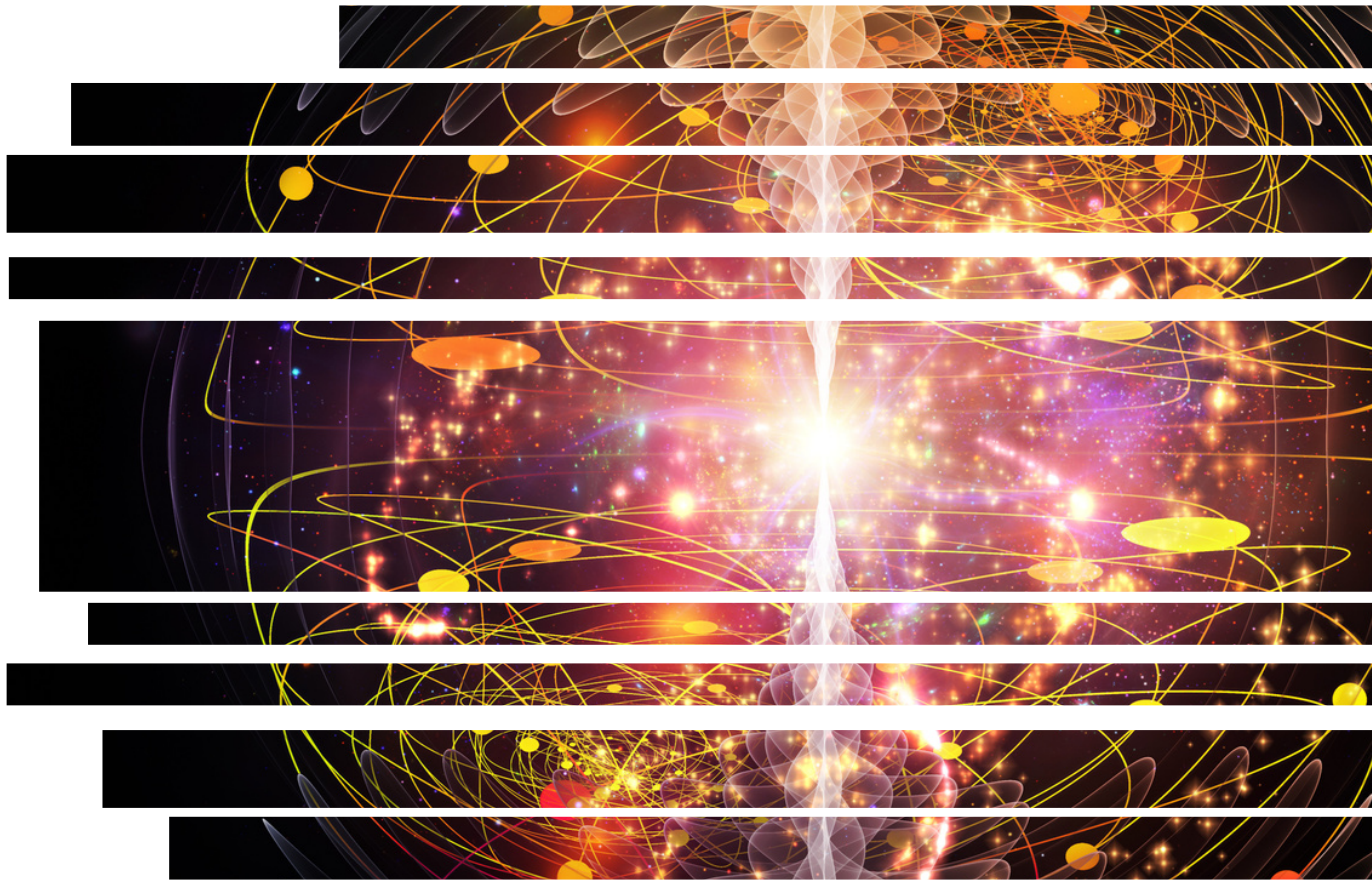




# Quantum Social Lab

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Explore **today** how quantum  
will impact **tomorrow**



part of **TtT** TUM THINK TANK

# Table of Contents

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|                           |    |
|---------------------------|----|
| 1. Foreword               | 1  |
| 2. About                  | 2  |
| 3. Research               | 4  |
| 3. Education              | 6  |
| 4. QuantWorld             | 8  |
| 5. Artistic Interventions | 10 |
| 6. Outreach and Events    | 12 |
| 7. Community              | 14 |
| 8. Policy and Impact      | 16 |

# Foreword

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*The Quantum Social Lab (QSL) was established in 2022 at the TUM Think Tank, cognizant of a pressing question: Is it too early – or perhaps already overdue – to address the implications and opportunities of evolving quantum technologies? We contend that such inquiry cannot wait.*

*Innovation does not occur in isolation. Every scientific and technological advance carries with it profound ethical considerations, legal challenges, and societal consequences, but also new potential. The Lab was founded to investigate these issues not from a position of detachment, but through a deep and constructive engagement with the very technologies under development. Our work is driven by a commitment to fostering innovation that leads to meaningful change.*

*The QSL approach is grounded in the belief that addressing the challenges posed by quantum technologies and realizing their opportunities requires more than technical analysis and solutions alone. It demands vision, creativity, and authentic dialogue with the communities most affected. By combining bottom-up engagement with state-of-the-art research on governance and policy, the Lab seeks to anticipate risks, identify opportunities, and contribute to pathways that render innovation not only feasible but also responsible.*

*Our work is defined by an interdisciplinary ethos that respects and integrates diverse fields – physics, mathematics, the social sciences, and philosophy – moving toward deep collaboration across boundaries.*

*QSL is not exclusively about research. It is an invitation to co-creating futures that are as inclusive and forward-thinking as they are innovative.*



**Fabienne Marco**  
Lab Director



**Urs Gasser**  
Lab Principal Investigator



# About

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*In the rapidly advancing world of second-generation quantum technologies is poised to revolutionize our understanding of what's possible.*

The Quantum Social Lab (QSL) is an interdisciplinary space dedicated to addressing the societal, ethical, and policy dimensions of this emerging field. We believe that technical progress alone can't capture the full implications of this powerful new era. To address this, we bring together a diverse community of researchers, students, developers, and artists from different disciplines and backgrounds to shape the ethical, legal, and societal dimensions of this emerging socio-technological domain.

