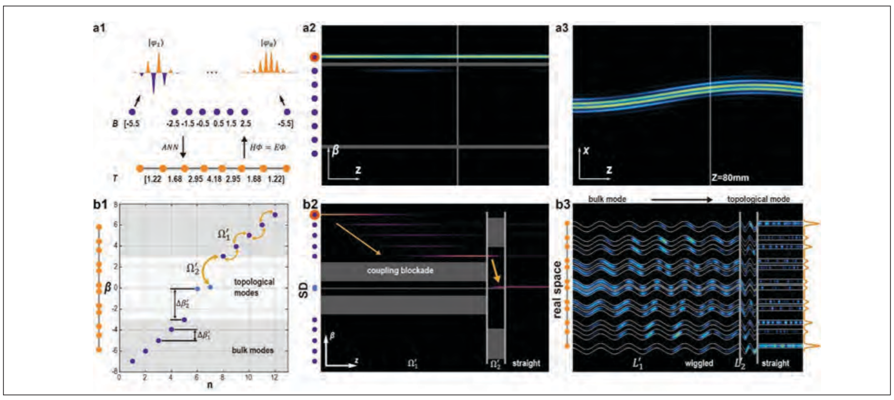
The implication of this work is substantial. By fine-tuning waveguide distances and frequencies, the researchers aim to optimize the design and fabrication of integrated photonic devices.

Professor Hrvoje Buljan of University of Zagreb commented, "Beyond photonics, this work offers a glimpse into geometrically inaccessible physics. It holds promise for applications ranging from mode lasing to quantum optics and data transmission."

Both Chen and Buljan note that the interplay of topological photonics and synthetic dimension photonics empowered by ANNs opens new possibilities for discoveries that may lead to unprecedented materials and device applications.

● This article was first published on **spie.org.**

Advanced Photonics (2024). DOI: 10.1117/1.AP.6.2.026005



Credit: Advanced Photonics (2024). DOI: 10.1117/1.AP.6.2.026005

Mode confinement and topological mode morphing in a synthetic dimension designed by ANNs. (a) Illustration of the mode arrays with outlying edges of eigenvalues. (a1) Sketch of the eigenvalue array and corresponding eigenmodes. The arrangement of the coupling array in real space is calculated by ANNs. (a2) The mode evolution dynamics in SD; the orange dot in the left column indicates the excited mode. (a3) Corresponding beam propagation dynamics in real space. (b) Mode morphing in a nontrivial lattice designed by ANNs. (b1) Lattice illustration in real space and corresponding eigenvalue distribution. (b2) Mode evolution during propagation in SD; shaded zones indicate the coupling blockades in SDs in different regions. (b3) Evolution of light in real space and morphing into a topological mode; the plot on the right shows the average intensity distribution in the straight waveguide region.

Quantum groups combine to drive European quantum computing sector

ORCA, Pixel Photonics, Sparrow Q, Niels Bohr Inst. work on 'SupremeQ' Eurostars project.

ORCA Computing, Pixel Photonics, Sparrow Quantum, and the Niels Bohr Institute (NBI) have announced their collaboration on the Eurostars project "SupremeQ". The initiative is bringing together quantum experts from the UK, Germany, and Denmark with the shared goal of "accelerating the development and commercialization of photonic quantum computing technologies to deliver quantum advantage".

Supported by Eurostars, a European funding program dedicated to assisting R&D-performing SMEs in developing marketable innovative products, processes, and services, the SupremeQ project will harness world-leading expertise.

The project's launch statement says, "It will draw upon single-photon sources from Sparrow Quantum and NBI, single-photon detectors from Pixel Photonics, and full-stack photonic quantum computing system architecture from ORCA Computing. By uniting efforts, the SupremeQ consortium aims to drive breakthrough innovation in photonic quantum computing, paving the way for quantum advantage."

'Growing market demand'

According to a report by analyst Fortune Business Insights, "the quantum computing market is forecasted to reach $6.5 billion by 2030 with a CAGR of 32.1%".

With a broad range of potential application areas offering significant advantages over current classical computations. The SupremeQ project aims to address the needs of this growing market demand for quantum computing capabilities by addressing key challenges such as system engineering for scale, high acquisition, and operation costs, as well as the need for specialized expertise.

By pioneering solutions for photonic quantum computing, the project aims to unveil groundbreaking innovations in performance, packaging, and system integration. Sparrow Quantum's single-photon sources and Pixel Photonics' detectors will be engineered to co-exist within a single cryostat.

With reduced complexity and enhanced component proximity, this crucial milestone heralds the path to multiplying qubits while offering considerable manufacturability and cost advantages.

ORCA Computing will draw upon its deep knowledge in quantum photonic system architecture. This expertise will be used to integrate these developments and demonstrate state-of-the-art photon processing efficiencies and reconfigurability within a standard data center rack.

These advances are necessary for the commercialization of quantum computers to reach advantage over classical computing systems signifying a significant leap toward achieving universal fault-tolerant quantum computing.

As the quantum computing market continues to evolve, the consortium is confident that their innovative SupremeQ solutions will generate considerable interest, driving diverse applications and accelerating the widespread adoption of quantum technologies across industries well beyond the conclusion of the Eurostars program.

ORCA PT-1 computer in assembly room.

(Photo: Business Wire)

Consortium perspectives

"I envision SupremeQ as a symphony of quantum brilliance, with each partner playing a unique instrument," said Dr. Kurt Stokbro, CEO of Sparrow Quantum. "Together, we're composing a masterpiece that I believe will make some noise around the world."

Nicolai Walter, CEO of Pixel Photonics, commented, "The advancements made possible through the SupremeQ project represent a significant leap forward in quantum computing technology. By combining cutting-edge components and innovative architecture, we will be well-positioned to redefine the boundaries of what is possible in quantum computing."

Richard Murray, CEO of ORCA Computing, said, "With its unparalleled performance, the outcome of this project will spearhead new frontiers in hybrid quantum-classical computation, driving significant advancements in machine learning and optimization."

And Peter Lodahl, Professor at the Niels Bohr Institute, added, "We are thrilled to collaborate with esteemed industry partners on the SupremeQ project, which represents a significant step forward in quantum computing innovation."

Author:
Matthew Peach, Editor in Chief, optics.org

One-way travel for light optical isolators based on Faraday rotators

In photonics and quantum physics, optical isolators quietly play a pivotal role in minimizing the effects of back-reflected light on the stability of a laser system. These devices transmit light in one direction while preventing transmission in the reverse direction. This simple optical component is a key part of photonic infrastructure for noise-sensitive quantum applications.

Most materials interact with light symmetrically, exhibiting similar behaviors for light traveling in opposite directions. Even a half-silvered mirror transmits light in both directions, requiring the suspect line-up in your favorite cop drama to occur in a well-lit room, so reflections obscure the witness on the other side. Optical isolators are different – they exploit a phenomenon first observed by Michael Faraday in 1845.

The Verdet constant is rarely constant in wavelength, making the operating wavelength another important design parameter. An optical isolator will have a strong extinction without realignment over a fixed operating range, and a larger wavelength-tunable operating range over which an isolator can be realigned without excessive transmission loss.

For better extinction, optical isolators can be constructed with multiple isolation stages.

