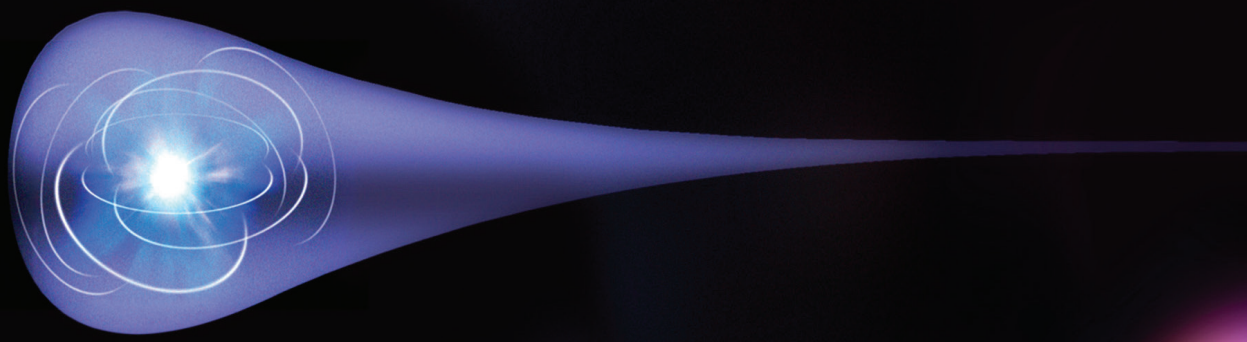
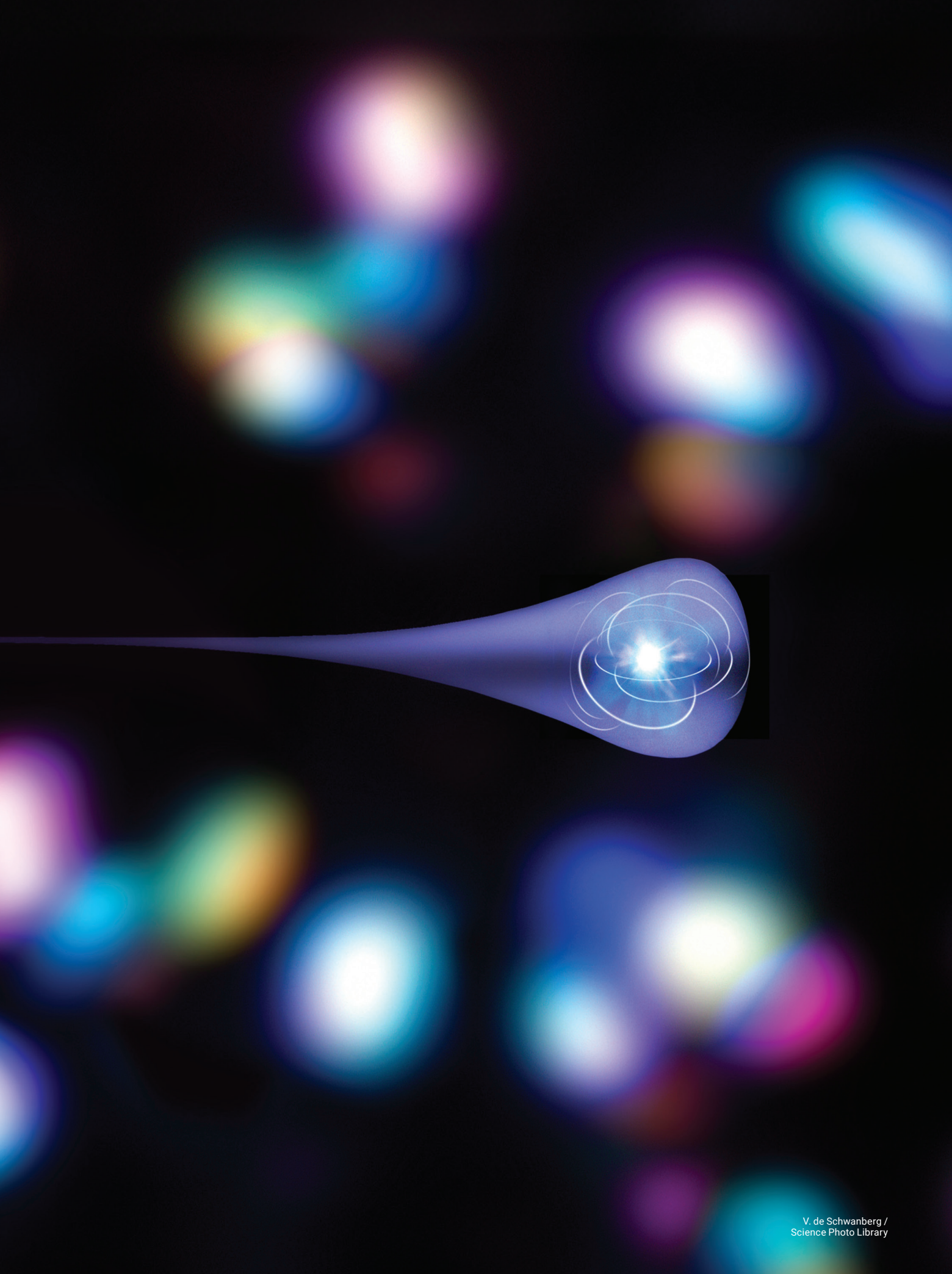
Hannah Lanford

