EUROPEAN PHYSICAL SOCIETY

Europe and the Future of Quantum Science

In 2025 we celebrate 100 years since the formulation of quantum physics, a scientific milestone that has shaped the modern world. In the 21st century, quantum physics will continue to develop, bringing with it new and unexpected results. Technologies based on these discoveries lead to applications which will benefit humanity.

- Quantum science underpins key technologies of the 21st century.
- The full potential of quantum science remains to be explored.
- Quantum technologies will change our lives, address societal challenges, and drive scientific and economic progress.
- Europe is in a strong position, with an established research base and will play a leading role in future quantum technologies.

The laws of quantum physics were first formulated in Europe in 1925 and describe the behaviour of the smallest constituents of matter, such as elementary particles, atoms and molecules. Quantum objects behave differently – and often counterintuitively – compared to the objects we encounter in our daily lives. Quantum physics triggered a technological revolution, and a century later a second quantum revolution is underway. We use this anniversary to highlight the transformative history of quantum science and technology and explore the immense future possibilities.

The first quantum revolution, built on the wave nature of quantum particles and on the existence of energy "packets" called quanta, began in the middle of the 20th century. This revolution not only deepened our understanding of the fundamental workings of the universe - culminating in the development of the Standard Model of particle physics - but also led to devices and technologies that are now fundamental to our daily lives. Examples include computers and consumer electronics (such as mobile phones) based on semiconductors, LED, lasers, modern medical imaging and treatments, positioning and navigation (GPS, Galileo, etc.), the new definition of the kilogram, photovoltaics, technologies and approaches underpinning climate research, and many others.

The second quantum revolution, where we can fully control the quantum behaviour of elementary constituents like atoms or photons started around the beginning of the 21st Century. This revolution changes the way we think about information, computing, measurement, and matter; leading, for example, to innovative methods for secure communication, quantum sensing, and new quantum materials.

Progress in quantum science continues to accelerate. Global efforts, particularly in Europe, underscore the field's importance, further highlighted by the United Nations' designation of 2025 as the International Year of Quantum Science and Technology.

Whilst some applications of quantum physics, like atomic clocks, moved quickly from research to practice, others, such as quantum computing, are currently transitioning from research to commercial applications.

Even after 100 years, quantum physics remains a field with a significantly untapped potential. Many fundamental questions are still open, which impact both our understanding of the field and its practical application. These include the search for quantum gravity, whether there is a maximum size for quantum systems, the scaling of quantum computing and the classical limit of quantum physics. Global challenges, including secure communication, efficient energy management, climate monitoring, advanced healthcare solutions, and novel drug design may be addressed using quantum science and technology. This underscores the transformative societal impact that quantum technologies could achieve, as well as our obligation to use them responsibly.

Everyone can appreciate the surprising and fascinating nature of quantum physics. Public engagement and outreach initiatives should appeal to all sectors of the society. Both to attract students to the field and raise to awareness of its societal impact. The EPS and national physical societies welcome and support initiatives to increase curiosity and interest in quantum science and technology, preparing our societies for the changes and opportunities to come. We also encourage the various emergent education programs on Quantum Science / Engineering / Computing in Europe to collaborate and exchange best practice. We support actions to train a new generation of students fostering scientific and industrial growth.

We encourage the creation of networks of academic and industrial stakeholders from startups to large corporations to promote scientific and technological development and build upon the ongoing second quantum revolution. The disruptive nature of quantum innovation makes it a field where many actors, from small companies to large corporations, can play a decisive role. We support the creation of an inclusive environment for all actors to develop and deliver innovations.

We welcome the recognition of the strategic importance of quantum technologies for the scientific and industrial competitiveness of our countries, by European policy makers. Their support to develop world-class fundamental research on quantum science and the creation of technology ecosystems across Europe is key for the success of the field.

Signatories:

European Physical Society
Austrian Physical Society
Danish Physical Society
French Physical Society
Finnish Physical Society
German Physical Society
Institute of Physics (UK)
Italian Physical Society
Lithuanian Physical Society
Society of Physicists of Macedonia
Polish Physical Society
Spanish Royal Physical Society
Swiss Physical Society

The declaration was drafted by:
Claus Lämmerzahl, ZARM and GOC, University of Bremen, Germany
Jean-Philippe Brantut, EPFL, Zurich, Switzerland
Christophe Couteau, University of Technology Troyes, CNRS, France
Anna Di Ciaccio, University of Roma Tor Vergata and INFN, Italy
Elisa Ercolessi, University of Bologna, Italy
Juan José García-Ripoll, Institute of Fundamental Physics, IFF-CSIC, Spain
Mairi Sakellariadou, King's College London, United Kingdom
Karol Zyczkowski, Jagiellonian University, Cracow and Polish Academy of Sciences, Warsaw, Poland