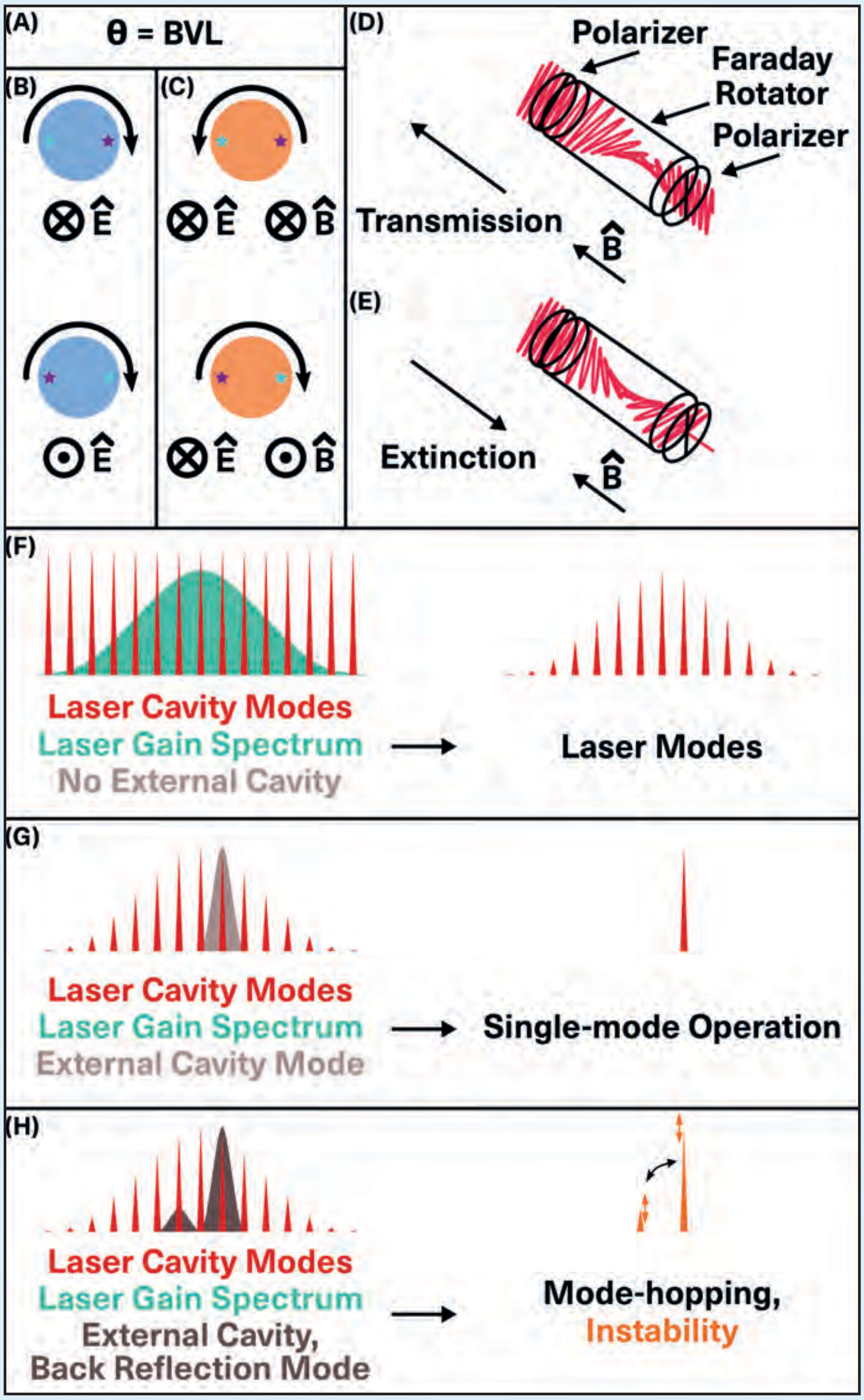
continued on next page

The eponymous Faraday Effect is simple: the polarization of light is rotated when passed through a material in a strong magnetic field. The rotation angle (θ) of the observed polarization is proportional to the magnetic field flux density (B) and the optical path length (L) via the empirical Verdet constant (V) of the rotator material, often garnets or ceramics (Fig 1.A).

In a half-wave plate, the rotation is determined by the material's birefringence, which is the same both forward and backward. Flip a waveplate around, and it will rotate light in the same way as it did before (Fig 1.B). However, a Faraday rotator depends on the magnetic field flux density (B). Flip the magnetic field, and now the Faraday rotator will rotate the light in the opposite direction as it did before (Fig 1.C).

To construct an optical isolator, sandwich a Faraday rotator between two polarizers in a magnetic field carefully chosen to get the right rotation angle. In the transmission direction, the first polarizer passes only ordinary-polarized light. The transmitted light is then rotated by a fixed amount, determined by the magnetic field and the rotator length. Lastly, the clean-up polarizer allows the rotated light (Fig 1.D).

In reverse, the optical isolator behaves differently. The last polarizer (now first) rejects all cross-polarized light. With the magnetic field flux in the opposite direction, the rotator now rotates the light in the reverse direction, and the first polarizer blocks the rotated light (Fig 1.E).



Credit: Toptica Photonics.

continued from previous page

One-way travel for light optical isolators based on Faraday rotators

Additional Faraday rotators and polarizers can be added, at the expense of transmission losses. Dual stage and even triple stage isolators can be produced for maximum isolation.

Sensitive laser diodes can be susceptible to feedback. The gain bandwidth of the gain medium overlaps with harmonics of the laser cavity to produce the laser's operating modes (Fig 1.F). For narrow linewidth measurements, only a single mode is desired, and an external cavity is added to coerce the laser into single mode operation (Fig 1.G). However, a back reflection can form another external cavity and cause a mode hop to a different wavelength (Fig 1.H), destabilizing the laser in both intensity and frequency. An optical isolator prevents back reflections from reaching the laser diode, keeping it in stable single mode operation.

AMO physics experiments rely on narrow linewidth lasers to address specific atomic transitions. Laser intensity noise or instability can confound a measurement. Isolating the laser is particularly crucial in quantum applications, where minute disturbances can significantly impact the measurement accuracy and fidelity of quantum states.

As qubits are susceptible to noise, intensity instability of the laser can cause errors in quantum computing. An atomic qubit can be bit-flipped just due to noise in the intensity of the laser "tweezer" holding it in place. In quantum sensing, the intensity noise of the laser used to address the sensor, for example a single-spin NV center, has a direct effect on the precision of the measurement. Optical isolators prevent disruptive feedback into the laser cavity for the highest stability.

As the world's leading manufacturer of high-performance lasers for quantum technologies, Toptica also pays close attention to the performance and quality of our optical isolators. Optical isolators must be carefully engineered, considering the center wavelength, thermal sensitivity of the Verdet constant, the desired bandwidth over which the isolator can operate, and even the alignment sensitivity of the isolator.

Credit: Toptica Photonics.

Toptica's Faraday isolators are manufactured in-house in single and dual stage configurations.

The optical isolators we assemble in our Pittsford, New York production facility are the best optical isolators for quantum applications, from performance to quality. Our new line of miniature optical isolators offer a low-SWaP (Size, Weight, and Power) solution for field deployment or integration into emerging quantum technologies.

Author:
Joseph Mastron, Product Manager, Toptica Photonics

QCi wins order for "revolutionary" underwater lidar

Quantum Computing Inc. (QCI), based in Hoboken, NJ, a developer of quantum optics and nanophononics technology, has won an order for its quantum lidar prototype from Johns Hopkins University, Baltimore, Maryland.

Valued at $200,000, the prototype represents a significant advance in underwater lidar, according to QCI, and will be utilized for testing and evaluation within Johns Hopkins' research and development program.

QCi says its quantum lidar "boasts unparalleled precision, with a remarkable resolution of 3mm and the capability to operate at depths of up to 30 meters."

The statement adds, "the system's ability to tune and time-gate single photons in the lidar return signals, and its capacity to adjust detection in both frequency and phase space, enables quantum measurements that elevate information gathering to new heights."

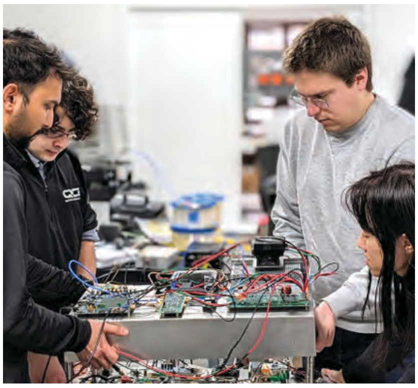


Photo: QCI.

Quantum Computing develops quantum optics and nanophononics technologies.

Jeevanandha Ramanathan, Research Scientist and leader of Quantum Remote Sensing platform at QCi, commented, "Our underwater scanning lidar is engineered with cutting-edge single-photon detection technology, coupled with a green laser at a wavelength of 532nm.

"The selection of green light is strategic for its superior ability to penetrate water, ensuring our system captures the most detailed and accurate underwater images possible. The integration of single-photon detection enhances sensitivity to an exceptional degree, enabling us to discern and measure faint signals bounced back by single photons," he said.

'Pivotal role'

Dr. William McGann, CEO of QCi, said, "This collaboration will play a pivotal role in enhancing our understanding of phytoplankton movement, nutrient distribution, and the physical behavior of water bodies under varying conditions. Together, these advanced capabilities will equip researchers and policymakers with the detailed data needed for comprehensive environmental management and protection strategies, aligning with QCi's mission of delivering practical and affordable quantum technologies for the world."

Author:
Matthew Peach, Editor in Chief, optics.org

Max-Planck progresses UV spectroscopy with high-resolution dual-comb method…

…and Stanford launches "micro" frequency comb, as basis for mass-market adoption of such devices.

Scientists in the group of Nathalie Picqué at the Max-Planck Institute of Quantum Optics, Garching, Germany, say they have made a significant leap in the field of ultraviolet spectroscopy by successfully implementing high-resolution linear-absorption dual-comb spectroscopy in the UV spectral range. This achievement "opens up new possibilities for performing experiments under low-light conditions, paving the way for novel applications in various scientific and technological fields."

The results are described in Nature.

