Embarking on the Second Quantum Revolution

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The initial foundations of Quantum Physics date back more than hundred years. Quantum Mechanics allows to understand and to calculate the properties and the behaviour of microscopic physical systems and was a big step forward. The First Quantum Revolution with the application of this knowledge invoked ground-breaking technological advancements like transistors and lasers. Meanwhile, science research created the ability to identify, control and manipulate individual quantum objects like photons, electrons, atoms and molecules. These abilities are the basis for new, quantum-driven, technologies. Presently the Second Quantum Revolution is evolving with an incredible speed, leading to disruptive novel technologies. They have the potential to revolutionize the way how we do science in future and to invoke a strong impact on our economy as well as on our society. Various rating agencies predict for Quantum Computing business volumes of $450 billion within the next 15 years and estimated $5 - $10 billion within the next three to five years for users. The competition in this novel Quantum Technology field is very strong.

Paying tribute to the crucial importance of this new technology the First EPS Forum 2022, which took place beginning of June at the Sorbonne University in Paris, featured several highlights in Quantum Technology. The community, including many young scientists as well as recognized seniors, were joined in listening to presentations for example by Nobel Prize Laureate Prof. Serge Haroche on the "Power and Strangeness of Quantum Physics", and on Photonic Quantum Technology. They were debating in a panel on the vision for Quantum Computing as well as exploring it in real hand-on exercises. Actions like this are highly welcome and preparing the community to familiarize and become "Quantum-Ready" for the future.

Quantum Technologies employ physical properties that are very different from classical concepts. Here Superposition, Entanglement and Uncertainty, with its randomization, play a crucial role. Quantum Technologies comprise a large variety of aspects. One very prominent area is given by Quantum Computer Hardware and their Quantum Computing Applications solving complex problems that cannot be addressed with conventional computing or speeding up Big Data analyses to master the challenges ahead of us. Creating and developing Quantum Materials with astounding novel properties, could be the basis for inventing future electronic devices performing faster but with less energy consumption. And then of course Quantum Sensing, opening with unprecedented precision novel opportunities for complex monitoring and experiments beyond our present imagination. Also, Quantum Communication is an area of intense interest due to its prospect of very secure information transmission providing a novel realm for cyber security for financial and other transactions or a faster Quantum Internet.

The novel Quantum Technologies open various windows to potential discoveries in science or solutions for society for example in fighting diseases. At the same time, they imply a strong influence on economy with the eventual industrial application. In order to benefit best and to enable profiting at the first possible instance, Europe is acting via the European Research Council and the European Innovation Council, and has invoked several funding lines to support research and commercialization, for example via the Quantum Flagship or pathfinder challenges to identify alternative approaches in Quantum Technology.

This fourth issue of the Europhysics News features Quantum Technologies with three dedicated articles: "Highly Unidirectional Molecular Motors" by Oliver Gröning, "Cold Rydberg Atoms" by Thierry Lahaye and "Quantum Games" by Sabrina Maniscalco. They open the possibility to look into three different topics in more detail.

Quantum Technology is part of our future. We, physicists in the EPS, are well positioned to become Quantum-Ready and inspire the public. ■

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A Quantum Ecosystem like no other

A barrierless, connected community is at the heart of the national quantum initiative in the Netherlands. In 2021, Quantum Delta NL was awarded €615 million from the Dutch government to implement the National Agenda for Quantum Technology (NAQT). At the core of this agenda is building a unique quantum ecosystem around the five hubs of quantum research excellence: Delft, Eindhoven, Leiden, Twente and Amsterdam (DELTA).

The spark that triggers the growth of almost every high-tech ecosystem around the world comes from the knowledge centers. They are where the cutting-edge research is being pursued and where the brightest talents are being developed who will ultimately push the laboratory research out into the real world. The quantum ecosystem in the Netherlands is no different.

▲ Architect's vision of what the House of Quantum could look like (by Cepezed).

The Delft University of Technology (TU Delft) and its research center QuTech have seen seven quantum spin-out companies form over recent years, all with a hardware focus: Single Quantum, Delft Circuits, QBlox, Orange Quantum Systems, QuantWare and QphoX. Elsewhere in the QDNL ecosystem there are several more established companies, with even more being developed: Quix Quantum (Twente); Leiden Cryogenics and Onnes Technologies (Leiden), Appsilon Enterprise (Delft) and Qu & Co, which recently merged with France-based Pasqal (Amsterdam). The influx of funding for research and capital investment in the companies creates a lot of new work opportunities. To help facilitate top talent joining this rapidly growing quantum ecosystem, every job and internship in both academia and industry are collated on the Netherlands' national job board (jobs.quantumdelta.nl).

This high concentration of quantum companies in Delft and the Netherlands has created a unique opportunity to build a world leading quantum community. The physical embodiment of that is the national quantum campus – a collection of buildings in all the hubs that are integrated and connected across the ecosystem. The Quantum Delta NL agenda originally planned for 7 buildings, totaling >45,000m^2 of technical labs, clean rooms, and offices. The first of those buildings will be open from the fall of 2022 in the Delftechpark, next to the TU Delft campus. It houses four companies, a community lab (rentable millikelvin fridge), and community space (restaurant, event space, flex working areas and meeting rooms). This will serve as the epicenter of the community in Delft, until the opening of the House of Quantum headquarters on the TU Delft campus in 2025. Memberships to this community building are available to international parties to allow them to sample the Dutch quantum community during working visits and discuss setting up potential satellite operations.

▼ Photo from the QDNL "Nodes of One Network" event in Amsterdam 2021.

If you are interested in connecting with the QDNL ecosystem in any way, reach out via info@quantumdelta.nl and sign up to our monthly newsletter via our website. ■