The International Year of Quantum Science and Technology



Throughout 2025, UNESCO's worldwide celebration will highlight the impact of all things quantum.



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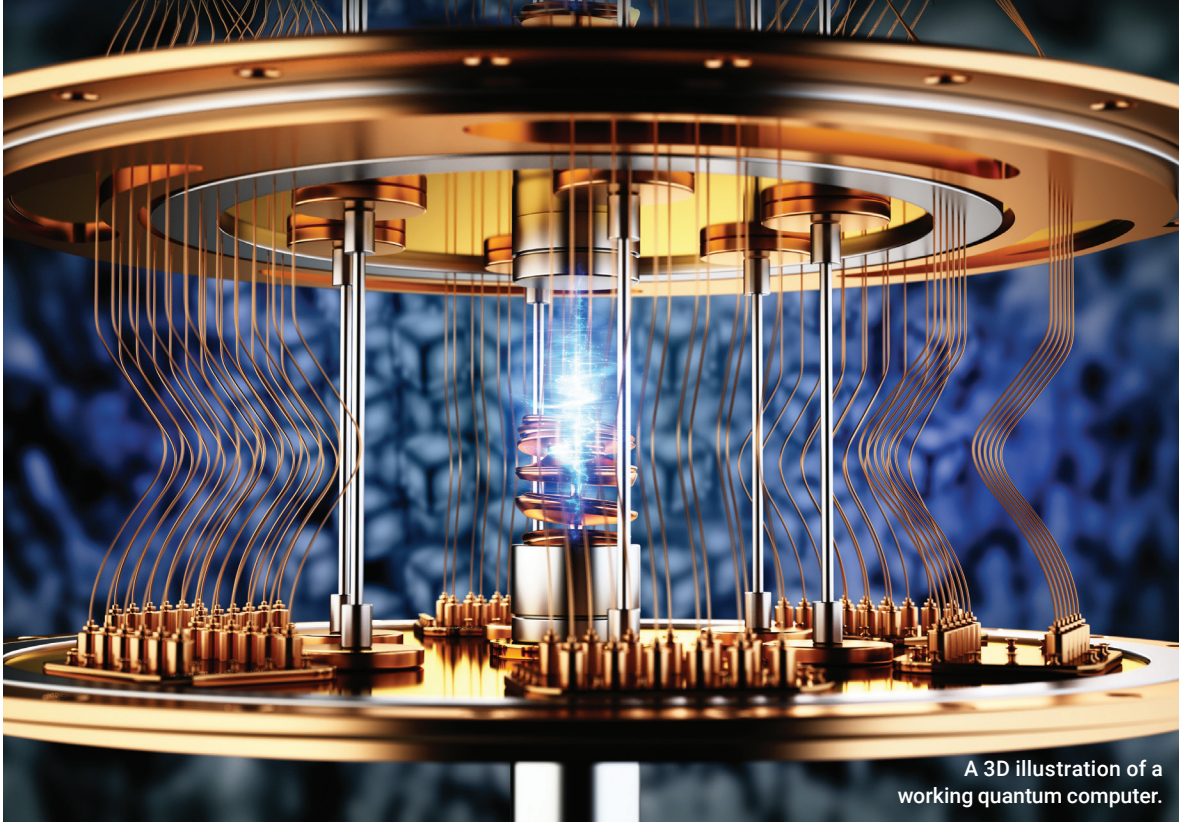