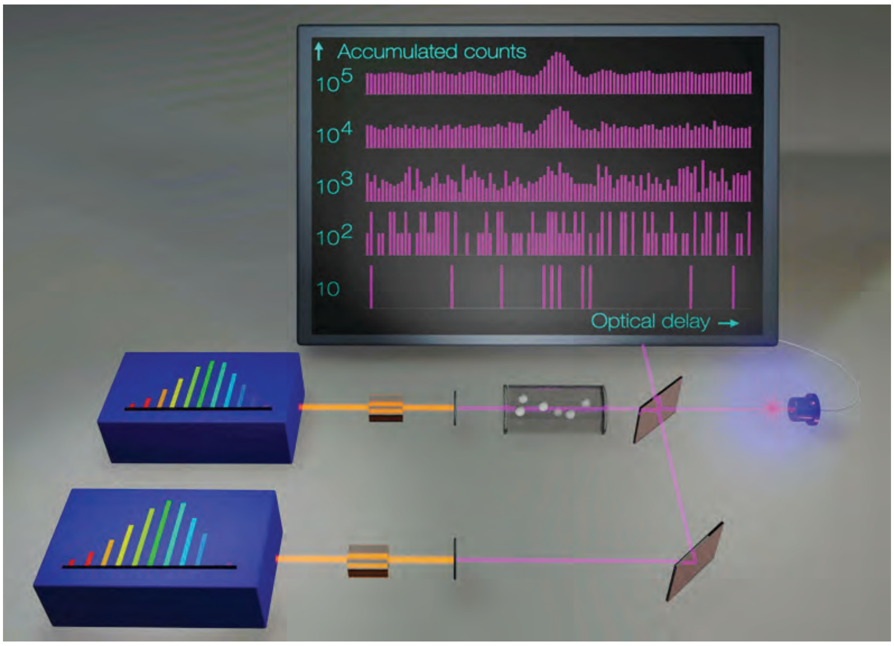
Dual-comb spectroscopy, a powerful technique for precise spectroscopy over broad spectral bandwidths, has been mainly used for infrared linear absorption of small molecules in the gas phase. It relies on measuring the time-dependent interference between two frequency combs with slightly different repetition frequencies.

A frequency comb is a spectrum of evenly spaced, phase-coherent laser lines that acts like a ruler to measure the frequency of light with extreme precision. The dual-comb technique does not suffer from the geometric limitations associated with traditional spectrometers and offers great potential for high precision and accuracy.

Low light intensities

However, dual-comb spectroscopy typically requires intense laser beams, making it less suitable for scenarios where low light levels are critical. The MPQ team has demonstrated that dual-comb spectroscopy can be effectively employed in starved-light conditions at power levels more than a million times weaker than those typically used.

This achievement was achieved using two distinct experimental setups with different types of frequency-comb generators. The team developed a photon-level interferometer that accurately records the statistics of photon counting, showcasing a signal-to-noise ratio at the fundamental limit. This opens up the prospect of dual-comb spectroscopy in challenging scenarios where low light levels are essential.



Credit: Nature (2024).

An ultraviolet photon-counting dual-comb spectrometer. Two ultraviolet frequency combs of slightly different pulse repetition frequencies are generated at very low light levels by nonlinear frequency conversion of near-infrared combs. One ultraviolet comb passes through a sample. The two feeble combs are then superimposed with a beam splitter and detected by a photon-counting detector. At power levels more than one million times weaker than usually employed, the statistics of the detected photons carry the information about the sample with its possibly highly complex optical spectrum.

The MPQ researchers precisely controlled the mutual coherence of two comb lasers with one femtowatt per comb line, demonstrating an optimal build-up of the counting statistics of their interference signal over times exceeding one hour.

"Our innovative approach to low-light interferometry overcomes the challenges posed by the low efficiency of nonlinear frequency conversion, and lays a solid foundation for extending dual-comb spectroscopy to even shorter wavelengths," said Bingxin Xu, the post-doctoral scientist who led the experiments.

One promising future application is the development of dual-comb spectroscopy at short wavelengths to enable precise vacuum- and extreme-ultraviolet molecular spectroscopy over broad spectral spans. Currently, broadband extreme-UV spectroscopy is limited in resolution and accuracy and relies on unique instrumentation at specialized facilities.

"Ultraviolet dual-comb spectroscopy, while a challenging goal, has now become a realistic one as a result of our research. Importantly, our results extend the full capabilities of dual-comb spectroscopy to low-light conditions, unlocking novel applications in precision spectroscopy, biomedical sensing, and environmental atmospheric sounding," said Picqué herself.

Stanford announces new type of frequency comb

Announced at the same time, researchers at Stanford University have unveiled a new type of frequency comb – a "microcomb" – which, they say, "could be the basis for mass-market adoption of the devices in everyday electronics."

The Stanford group has integrated two different approaches for miniaturizing frequency combs into one easily producible, microchip-style platform.

Among the many applications the researchers envision for their versatile technology are powerful handheld medical diagnostic devices and widespread greenhouse gas monitoring sensors.

"The structure for our frequency comb

continued on next page

continued from previous page

Max-Planck progresses UV spectroscopy with high-resolution dual-comb method

brings the best elements of emerging microcomb technology together into one device," said Hubert Stokowski, a postdoctoral scholar in the lab of Amir Safavi-Naeini, and lead author of the study, also published in Nature.

"We can potentially scale our new frequency microcomb for compact, low-power, and inexpensive devices that can be deployed almost anywhere, Stokowski added.

"We're very excited about this new microcomb technology that we've demonstrated for novel sensors that are both small and efficient enough to be in someone's phone, someday," said Safavi-Naeini, associate professor in the Department of Applied Physics at Stanford's School of Humanities and Sciences and senior author of the study.

This new device is called an Integrated Frequency-Modulated Optical Parametric Oscillator, or FM-OPO. The tool's complex name indicates that it combines two strategies for creating the range of distinct frequencies, or colors of light, that constitute a frequency comb.

One strategy, optical parametric oscillation, involves bouncing beams of laser light within a crystal medium, wherein the generated light organizes itself into pulses of coherent, stable waves. The second strategy centers on sending laser light into a cavity and then modulating the phase of the light – achieved by applying radio-frequency signals to the device – to ultimately produce frequency repetitions that similarly act as light pulses.

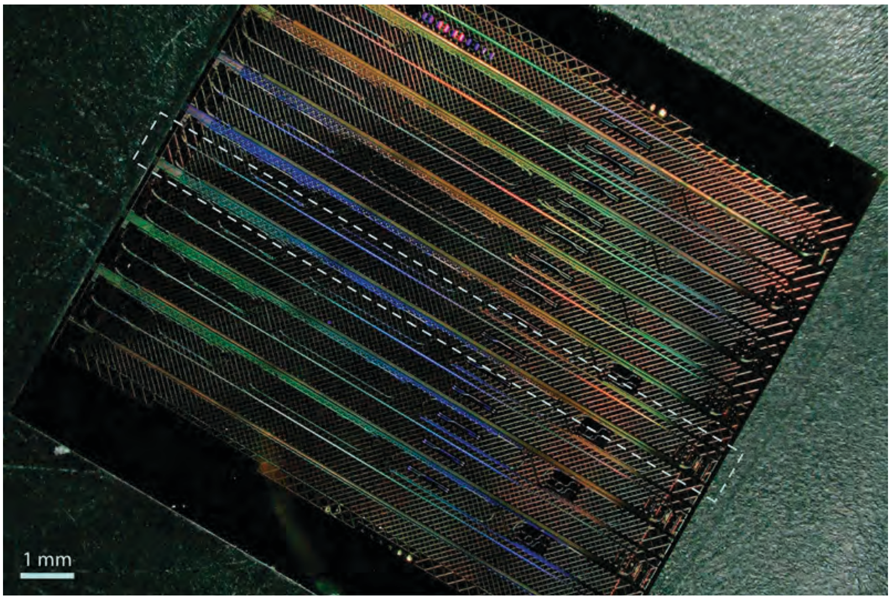


Image credit: Kevin Multani and Hubert Stokowski.

A microscope image showing a thin-film lithium niobate chip that contains eight of the new "FM-OPO" devices. One device has a footprint around 1×10 mm2 (highlighted here with a dashed rectangle).

Strategic combination

These two strategies for microcombs have not been used widely because both come with drawbacks. These issues include energy inefficiency, limited ability to adjust optical parameters, and suboptimal comb "optical bandwidth" where the comb-like lines fade as the distance from the center of the comb increases.

The researchers fashioned the components at the heart of the new frequency comb using integrated lithium niobate photonics. These light-manipulating technologies build upon advances in the related, more established field of silicon photonics, which involves fabricating optical and electronic integrated circuits on silicon microchips. "Lithium niobate has certain properties that silicon doesn't, and we couldn't have made our microcomb device without it," said Safavi-Naeini.

Next, they brought together elements of both optical parametric amplification and phase modulation strategies. The team expected certain performance characteristics from the new frequency comb system on lithium niobate chips – but what they saw proved far better than they anticipated.

Overall, the comb produced a continuous output rather than light pulses, which enabled the researchers to reduce the required input power by approximately an order of magnitude. The device also yielded a conveniently "flat" comb, meaning the comb lines farther in wavelength from the center of the spectrum did not fade in intensity, thus offering greater accuracy and broader utility in measurement applications.

