



## **Seeing the Unseen Quantum physics and art as entangled worlds**

**To mark the end of the International Year of Quantum Science and Technologies proclaimed by UNESCO, the ERES Foundation presents a colourful, 'reality-bending' exhibition with an excellent science programme that shines a light on the world of the infinitesimal. Mysterious, enigmatic and counterintuitive: quanta are highly valued and form the basis of all modern technologies, from mobile phones and laser pointers to medical scanners.**

But anyone who ventures into the world of quanta often has to take a leap of faith. Once immersed in the realm of the smallest particles, doors open to astonishing realities. At tiny scales, smaller than a billionth of a metre, which exceed the human imagination, atoms and electrons reign in secret. Different laws apply than in the visible, macroscopic world. This is because quanta do not behave as we are accustomed to with everyday objects, i.e. they behave somewhat 'crazy'. Particles can be in two places at once and be spookily connected. Are they here and there, or perhaps not there at all? Probability clouds are their home. And they can be waves at the same time. But no matter what state they are in, they are measurable and can be determined exactly in experiments.

### **Linking art and science**

With the project "**Seeing the Unseen – Quantum Physics and art as entangled Worlds**", the ERES Foundation invites you on a journey through the quantum world one hundred years after the groundbreaking discoveries of Niels Bohr, Albert Einstein, Werner Heisenberg, Max Planck, Erwin Schrödinger and others, seeking to intertwine it with contemporary art. An experiment with an open outcome, the aim of which is to create an intuitive and rational approach to one of the most promising scientific disciplines of our time. As a radically new technology, quantum computers in particular have the potential to change the world in the near future. These are topics that also fascinate artists.

### **Excellence in the science programme**

The ERES Foundation greatly appreciates having gained a cooperation partner in the **Munich Center for Quantum Science and Technology (MCQST)** cluster of excellence, which is providing scientific support for this project. An outstanding programme of lectures provides insights into one of the world's leading epicentres of modern quantum physics – Munich. Here, exciting developments with great challenges and enormous potential are just beginning in areas such as quantum computing, quantum cryptography and quantum sensor technology. Could a quantum computer made in Bavaria revolutionise computing? Can tap-proof quantum keys be used over long distances? Will tiny imperfections in

diamonds lead to a sixth sense and revolutionise medical technology? Will there also be quantum computers that work at room temperature and use neutral atoms?

At MCQST, scientists from **Ludwig-Maximilians-Universität (LMU)**, **Technical University of Munich (TUM)**, **Max Planck Institute for Quantum Optics**, **Walther-Meißner-Institut** and **Deutsches Museum** are working together on a research programme covering all areas of quantum science.

### **Schrödinger's cat gets competition**

Quantum physics is considered difficult to describe in words and images. Mathematical formulas are its language, but who can master all the root exponents and variables in the numerus? One highlight of the exhibition is therefore an innovative visualisation model with colourful beads that translates the abstract laws of quantum mechanics into clear rules of play and is likely to give Schrödinger's cat a run for its money: recently published in the "New Journal of Physics", visitors to the exhibition have the opportunity to get to know the 'quantum bead game'. Its inventor, **Prof Dr Steffen Glaser (TUM/MCQST)**, discovered striking parallels to the concrete art of the 1960s when realising corresponding manageable models. Swiss artist **Paul Talman** created works with object-like "Kugelbilder" that made rotational movements in three-dimensional space physically tangible. In doing so, he astonishingly accurately predicted the behaviour of quantum bits.

### **The artistic positions**

Conceptual connections between contemporary art and quantum physics lie in the areas of observer dependence, superposition and the idea of an open, non-deterministic reality. While quantum physics shows that the state of a particle is only determined by the act of observation, contemporary art no longer formulates the artwork as an objectively defined message, but as an open system.

The ERES Foundation has also commissioned artistic works for this extensive project: **Mehmet & Kazim** expand and shrink their exhibition space from micro to macro and present painting as an overlay of possibilities that only intersect in the act of seeing. Media artist **Tamiko Thiel** has created a mixed reality space in which the normal world overlaps with the micro world of quantum physics. Using smartphones and augmented reality, we find ourselves in the midst of probability clouds, entangled pairs and spinning electrons (collaboration: /p).

Laser light pioneer **Elsa Garmire**, artist and scientist, lets flashes of light dance psychedelically across a screen. With her psychedelic, colourful laser formations, she pioneered the field of quantum technology-generated effects in the 1970s. Her invention is still used today, for example in light shows at rock concerts. **Herbert W. Franke** makes dancing electrons appear as highly aesthetic forms of vibration. As early as the 1950s, Franke experimented with visualising electron movements and used early computers to create precursors to pictorial representations of quantum physical phenomena. **Tan Mu's** painterly homage to the chandelier beauty of superconducting quantum computers bathes the room in shades of gold and orange. Within it, **Roman Lipski's** hand-tufted 'Qarpet' appears like a giant textile quantum chip. The artist trio **Troika** opens up a large space for reflection on the evolutionary history of humankind with a small collage of a flint biface and a wafer. **Ayoung Kim**, a rising star in the international multimedia art scene, traces a speculative future scenario following a possible quantum revolution in her video 'Delivery Dancer's

Sphere'. The transformation of "Wonder Woman" in **Dara Birnbaum's** video work evokes thoughts of the principle of teleportation. **Agustina Woodgate's** glass sculptures are filled with diamonds that capture in carats the units of measurement such as temperature, energy and time required for quantum experiments. **Jonas Lund's** interface "Network Maintenance" is part of a networked system based on modern quantum cryptography processes. **Thomas Struth's** photograph "Synchrotron Radiation Lab, PTB; Berlin 2012" provides access to a technoid world that remains largely hidden from the public. **Ecke Bonk's** "Erwin Schrödinger" portrays one of the founders of quantum mechanics in an alienated grid, while Alicja Kwade's "CitrusQuantum" transforms complex scientific concepts into a humorous sculptural metaphor.

A total of around 20 artistic positions are represented in the exhibition. In addition, visitors can experience **models** of superconducting **quantum computers** and those that work with neutral atoms. Artistic drawings by the charismatic quantum field theorist **Richard Feynman** are also on display.

Parallel to the exhibition in Römerstraße, **Paul Valentin** and **Tatjana Vall** are presenting "It is plain that all is hidden" at ERES Projects in Theresienstraße 48, a large-scale installation centred around an impressive glass plate hologram. This is also a commissioned work.

#### **Guided tours with young quantum scientists**

A special highlight of the collaboration with MCQST are the guided tours. This time, the tours of the exhibition will be offered as a dialogue guidance by a member of the ERES Foundation, accompanied by young quantum scientists, providing a deeper understanding of how quantum computers work and what they will be capable of in the future.

**An exhibition catalogue will be published (DE/EN).**

**Artists: Dara Birnbaum, Herbert W. Franke, Elsa Garmire, Ayoung Kim, Alicja Kwade, Roman Lipski, Jonas Lund, Mehmet & Kazim, Tan Mu, Semiconductor, Thomas Struth, Paul Talman, Tamiko Thiel, Troika, Agustina Woodgate, and others.**