A 3D illustration of a working quantum computer.

Getty Images, adventtr

In the spring of 1925, a young Werner Heisenberg was suffering from an acute allergy attack while working at the University of Göttingen, Germany. Seeking relief, he headed to the craggy German island of Helgoland, where he found not only respite from pollen but also the time and space to clarify his ideas about the intensity of spectral lines. On returning to Göttingen, he worked with Max Born and Jordan Pascual to develop matrix mechanics—the first consistent description of what would become modern quantum mechanics.

This year marks the 100th anniversary of this seminal development. In recognition not only of this milestone but also of the continued growth and importance of quantum science in many facets of life, UNESCO has declared 2025 to be the International Year of Quantum Science and Technology (IYQ). Throughout the year, events and celebrations are planned around the world, with the goal of increasing awareness of the field's impact and inspiring people to become "the next generation of quantum pioneers," according to the IYQ website. The celebration will kick off with an opening ceremony in Paris, France, in early 2025.

"One of our big aims is to demystify quantum," says IYQ steering committee cochair and 2005 Optica President Sir Peter Knight, Imperial College London, UK. "We want to demonstrate how it's led to a whole raft of things you see everywhere, every day: lasers, semiconductors, superconductors, GPS because of atomic clocks. In 100 years, it's been transformative."

The long road to IYQ

Getting the UN to declare an international year is no small feat, as it requires significant cross-border collaboration and diplomatic finesse. "It's quite complicated to get these things through any UN committee," explains Knight. "You need a lot of coordination, and it's very much a global thing."

The idea for IYQ emerged more than three years ago, as a grassroots effort from a group of scientists and educators, including a group at the American Physical Society (APS) Forum on the History and Philosophy of Physics. Inspired by the quantum mechanics anniversary, APS and Deutsche Physickalische Gesellschaft (DPG), the Germany physical society, spearheaded the initial push to commemorate the year. Those societies are among the five founding partners for IYQ, which also include Optica, SPIE and the Chinese Optical Society.

In October 2021 came an important landmark: an endorsement from the the International Union of Pure and Applied Physics (IUPAP) during its 30th general assembly. This was a significant step, according to IYQ steering committee member Joseph Niemela, International Center of Theoretical Physics (ICTP), Italy. "That endorsement helped interest UNESCO [the UN Educational, Scientific and Cultural Organization] in the idea for this international year," Niemela explains. "They trust IUPAP—it really represents physics internationally. So that got their attention."

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The coalition of scientific organizations that had grown up around this effort then put together an initial proposal, which was endorsed first by UNESCO's Executive Board in May 2023 and then by acclamation at the body's 42nd General Conference in November 2023. Mexico was the lead sponsor of this resolution, with 56 other countries cosponsoring. The final hurdle was to get approval from the UN General Assembly. Ghana, thanks in part to the efforts of Chief Programme Specialist at the Ghana Commission for UNESCO and the Ghanaian representative for IYQ Riche-Mike Wellington, formally submitted a draft resolution to the General Assembly in New York in May 2024. It garnered cosponsorship from more than 70 countries, and the resolution was officially approved on 7 June.