The new microcombs, with further honing, should be readily manufacturable at conventional microchip foundries with many practical applications such as sensing, spectroscopy, medical diagnostics, fiber-optic communications, and wearable health-monitoring devices.

Image credit: Petra Parikova/Ula Stokowska.

Amir Safavi-Naeini (left) and Hubert Stokowski.

Author:
Matthew Peach, Editor in Chief, optics.org

KTH Sweden develops 3D printed silica glass micro-optics on fibers…

…and UK's EPSRC awards £1.2 million grant to Aston's Picometer Surface Nanoscale Axial Photonics project.

In what is described as "a first for communications", researchers in Sweden have 3D printed silica glass micro-optics on the tips of optic fibers. They say that the advance could enable faster internet and improved connectivity, as well as innovations like smaller sensors and imaging systems.

The scientists at KTH Royal Institute of Technology in Stockholm say integrating silica glass optical devices with optical fibers enables multiple innovations, including more sensitive remote sensors for environment and health care. The printing techniques they report also could prove valuable in production of pharmaceuticals and chemicals.

The work is described in the journal ACS Nano.

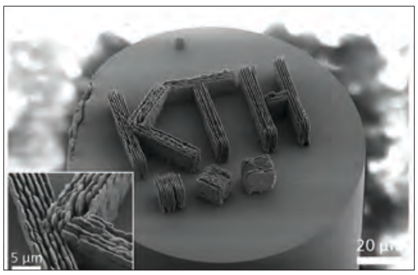
KTH Professor Kristinn Gylfason says the method overcomes longstanding limitations in structuring optical fiber tips with silica glass, which often require high-temperature treatments that compromise the integrity of temperature-sensitive fiber coatings.

In contrast to other methods, the process begins with a base material that does not contain carbon. That means high temperatures are not needed to remove carbon in order to make the glass structure transparent. Lead author Lee-Lun Lai says the researchers printed a silica glass sensor that proved more resilient than a standard plastic-based sensor after multiple measurements.

New applications

"We demonstrated a glass refractive index sensor integrated onto the fiber tip that allowed us to measure the concentration of organic solvents. This measurement is challenging for polymer-based sensors due to the corrosiveness of the solvents," said Lai.

Study co-author, Po-Han Huang added, "These structures are so small you could fit 1,000 of them on the surface of a grain of sand, which is about the size of sensors being used today."



Credit: Lee-Lun Lai, et al.

3D printing 1,000 times smaller than a grain of sand. Microscopic image of a printed glass demonstration structure on tip of optical fiber.

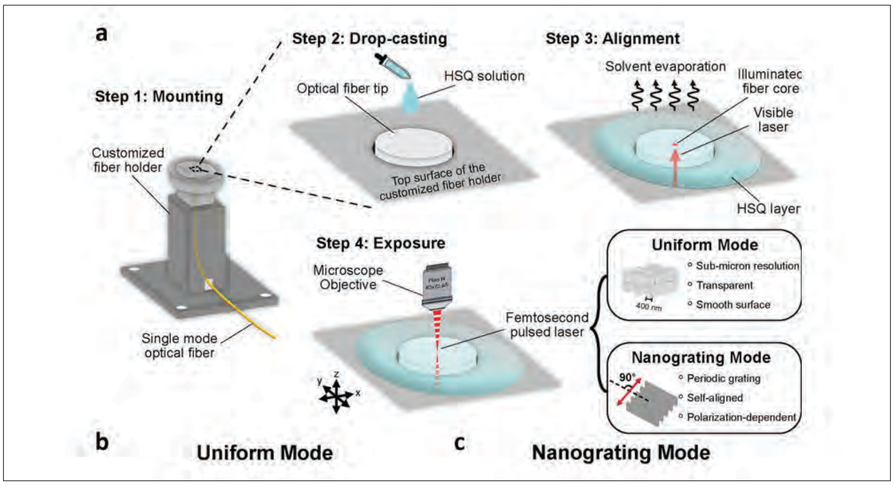


Image: courtesy of Aston U. / Shutterstock.

Printing process and example 3D structures in glass on optical fiber tips. (a) The fabrication process. Step 1: Mounting single-mode optical fiber in a customized fiber holder. Step 2: Drop-casting HSQ solution on the optical fiber tip. Step 3: Evaporating solvent. Injecting a visible laser from the other end of the fiber to illuminate the fiber core for alignment. Step 4: Exposing the HSQ layer with the femtosecond pulsed laser. Uniform Mode and Nanograting Mode can be selected by choice of exposure parameters. (b) A woodpile structure printed using Uniform Mode. The inset shows a close-up of the printed structure: the lateral width of each beam is below 400 nm. (c) Characters "KTH" and three blocks printed using Nanograting Mode. The inset shows that the three segments of the letter "K" are made of Nanogratings with distinct selected orientations. Credit: Lee-Lun Lai, et al. Picometer-scale optical devices will be developed for use across manufacturing, IT and agriculture.

The researchers also demonstrated a technique for printing nanogratings, ultra-small patterns etched onto surfaces at the nanometer scale. These manipulate light in precise ways and have potential applications in quantum communication.

Gylfason says the ability to 3D-print arbitrary glass structures directly on a fiber tip opens new frontiers in photonics. "By bridging the gap between 3D printing and photonics, the implications of this research are far-reaching, with potential applications in microfluidic devices, MEMS accelerometers and fiber-integrated quantum emitters," he said.

Aston receives £1 million to 'revolutionize' mini optical devices

Meanwhile, researchers at Aston University, Birmingham, UK, have received more than £1 million ($1.27 million) to develop optical devices that are so small they would also fit on the surface of an optical fiber. Potential applications are in manufacturing, IT and agriculture.

The £1,167,290 grant has been given by the UK's Engineering and Physical Sciences Research Council (EPSRC) for the Picometer Surface Nanoscale Axial Photonics (PicoSNAP) project. The award will be used to develop Surface Nanoscale Axial Photonics (SNAP) technology which enables the fabrication of miniature photonic devices.

Traditionally, the precision of microscopic devices has been constrained by the size of atoms, with fabrication technologies plateauing at several nanometers. However, PicoSNAP technology, which was pioneered by Professor Misha Sumetsky of Aston Institute of Photonic Technologies (AIPT), has enabled devices to be scaled down even further so they can be measured in picometers.

Prof. Sumetsky is aiming to develop a reliable manufacturing process to enable production of the devices that is both ultra-accurate and easy to reproduce. If successful, the project will not only bring in a new revolutionary technology but also deliver miniature optical devices with performance not previously possible to achieve, and ready for practical applications.

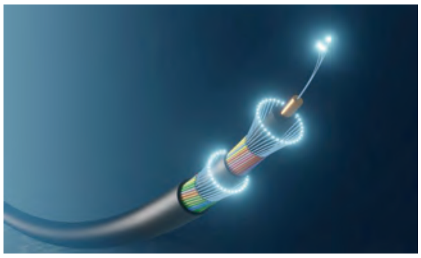


Image: courtesy of Aston U. / Shutterstock.

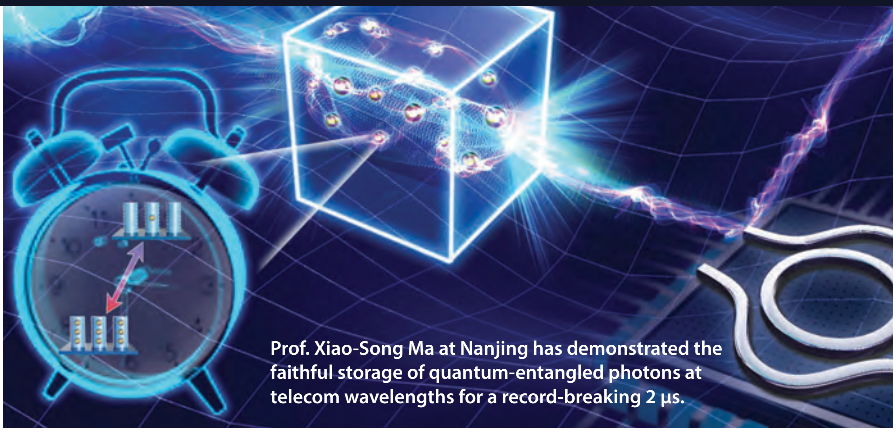
Picometer-scale optical devices will be developed for use across manufacturing, IT and agriculture.

He said, "The lack of reliable, scalable manufacturing processes with picometer precision remains a major obstacle, and SNAP technology has the potential to address this need with its exceptional precision and performance. "The goal of this project is the development of the process, which requires insight into the depth of associated physical phenomena, as well as the design and fabrication of new micro devices critical for the future communication, optical signal processing, microwave and sensing technologies."

Author:
Matthew Peach, Editor in Chief, optics.org

Researchers moving toward networked quantum devices

Nanjing University team achieves quantum storage of entangled photons at telecom wavelengths in a crystal.



