

Our quantum world

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Lasers. MRIs. Precision timekeeping. Solar cells. SI units of measure. High-contrast, high-efficiency display devices. Ultraprecise sensors. Optimized drug development. Secure communications. Most of us don't think about it, but we interact with quantum-enabled devices and applications on a regular basis, and that's only going to accelerate.

The United Nations has declared 2025 to be the International Year of Quantum Science and Technology (IYQ). The timing is intentional: This year marks a century since what is traditionally considered to be the start of the “new quantum theory.” (We'll have more about that timing in an upcoming issue of *PHYSICS TODAY*.)

The goals of the yearlong event are broader than just recognizing the advances and impact that quantum science and technologies have had. As described in the story by Toni Feder on page 7, the focus will also be on raising awareness—among the public and policymakers—about the importance of quantum science and applications and their potential to help address the world's most pressing needs.

To kick off *PHYSICS TODAY*'s celebration of the IYQ, we present this special archival issue, in which we've pulled together several of our most enjoyable and informative quantum pieces. Most readers of *PHYSICS TODAY* will have some familiarity with quantum mechanics but not necessarily with the history, the current state of the science, or the central concepts behind some of the most promising applications. We had a wealth of archival content to choose from, and filling those gaps was a prime goal of our selection process.

We present the articles in rough chronological order of their themes:

- ▶ I. I. Rabi, known for his work on molecular beams, was a graduate student at Columbia University in the 1920s and an eyewitness to the quantum revolution. In a transcription of a 1979 talk that *PHYSICS TODAY* originally published in 2006, he shares his colorful recollections of that era.
- ▶ In a 1952 essay, Freeman Dyson, one of the main contributors to the development of quantum electrodynamics—the most precise, extensively tested theory in physics—draws parallels to the history of classical electrodynamics to convey “in simple words” the fruits of 25 years of development.
- ▶ John Bell's name is inseparable from discussions about the foundations of quantum mechanics. In a 2015 article, Reinhold Bertlmann recounts lively stories about working with Bell and explains why debates about those foundations still exist.
- ▶ In his memorably titled 1985 article “Is the Moon there when nobody looks? Reality and the quantum theory”—



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arguably *PHYSICS TODAY*'s most well-known article—David Mermin works through what “Bell-type” experiments say about the quantum nature of the world around us.

- ▶ Barbara Terhal, Michael Wolf, and Andrew Doherty in a 2003 feature describe how the irreducible quantum mechanical property of entanglement has emerged as an exploitable resource for such technologies as quantum teleportation, quantum communication, and, especially, quantum information processing.
- ▶ In their article from 2000, Daniel Gottesman and Hoi-Kwong Lo explain the principles underlying another emerging quantum technology: quantum cryptography.
- ▶ Lasing is an inherently quantum mechanical phenomenon. And as Philip Bucksbaum explains in an article from 2006, the ability of lasers to control and measure the quantum world is opening a wealth of new applications.
- ▶ In a 2021 article, Christine Middleton tours the layers of organization, operation, and abstraction that allow a user-friendly experience to emerge from the underlying qubits in a quantum computer.
- ▶ A 2014 Quick Study by Sheila Dwyer explores how the Heisenberg uncertainty principle can be exploited to improve the precision of quantum measurements—a technique that made possible the 2015 detection of gravitational waves.

The developments surveyed in these articles are snapshots in time of our understanding of the quantum world and of the advances then on the horizon. Collectively, they have helped shape today's frontier in quantum science. Fittingly, we end this special archival issue with a look at one direction of current research: macroscopic qubits.

Over the course of *PHYSICS TODAY*'s 77 years, we have published many more quantum-related articles than we have been able to include in this special archival issue. They are collected on our website at <https://physicstoday.org/quantum>.

Our celebration of the IYQ will continue throughout the year, as we bring you articles, Q&As, explainers, and other pieces that look both backward and forward. Like this editor's note and the story on page 7, each of our quantum-themed pieces will carry the IYQ logo.