The group that traveled to New York to give the presentation to the General Assembly included Niemela; Ama Serwah Nerquaye-Tetteh, Secretary General of the Ghana Commission for UNESCO; Nobel Laureate William Phillips, National Institute of Standards and Technology, USA; Yanne Chembo, University of Maryland, USA, and representative of the African Optical Society; and Ana María Cetto, Universidad Nacional Autónoma de México, Mexico; among others. Niemala says, "I think it was fortuitous. We had a lot of diverse points of view, which all added up, and we covered a lot of territory."

Coordination of IYQ will be overseen by the IYQ Secretariat, convened by UNESCO and APS. The IYQ Global Fund, which will support international coordination and global events, is managed by the IYQ Steering Committee. This committee is cochaired by Knight and Rosario Fazio, ICTP, Italy, and composed of representatives from each of the IYQ founding partners as well as leaders from universities, research institutions, scientific societies, governments and industry around the world.

Education at all levels

An overarching goal of any international year is outreach and education, and IYQ is no exception. The UN resolution proclaiming the year states that it should be observed through activities "aimed at increasing public awareness of the importance of quantum science and applications." Quantum science can present a particular challenge on the outreach front because its principles feel counterintuitive to many. But Knight says that can actually be part of the draw.

"Quantum, holy cow, it sounds difficult. Whenever you talk to people, though, they're actually interested in the conceptual underpinnings of it all *because* it seems so peculiar," Knight says. "Although the concepts can be tough because they're so unlike anything we see in everyday experience, that actually pulls people in. They want to understand how all these seemingly counterfactual things actually work." He also notes that the time is ripe for this particular effort, as the public has become receptive to the topic through frequent coverage in popular media.

Courtesy of P. Knight

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> —*Sir Peter Knight*
> *Imperial College, London, UK*

Cetto joins Knight in stressing that IYQ provides an opportunity to demystify quantum science, both in and outside the scientific community, in particular because it has been portrayed as contrary to the rest of physics. "Quantum mechanics is often presented in textbooks and even specialized literature as something magical—and that is not correct," she explains. "Quantum mechanics can be explained as part of physics. So for me, contributing to a proper understanding of quantum mechanics through education and outreach is a key motivation for being involved in this initiative. We physicists have a major responsibility in how we convey this message to the world."

Courtesy of J. Niemela

> “It’s one thing to have a scientific solution to a problem. But it won’t be useful unless people trust what you’re doing.”
>
> —*Joseph Niemela*
> *ICTP, Italy*

IYQ outreach is intended to reach all levels—not just policymakers or the scientific community, but educators, school-aged children and the general public as well. “There’s always the problem of how much governments are giving to basic research and development, so it’s important to talk to policymakers,” says Niemela. “But a big part of the year is also to excite young people about science.” One aim is to spark interest in students to become the next generation of the quantum workforce, and increase STEM education more generally. Technologies can’t move forward without new workers with innovative ideas, and an international year provides a platform to recruit them.

More broadly, the organizers hope to grow public trust in science and support for funding. “We need to emphasize that fundamental science is done mostly out of curiosity—either wanting to understand something or wanting to solve a problem,” says *Optica Quantum* editor-in-chief Michael Raymer, University of Oregon, USA. “I believe that most scientists are not doing research for political or financial reasons, they’re doing it to improve their understanding or improve the world. And this international year is a chance to get that message across and rebuild some of the public trust in science that may have been lost.”

Niemela also points to the importance of public trust as a necessary prerequisite to implementing new, beneficial technologies. “It’s one thing to have a scientific solution to a problem. But it won’t be useful unless people trust what you’re doing—if you have a program to solve a societal problem, you have to get society behind it,” he says. “That was some of my thinking behind an international year for quantum science and tech.”

John Dudley, University Bourgogne Franche-Comté, France, who chaired the 2015 International Year of Light and helped bring IYQ to fruition, agreed. “While we may naturally think that this is a physics celebration, it goes far beyond that and really touches on trying to raise awareness of the need for science investment and education among all citizens of the world,” says Dudley.