Prof. Xiao-Song Ma at Nanjing has demonstrated the faithful storage of quantum-entangled photons at telecom wavelengths for a record-breaking 2 µs.

Photo credit: The group of Prof. Xiao-Song Ma, Nanjing Univ.

Networking is everything. To realize their full potential, quantum devices must be networked, and in principle this can be done using the fiber optic networks employed for classical telecommunications. To do so, however, requires that the information encoded in quantum systems be reliably stored at the frequencies used in telecom networks—a capability not yet achieved.

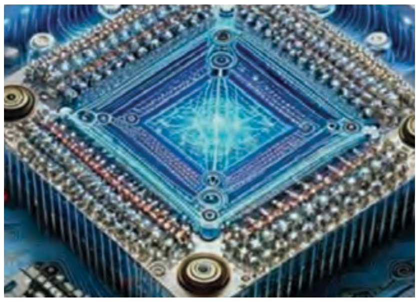
Now, researchers at Nanjing University report storage and retrieval of the entangled state of two telecom photons generated from an integrated photonic chip. It combines the natural narrow linewidth of the entangled photons and long storage time of erbium ions. The researchers achieved a storage time of 1.936 µs, more than 387 times longer than in previous works. The researchers explain that other recent work has triggered a resurgence of interest in using erbium ions for quantum memory—that is, on-chip storage of weak coherent light with laser written waveguides. They say the next milestone of quantum memory in this system is to store quantum entanglement in erbium ions and that entanglement is preserved after storage.

In the current work, the entangled photon pairs are generated from an integrated photonic chip based on a silicon nitride microring resonator with natural narrow linewidths compatible with erbium ions. The team certified successful storage of entanglement in the crystal using entanglement witness measurements with more than 23 standard deviations at 1.936 µs. The researchers note that further improvements are needed to scale the system.

(Jiang et al., Nat. Comm. 2023, doi : 10.1038/ s41467-023-42741-1

Twente leads 'QU-PIC' project to drive growth of quantum computing

Aim is to establish European sovereignty with a toolbox of PIC quantum building blocks.



QU-PIC is aiming to make quantum computing systems smaller, more stable and scalable.

Image courtesy of U Twente.

The University of Twente, in the Netherlands, is coordinating a new project intended to accelerate the development of quantum computing systems.

The project, entitled QU-PIC, aims to establish "European sovereignty" in the emerging quantum field with a toolbox of photonic integrated circuit (PIC) quantum building blocks.

Photonics is one of the main enabling technologies for quantum computing systems, but – based on bulk optics, as they usually are – they are not yet scalable.

Typically, huge tables filled with lasers are needed to manipulate and read out ions. Therefore QU-PIC is aiming to make quantum computing systems smaller, more stable and scalable.

QU-PIC researchers and associated companies state that they "see a need for a universal photonic integrated platform that can operate with light coloured from UV to mid-infrared, therefore covering a broader range of light than is currently possible."

Project lead Sonia Garcia Blanco commented, "The integrated photonics platforms studied so far do not cover the UV, leading to complicated integration schemes where several passive PIC platforms need to be combined."

Quantum building blocks

QU-PIC's overarching goal is to create a toolkit of PIC quantum building blocks that facilitates the swift progression from conceptualisation to a fully packaged quantum computing system. By developing essential technologies within the European supply chain, QU-PIC seeks to contribute significantly to establishing European Sovereignty in the emerging quantum field.

The project is coordinated by Prof. Blanco, full professor at Twente's Integrated Optical Systems group (IOS; Faculty of Science and Technology). Other principal investigators of UT working on this project include: Prof. Klaus Boller, Dr. Jelmer Renema and Prof. epijn Pinkse, Prof. Bram Nauta and Dr. Anne-Johan Annema.

QU-PIC is a project that spans an international consortium of 11 research institutes and companies. The participating organisations are the University of Twente, Ghent University, Quix Quantum, Tematys, Toptica Photonics, Aluvia Photonics, WWU Münster, Technische Universität Berlin, Chalmers University of Technology, Physikalisch-Technische Bundesanstalt (PTB), and Eagleyard Photonics.

The total budget comprises around €6 million ($6.4 million). QU-PIC officially kicks off on the 15th of February, 2024.

Author:
Matthew Peach, Editor in Chief, optics.org

Quintessent lands $11.5M to advance optical interconnects

Santa Barbara startup is developing quantum-dot frequency comb lasers for applications in 'accelerated' computing.

Quintessent, a spin-out from John Bowers' photonics research group at the University of California, Santa Barbara (UCSB), says it has closed an oversubscribed round of seed funding worth $11.5 million.

Intended to aid its development of ultra-high-speed optical interconnects incorporating heterogeneous silicon photonics and quantum dot (QD) lasers, the latest support comes from a group of venture backers led by Osage University Partners (OUP).

The round also featured a new investor in the form of M Ventures, with further participation from existing supporters Sierra Ventures, Foothill Ventures, and Entrada Ventures.

AI-catalyzed transition

Saying that new photonic connectivity is needed to match the progression of high-speed computing required by the development of artificial intelligence (AI) applications, Quintessent has been working closely with Israel-headquartered foundry partner Tower Semiconductor. Tower offers silicon photonics foundry services on 200 mm wafer diameters at its Newport Beach, California, facility.

A year ago Tower and Quintessent claimed a world first, with their demonstration of O-band QD lasers based on a gallium arsenide (GaAs) platform, heterogeneously integrated with a commercial foundry silicon photonics process.

"The proliferation of AI is catalyzing a rapid transition and growth of the world's computing infrastructure from general purpose architectures to ones specifically designed for accelerated computing," stated the startup.

Those "accelerated" computing requirements demand high-speed interconnections that, at the moment, represent a critical bottleneck to accelerating wider system performance at scale.

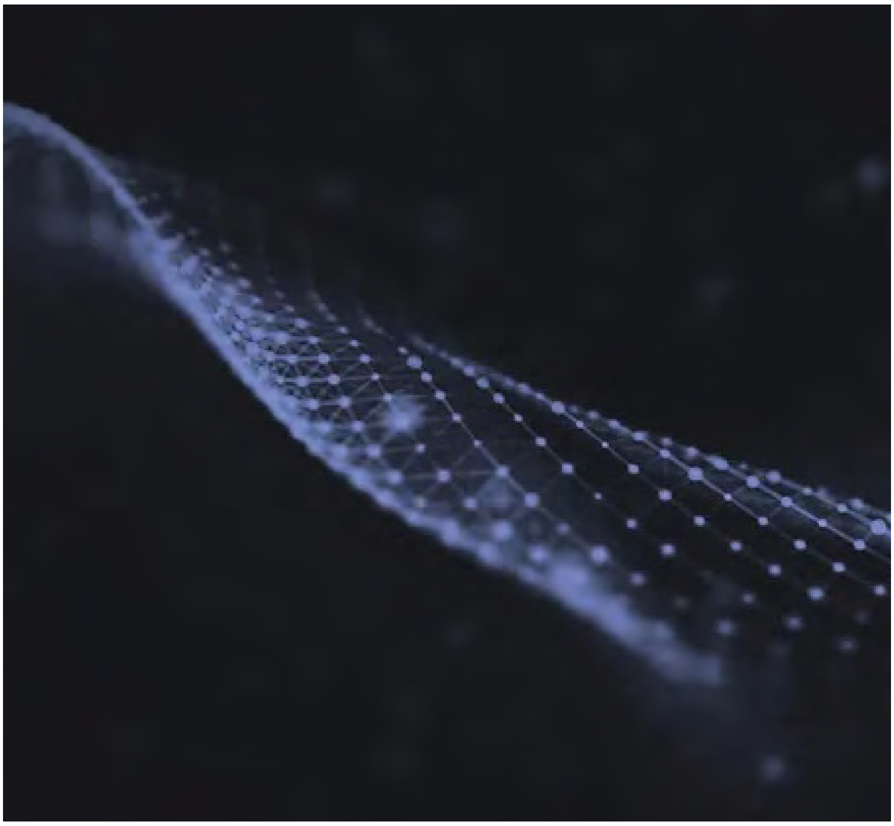


Image: Quintessent.

Interconnect fabric: UCSB spin-out Quintessent is working on next-generation photonic interconnects based on its novel quantum-dot frequency comb lasers.

"Achieving sustainable growth of computing and data movement will require new technologies and architectures that can match the rapid progression of bandwidth (density) scaling from computing and switching interfaces while simultaneously minimizing power, latency, fiber count, chip size, and total cost of ownership," adds Quintessent - also noting that significant improvements in reliability will be required.

QD comb laser

Alan Liu, the firm's CEO and co-founder with Bowers, said in a statement announcing the seed round: "This new funding allows us to grow our team and accelerate the development of highly scalable and highly reliable optical interconnects that transcend the scaling limitations of incumbent solutions, built on top of a unique technology stack including our multi-wavelength comb laser."

Liu, who completed his PhD in Bowers' lab, added in a LinkedIn post: "This new round of funding will accelerate our quest to create a new class of optical compute interconnects with scalable and reliable foundations."

Manny Stockman, a partner at OUP who is now set to join Quintessent's board of directors, also commented:

"Novel chip-scale laser architectures have rarely been the focus of today's photonics companies because the industry is still so nascent and focused in on engineered solutions.

"But at OUP, as we observed various AI and computing hardware companies push the limits of bandwidth and packaging with optical systems, we found they were all challenged by the scaling and cost of their optical laser source.

"Quintessent's plans to productize interconnect solutions powered by multi-wavelength quantum-dot comb lasers may become one of the most critical product developments in photonics at just the right time to intercept the surging demand for optical connectivity at the largest computing corporations in the world."

Author:
Mike Hatcher, Business Editor, optics.org

IonQ claims quantum interconnect advance

Quantum computing firm says it has generated photons entangled with ions repeatedly and reproducibly.

IonQ, a US company already offering quantum computing via a cloud service, now claims to have demonstrated what it calls "commercial-grade" ion-photon entanglement - a requirement for future quantum networks based on photonic interconnects.

While there have been earlier demonstrations of such entanglement in academic settings, IonQ says that it has generated photons entangled with ions "repeatedly and reproducibly", creating a quantum state that would enable future networks with the ability to communicate and transfer quantum information.

"IonQ's research team demonstrated the generation and collection of single photons from an ion qubit, successfully routing those photons to specialized detection optics used to verify ion-photon entanglement across this network," announced the firm in a press release.

"The work represents a crucial first step towards developing photonic interconnect protocols for quantum computing applications running across multiple quantum processing units (QPUs)."

Photonic interconnects

While the Maryland-headquartered company has not published a peer-reviewed article detailing the development, a related blog post from the firm states that ion-photon entanglement to form a network node represents one of the most challenging milestones towards the deployment of interconnected QPUs.

"Such a node must [show] three key capabilities," it says. "First, the node must have the ability to generate "interconnect photons" entangled with the interconnect qubit. Second, the node must be capable of sending these interconnect photons through fiber-optics to a detection hub. Lastly, the detection hub must be able to manipulate and measure the state of the interconnect photon to confirm ion-photon entanglement."

In contrast to classical supercomputers, which distribute workloads across multiple cores and processors to operate in parallel, quantum networks entangle cores to form a single, more powerful quantum computer capable of running complex algorithms.

"Photonic interconnects will lead to integrated computation across quantum networks, not just communication between siloed parts as seen in classical setups," explains IonQ.

"Photonic interconnects enable the entanglement of remote qubits across multiple, physical locations. Ions have unique advantages in the use of photons for networking - as the interactions between atoms and photons are a well-studied and understood area of quantum information science."

Photonic scaling

As a result, says the firm, IonQ's approach has always anticipated scaling its technology through photonic interconnects. The compatibility of ions with photonic networking is a core reason why it chose this particular approach to quantum computing in the first place.

"While the science and procedure behind photonic interconnects has been understood for years in a research setting, an important endeavor for IonQ has been transitioning this technology from a lab setting to commercial grade," it said.

Pat Tang, IonQ's VP of research and development, added: "This brings us one step closer to achieving commercial quantum advantage by running deeper, more complex circuits, and lays the foundation to develop future quantum applications and quantum networking solutions."

The latest development comes a few months after IonQ extended its existing relationship with the US Air Force Research Lab (AFRL) with a $25.5 million deal to deploy two quantum computing systems for quantum networking research.

In addition, earlier this month the company officially opened a new quantum data center facility near Seattle. The site is set to serve as its primary production engineering location in the US and house the firm's growing research and manufacturing teams.

According to their most recent financial update, the IonQ executive team expects to report annual sales of around $22 million for 2023, alongside bookings in excess of $60 billion. However, in the first nine months of 2023 the firm also piled up an operating loss in excess of $100 million.

Author:
Mike Hatcher, Business Editor, optics.org

Photo: IonQ.

IonQ's management team and Washington senator Maria Cantwell (second from right) officially cut the ribbon at IonQ's new quantum data center and manufacturing facility in the Seattle suburbs.

ICFO develops QUIONE, quantum simulator that observes individual atoms…

…and Toshiba-Single Quantum collaboration doubles range of secure QKD communications.

Quantum physics needs high-precision sensing techniques to delve deeper into the properties of materials. From the analog quantum processors that have emerged recently, the so-called quantum-gas microscopes have proven to be powerful tools for understanding quantum systems at the atomic level.

Now, researchers from ICFO, Barcelona, Spain, have built their own quantum-gas microscope, named QUIONE after the Greek goddess of snow. The group – Sandra Buob, Jonatan Höschele, Vasiliy Makhalov and Antonio Rubio-Abadal, led by ICREA Professor at ICFO Leticia Tarruell – explains how their microscope is the only one imaging individual atoms of strontium quantum gases in the world, as well as the first of its kind in Spain.

Beyond the significant images, in which individual atoms can be distinguished, the goal of QUIONE is quantum simulation. As ICREA Prof. Leticia Tarruell explained, "Quantum simulation can be used to boil down very complicated systems into simpler models to then understand open questions that current computers cannot answer, such as why some materials conduct electricity without any losses even at relatively high temperatures."

The singularity of this experiment lies in the fact that they have managed to bring the strontium gas to the quantum regime, place it in an optical lattice where the atoms could interact by collisions and then apply the single atom imaging techniques. These elements altogether make ICFO's strontium quantum-gas microscope unique in its kind.

Why strontium?

Until now, these microscope setups relied on alkaline atoms, such as lithium and potassium, which have simpler properties in terms of their optical spectrum compared to alkaline-earth atoms such as strontium.

In recent years, the properties of strontium have made it a popular element for applications in the fields of quantum computing and quantum simulation. For example, a cloud of strontium atoms can be used as an atomic quantum processor, which could solve problems beyond the capabilities of current classical computers.

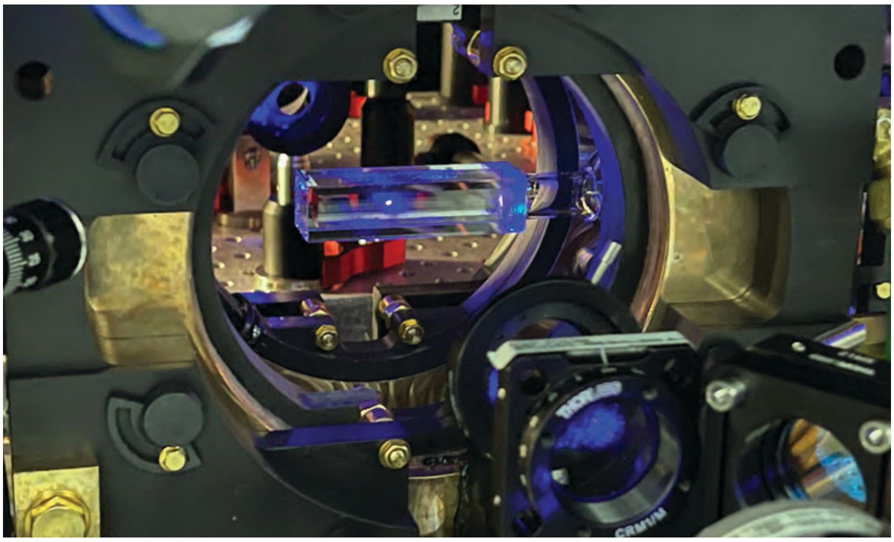
QUIONE, a quantum simulator of real crystals

The team first lowered the temperature of the strontium gas. Using the force of several laser beams, the speed of atoms can be reduced to a point where they remain almost motionless, reducing their temperature to almost absolute zero in just a few milliseconds. At that point, the atoms display new behavior like quantum superposition and entanglement.

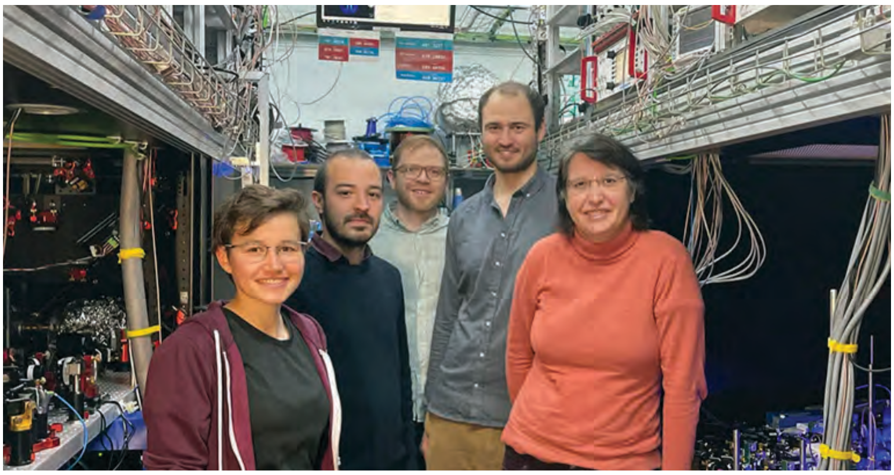
After that, with the help of dedicated lasers, the researchers activate the optical lattice, which keeps the atoms arranged in a grid along space. "You can imagine it like an egg carton, where the individual sites are actually where you put the eggs. But we have atoms and the optical lattice," said Sandra Buob, first author of the article.