Looking to the real world

One way to approach quantum outreach is to draw attention to the real-world applications that are already in use or will be in the near term, improving lives around the world, in addition to the promises that the future holds. “We’ve got lots of good impact stories—how we can use quantum to deal with some of the big global challenges,” says Knight. And this is one of the reasons that he believes 2025 is the right time for an international year. “The fruits of this long-term investment are beginning to be realized now,” he explains. “What we’re hoping to do [this] year is to actually show that there are devices that people are using. We don’t want to say, ‘Yeah, it’s really exciting. By the way, it takes five optical tables and 10 Ph.Ds. to run.’ We want something you can pull out of a suitcase and use.”

One such example is in medical research and diagnostics. Raymer brings up the use of quantum information techniques to develop and improve medical sensing like MRIs, ultrasounds and CAT and PET scans. He mentions Cerca Magnetics, a UK-based company that has commercialized quantum devices capable of detecting tiny magnetic fields in a wearable, helmet-based system that can record neural activity deep within the brain (for more on the company, see “Quantum Promise Becomes Commercial Reality,” OPN, July/August 2023, p. 48). Cerca’s scanners, which have already been deployed in some hospitals

> “One of Africa’s biggest assets is its people. We don’t lack young people who have the enthusiasm to learn [quantum science].”
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> *—Yanne Chembo*
> *University of Maryland, USA*

Courtesy of Y. Chembo

as a research system, allow patients to move freely during their scan and can be easily adapted for use with babies and children.

Another quantum science application is in the development of better batteries and solar cells. According to Raymer, researchers are using rudimentary quantum computers to try to simulate battery performance and thereby design new and improved batteries. “Anything that has to do with electronics or chemical processes—the deeper you understand it from a quantum point of view, the better you can design and build it,” he explains. “And this is huge. If you want to convert the world to electrical energy storage, you need good batteries and solar energy converters.”

Knight frequently uses the example of GPS to illustrate the prevalence and utility of quantum in everyday life. “I always say, ‘I bet you used quantum technology this morning.’ If you used a satnav to drive, it’s talking to a constellation of satellites, which have atomic clocks in them, which use precessing atomic magnets in coherent superposition. We use it every day.” He also cites the use of quantum in the task of load optimization for electricity generation. As the number of power plants around the world increases, the problem of load shedding becomes too complex to solve with a classical computer, so utilities are turning to quantum technology in an attempt to tackle it.

A 3D-printed helmet that uses quantum sensors to measure human brain function.

Cerca Magnetics Ltd. / L. Gilligan Lee, University of Nottingham

The much-discussed areas of quantum computing and quantum cryptography are tantalizing, longer-term goals. “But even quantum computing has made huge advances. The fidelity of what we can see in quantum gates has improved to such an extent that we know that we can do something about error correction and make a fault-tolerant machine,” says Knight. “We have a clear roadmap now, whereas I think even five years ago, that roadmap was pretty hazy.”

The excitement around such developments, though, must be tempered by realism. Knight highlights the need to be honest in messaging. “I don’t want to mislead people. And in particular with quantum computing, you need patience. But that patience is paying off already.” He explains that avoiding hype and setting reasonable expectations is an important part of the year. “To get a scaled-up quantum computer of substance—we’re talking at least a decade away. But there are quantum sensors and imaging that will transform people’s lives now.”

Courtesy of A.M. Cetto

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> —*Ana María Cetto*
> *UNAM, Mexico*

Quantum for all

During the development of IYQ, the stakeholders and organizers came up with a set of guiding principles for the year, for all those working on planning a public-facing celebration. The first two are “no one owns quantum science” and “everyone is invited.” Expanding on these ideas, the guidelines state that knowledge about quantum should be free and available to all, and encourage everyone to reach out to people with different cultural backgrounds and aesthetic sensibilities to share these insights. That same sentiment is echoed in the UN resolution itself, which stresses that “the celebration of scientific discoveries provides an opportunity to promote science, technology, engineering and mathematics education and research for all, including youth, girls and women, especially in developing countries, in emerging technologies, and to encourage their greater participation in science ...”