The atoms in the egg cup interact with each other, sometimes exhibiting quantum tunneling to move from one place to another. Such "quantum dynamics" between atoms mimics that of tunneling in certain materials. Therefore, the study of these systems can help understand the complex behavior of certain materials, which is the key idea of quantum simulation.

continued on next page


Credit: ICFO.

Quione glass cell with strontium gas cloud in the center.


Credit: ICFO.

The ICFO team in the lab. From left to right: Sandra Buob, Antonio Rubio-Abadal, Vasiliy Makhalov, Jonatan Höschele, and Leticia Tarruell.

continued from previous page

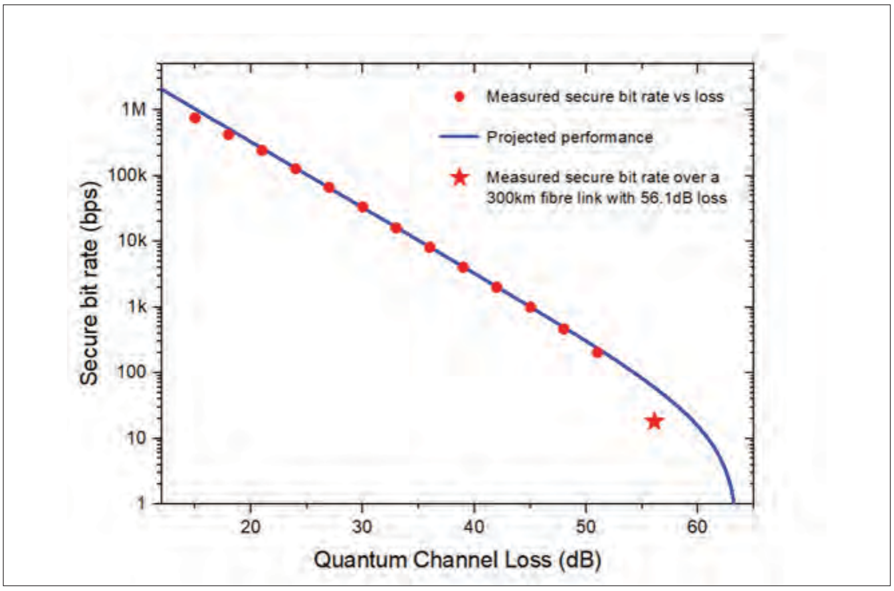
ICFO develops QUIONE, quantum simulator that observes individual atoms

Toshiba collaboration doubles range of QKD communications

Toshiba Europe and Single Quantum B.V. have collaborated to test and validate long-distance deployments of Quantum Key Distribution (QKD) technology.

Following extended validation testing of Toshiba's QKD technology and Single Quantum's superconducting nanowire single photon detectors (SNSPDs), the partners have announced a solution that substantially extends the transmission range for QKD deployment over fiber connections – up to and beyond 300km.

QKD uses the quantum properties of light to generate quantum secure keys that are immune to decryption by both high-performance conventional and quantum computers. Toshiba's QKD is deployed over fiber networks, either coexisting with conventional data transmissions on deployed "lit" fibers, or on dedicated quantum fibers.



Credit: ICFO.

Toshiba and Single Quantum's QKD transmission performance over a wide range of optical losses along with the performance across a 300km link.

Toshiba's QKD technology can deliver quantum secure keys in a single fiber optic link at distances of up to 150km using standard integrated semiconductor devices. Achieving longer distance QKD transmission is challenging due to the attenuation of the quantum signals along the fiber length. To provide extended QKD transmission, operators typically concatenate links together.

"Forward-thinking organizations are already deploying QKD on networks to protect their data from the risk posed by quantum computers," said Dr Andrew Shields, Head of the Toshiba Quantum Technology Division.

icfo.eu

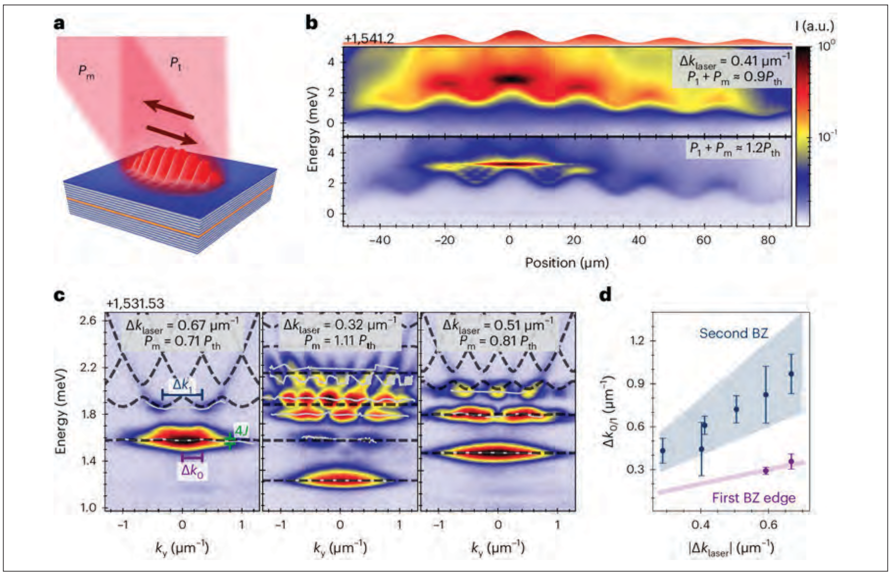
toshiba.eu

singlequantum.com

Author:
Matthew Peach, Editor in Chief, optics.org

Japan's RIKEN and NTT scientists create 'optical conveyor belt' for quasi particles…

…and Coherent launches novel fiber for lidar and cold atom trapping for quantum computing.



Credit: Nature Photonics (2024).

Band structures of a polariton conveyor belt. a, A diagram of the sample excitation. The angle between the lasers controls the fringe periodicity, while the frequency offset controls their speed and movement. b, Example real-space tomography (intensity normalized) just below and just above the condensation threshold. The red-colored diagram on top corresponds to the intensity of the laser interference pattern. c, Example band structures (intensity normalized) at zero frequency offset for different lattice periods and depths. d, The average size of the first and second Brillouin Zones (BZs) as functions of Δk_{laser}.

Using interference between two lasers, a research group led by scientists from RIKEN and NTT Research, both based in Japan, have created what they call an "optical conveyor belt" that can move polaritons — a type of light-matter hybrid particle — in semiconductor-based microcavities.

They conclude that this achievement could lead to the development of new devices with applications in areas such as quantum metrology and quantum information. The work is described in *Nature Photonics*.

The scientists used the interference between two lasers to create a dynamic potential energy landscape for a coherent, laser-like state of polaritons known as a polariton condensate.

They achieved this by introducing a new optical tool – an optical conveyor belt – to enable the control of the energy landscape and the interactions between neighboring particles. By further tuning the frequency difference between the two lasers, the conveyor belt moves at speeds of the order of 0.1 percent of the speed of light, driving the polaritons into a new state.

Non-reciprocity—a phenomenon where system dynamics are different in opposing directions—is a crucial ingredient for creating what is known as an artificial topological phase of matter. Quantum materials can also be engineered with a non-zero topology, which in this case is more abstractly embedded into the band structure.

Opportunities for quantum technologies

The RIKEN/NTT announcement states that, "it is extremely challenging to introduce non-reciprocity into engineered optical platforms, and this simple, extendible experimental demonstration opens new opportunities for emerging quantum technologies incorporate functional topology."

The research group, including first author Yago del Valle Inclan Redondo, and led by Senior Research Scientist Michael Fraser, both from RIKEN CEMS and NTT Research, together with collaborators from Germany, Singapore and Australia, have conducted a study in this direction.

Fraser commented, "We have created a topological state of light in a semiconductor structure by a mechanism involving rapid modulation of the energy landscape, resulting in the introduction of a synthetic dimension."

A synthetic dimension is a method of mapping a non-spatial dimension, in this case time, into a space-like dimension, such that the system dynamics can evolve in a higher number of dimensions and become better suited to realizing topological matter.

Using this simple experimental scheme involving the interference between two lasers, the scientists were able to organize polaritons in precisely the right dimensions to create an artificial band structure, meaning that the particles organized into energy bands like electrons in a material.

"Photonic states with topological properties can be used in advanced opto-electronic devices where topology might greatly improve the performance of optical devices, circuits, and networks, such as by reducing noise and lasing threshold powers, and dissipationless optical waveguiding. The simplicity and robustness of our technique opens new opportunities for the development of topological photonic devices with applications in quantum metrology and quantum information," said Fraser.

New fiber for lidar and cold atom trapping for quantum apps

Optical networking and laser company Coherent, has launched a novel single-mode, polarization-maintaining erbium-ytterbium optical fiber for high-power 1550 nm, narrow linewidth, and single-frequency amplifiers. The company states that it is "now the first company to support pure SM, PM optical fibers for >20 W average power capabilities."

Coherent adds that its innovation is "merging exceptional high-power performance and superior beam quality to achieve unique performance characteristics previously unavailable". Additionally, the fiber features a 130 μm geometry made possible by a proprietary manufacturing technology.

"This is the world's first exclusively single-mode, polarization-maintaining erbium-ytterbium co-doped fiber for high-power applications," said Kanishka Tankala, VP Specialty Fiber Products. "It is optimal for quantum computing and coherent lidar research while also significantly improving the power scalability of current single-frequency amplifier systems."

Author:
Matthew Peach, Editor in Chief, optics.org

Toshiba tests show QKD can be integrated into existing regional networks

Deployment with network operator Orange shows that quantum keys are compatible with 400 Gb/s channel speeds.

Toshiba Europe, one of the pioneers of quantum key distribution (QKD) for securing optical communications links, says that its latest tests show the technology works when deployed on a high-speed network nearly 200 km long.

Its experiments with network operator Orange evaluated the performance of a QKD system using 1310 nm wavelength transmission, co-propagated with dense-wavelength division multiplexing (DWDM) data channels using near-1550 nm transmission.

And according to their research paper, published in the Journal of Lightwave Technology earlier this month, it was possible to transmit a 400 Gb/s data channel while transporting a QKD-secured 100 Gigabit Ethernet data stream.

"Encryption is demonstrated at the same time as co-propagation," reported Toshiba Europe's Andrew Shields and colleagues, of a setup using three QKD systems and two trusted nodes to secure a 184 km link.

Last year, Toshiba and Orange had shown that QKD technology could be deployed on existing fiber networks alongside existing classical data services, while the latest experiments sought to evaluate its suitability for a more complex architecture emulating current optical fiber network deployments.

Photo: Toshiba Europe.

Once of the world's leading exponents of QKD encryption, Toshiba now sells various versions of the technology - including long-distance and multiplexed iterations.

Real-life networks

"We've seen that many organizations are moving from merely evaluating the threat posed by quantum computing to taking action to protect themselves," commented Shields, who heads up Toshiba's quantum technology division based in Cambridge, UK.

"These lab evaluations have demonstrated that our QKD technology can be successfully deployed on real-life networks for real-life applications, today, without the need for further investment in new infrastructure."

Laurent Leboucher, the group CTO and senior VP at Orange Innovation Networks, added: "Data security is the bedrock of our services at Orange, and we're excited to reveal the successful outcomes of our collaboration with Toshiba.

"Our [latest] work demonstrates that QKD can be integrated into existing regional network infrastructures, marking a significant advancement in quantum-secure communications."

During the latest experiments, Toshiba and Orange tested two different types of QKD technology within the end-to-end system.

Two 67 km sections used Toshiba's long-distance technology, which features two optical fibers to carry both quantum and classical signals, while a single 50 km link used the firm's multiplexed QKD technology - where the quantum channel co-propagates with the data channels.

The company, which has been at the forefront of QKD development for more than two decades, says that the paper published with Orange provides experimental results and important considerations for any organization planning to implement QKD encryption.

"[The work] demonstrates how it's possible for high-speed quantum secure data encryption to be deployed over multi-link fiber networks, co-existing with conventional data services utilizing the type of network infrastructure often used in metropolitan settings," it stated.

Toshiba Europe has also been working closely with the likes of BT and banking giants HSBC and SoftBank to demonstrate the high security and practicality of its QKD systems, while in September 2023 it officially opened its new £20 million Quantum Technology Centre in Cambridge.

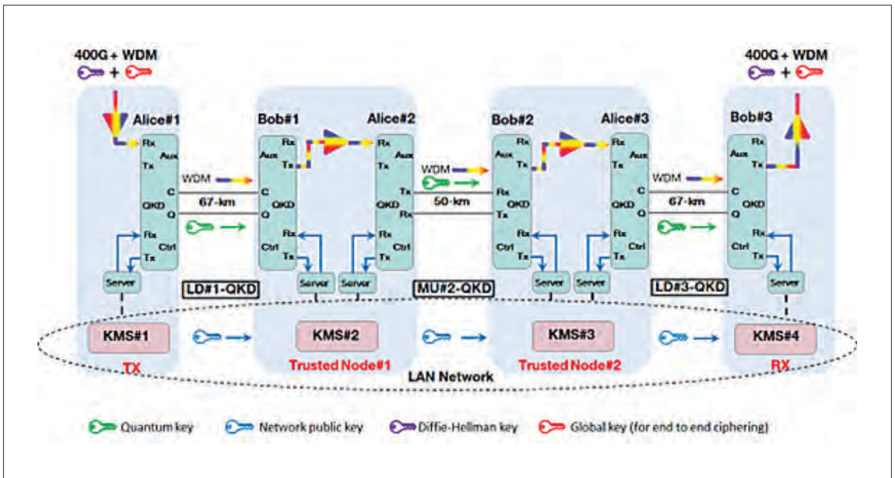


Photo: Toshiba Europe.

The latest work by Toshiba's quantum division and partner Orange showed that QKD can be used to secure a near-200 km "real-world", high-speed data network, using multiple keys and two trusted nodes.

Author:
Mike Hatcher, Business Editor, optics.org

Press Release

Quantum Machines and Hamamatsu Photonics Team Up for Enhanced Quantum Computing Control

The combined solution integrates OPX with ORCA Cameras to provide ultra-fast camera readout capabilities for cold atoms and trapped-ions qubits.

Quantum Machines (QM), the leading provider of processor-based quantum controllersTM today announced the integration of its advanced Observe, with Hamamatsu's high-speed ORCA® -Quest camera. The collaboration between Quantum Machines and Hamamatsu pushes the boundaries of quantum computation, communication, and sensing.

QM's Observe is a high-speed camera interface with an image processor that complements the OPX quantum control suite. This combination of Observe and ORCA cameras provides ultra-fast camera readout capabilities for cold atom and trapped-ion qubits. The integration not only boosts the speed but also maintains flexibility, allowing researchers to interface with personal computers for additional image processing capabilities.

Key Advantages:

- Real-time Image Processing:
  The solution achieves a market-leading image processing speed, offering quantum researchers unprecedented control over their experiments.
- Seamless OPX Integration:
  The integration with QM's OPX facilitates effortless programming using the QUA language, ensuring feedback times below 100 µs, not including camera exposure and related delays.
- Trusted and Proven:
  The system's reliability is evidenced by its adoption in prestigious laboratories and by leading quantum computing adopters globally.

Compatibility and Performance:

- OPX+ supports Camera Link and CoaXPress interfaces and is compatible with leading quantitative CMOS (qCMOS) cameras such as Hamamatsu's.
- The Hamamatsu ORCA-Quest offers enhanced scalability thanks to its smaller pixel size and higher resolution. This improvement allows for the utilization of more compact optical configurations while also increasing the number of detectable samples.
- The solution guarantees real-time, deterministic frame acquisition and image processing.

"The collaboration between QM and Hamamatsu is a game-changer, enhancing the precision and speed of quantum measurements," said Itamar Sivan co-founder and CEO of Quantum Machines. *"This synergy between our technologies paves the way for advancements in quantum computing, bringing us closer to realizing its full potential. We're not just enhancing our system's capabilities; we're redefining the boundaries of what's possible in quantum research."*

"Hamamatsu is highly enthusiastic about the potential of photonics in the quantum world as a leading photonics company. Our collaboration with Quantum Machines has accelerated the development of our camera systems, optimized for quantum computing. We are proud to announce the beginning of an adventure towards fault-tolerant quantum computing, together with Quantum Machines," said Tadashi Maruno, Representative Director, President and Chief Executive Officer of Hamamatsu Photonics.

About Hamamatsu's ORCA-Quest:

The ORCA-Quest camera is designed to excel in low-light conditions, providing high-quality images and reliable data through its exceptionally low read noise at effective row readout times of 3.6 microseconds. This feature is especially critical when detecting minimal photon emissions, ensuring no detail is lost in the noise.

www.hamamatsu.com

About Quantum Machines OPX:

The OPX family of processor-based quantum controllers stands out for its comprehensive control capabilities, specifically tailored for scaling quantum computing to 1,000 qubits and beyond. It supports the most complex quantum programs across various quantum systems, thanks to its user-friendly programming and swift execution.

www.quantum-machines.co
info@quantum-machines.co