Recognition of the work being done by underrepresented groups and outreach to encourage their interest and growth in STEM fields are therefore central parts of the initiative. “We want to work on diversity,” says Knight. “If you look at physics, the gender ratios are appalling. Now, we have the opportunity to enthuse people.”

The year will spotlight the contributions of women who work in the area, giving visibility to this active segment of the quantum community. “The participation of women is increasing, so we’re reaching a kind of critical mass where we can make our voices heard without having to yell,” says Cetto. “Women play an important role in opportunities like this one because we can show the public that we are already part of this community and part of the solution to scientific problems. We want to change the perception about the role of women in the field and encourage more women to follow this path.”

Encouraging the growth of quantum science in developing countries is also a significant aim. As the African Physical Society representative, Chembo underscored the opportunities that investment in quantum can provide for African countries, and the importance of outreach efforts like IYQ in realizing that goal. “Because African countries are facing challenges that are so immediate, it can be difficult to convince policymakers to invest resources in something that is not going to, at least indirectly, help them address the very fundamental problems that they are trying to solve,” Chembo explains. “But I think the same way that mobile communications

A quantum hackathon hosted by Qiskit, quantum-computing software from IBM, in Pilanesberg, South Africa, in 2019.
IBM Research, CC BY-ND

actually ended up being a huge boost to the African economy in spite of initial skepticism, quantum technology likely is also going to contribute greatly to African development. It's going to pay huge dividends down the road."

He cites the development of a quantum workforce as a top priority. "One of Africa's biggest assets is its people. We don't lack young people who have the enthusiasm to learn these things. So we want to make sure that in Africa, we have enough people who are trained in quantum technology and understand quantum science." From there, he says, the next step is understanding which quantum technologies can have the most immediate effect on African populations. "And that can be pharmaceuticals. It can be communications, computation—any number of applications."

A bright outlook

Plans are underway for a full slate of activities throughout the year, both organized by the IYQ partners and by other organizations around the world. The IYQ website will be a centralized resource to organize and track these events, and it will be updated throughout the year. The steering committee has promoted the creation of national nodes in various countries to support different groups to organize activities in schools, at conferences, in museums, at public events and in many other arenas.

Optica is planning a series of distinguished lectures at Optica conferences, and the annual Frontiers in Optics meeting will have a quantum theme as a vehicle to showcase early-career researchers in quantum science and technology. Optica will also host a "Demystifying Quantum" series at three events in 2025. These one-day courses are intended to enable researchers in adjacent fields to gain a level of fluency in and familiarity with quantum science, to the mutual benefit of all involved. According to Raymer, *Optica Quantum* is looking to publish a special commemorative perspective paper highlighting quantum topics and development. Other Optica Publishing Group journals will highlight quantum-related papers as well, to bring this research to the fore.

Chembo emphasizes the importance of the organic nature of the year, encouraging people to plan their own events under the IYQ banner. He explains that, like quantum science, the year belongs to everyone. "There isn't a board room full of executives planning everything and setting up these events," says Chembo. "I encourage everyone to make this year their own around the world." He adds that he's excited to see the unexpected and surprising directions it takes: "I'll know the event has been successful if anyone ever organizes something like a symposium on quantum poetry. I'll travel to attend!"

Courtesy of M. Raymer

> "We need to emphasize that fundamental science is done mostly out of curiosity ... wanting to understand something."
>
> —*Michael Raymer*
> *University of Oregon, USA*

The year's organizers hope that its impact will echo far beyond this one year, with an eye toward improving the future in addition to commemorating past achievements. "If all we do is spend a year patting ourselves on the back for the invention of quantum mechanics, then that is a huge wasted opportunity to actually make a positive change for the future," says Dudley.

By embracing a wide variety of formats and venues, IYQ events and activities will spread the word about the impact of quantum and share the boundless enthusiasm of those who have dedicated their careers to studying it. "The bottom line," says Knight, "is that it's going to be enormous fun." OPN

Hannah Lanford is OPN's managing editor.