The foundation for our work was laid during the teaching of a course on Quantum Governance at the Technical University of Munich (TUM), which revealed that a more explicitly interdisciplinary perspective was needed. This recognition led to the organization of the International Quantum Forum, hosted by the TUM Think Tank in collaboration with Yale University and Arizona State University, supported by the Quantum Delta Netherlands, among others. Bringing together contributions from international scholars, the event aimed to foster dialogue on the governance, security, and broader societal implications of quantum technologies. It marked the beginning of a research agenda that combines critical inquiry with international cooperation.

While the precise impact of these technologies remains uncertain, their disruptive potential makes it urgent to explore their governance and ethical challenges now. The QSL's interdisciplinary ethos allows us to integrate diverse perspectives from the social sciences, philosophy, physics, and beyond, ensuring a comprehensive and forward-thinking approach.

In its early phase, the QSL has established core strengths in research, education, policy engagement, and outreach. Our research primarily addresses the governmental and societal questions raised by quantum technologies while remaining firmly connected to their technical foundations. Beyond our university teaching, we run the Young Quantum Social Scientists (YQSS) program, which supports early-career talent in exploring the societal implications of quantum innovation. We also develop policy-oriented initiatives that foster global dialogue on the opportunities and challenges of quantum tech, in close collaboration with partners within and beyond TUM.

Equally vital is our outreach mission, which connects cutting-edge research with emerging talent and the wider public. By organizing flagship events like the International Quantum Forum and collaborating at conferences and gatherings worldwide, QSL helps shape an informed and inclusive conversation on the future of quantum technologies.

Together, these community-driven activities reflect our commitment to advancing responsible innovation and shaping globally relevant perspectives on this new era.



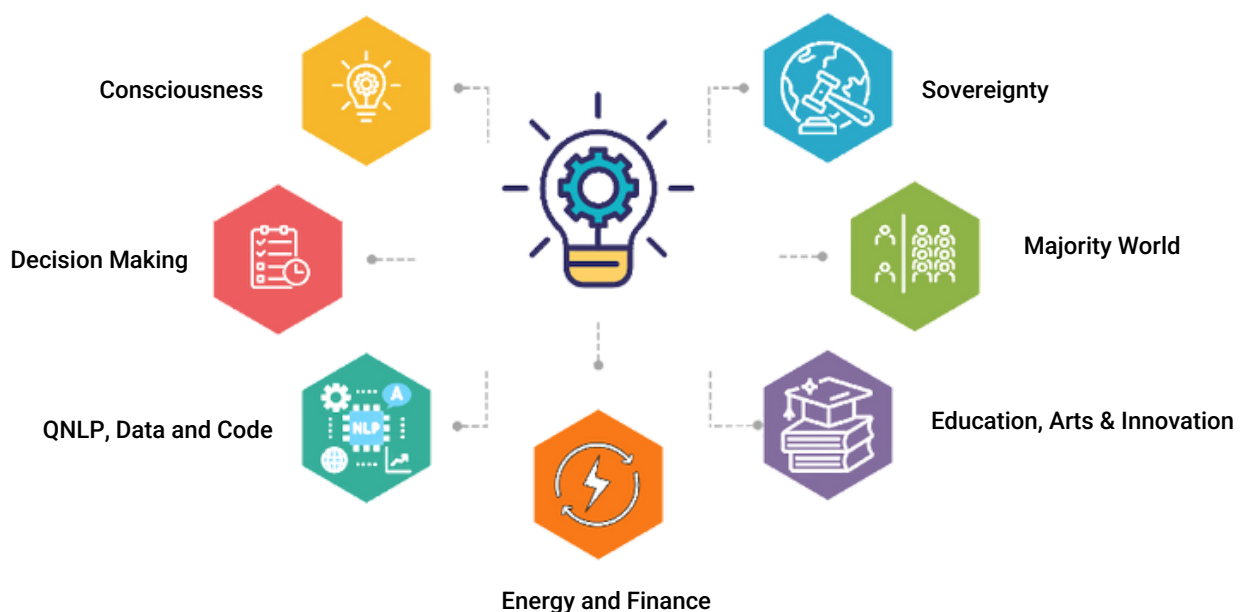
# Research

*To ensure a responsible quantum future, our research is grounded in the core principles of safeguarding, engaging, and advancing.*

The Quantum Social Lab explores how quantum technologies can be responsibly governed and which policies are needed to steer this transformative field. Our research focuses on developing and testing new governance frameworks and mechanisms — such as the ELSPI framework, guardrails, and policy sandboxes — to anticipate challenges before they arise.

Building on the ELSPI framework and its core principles of safeguarding, engaging, and advancing, we examine existing and emerging policies across sectors to identify opportunities and risks. In their latest work, Urs Gasser and colleagues demonstrate how these anticipatory approaches can be more effective than traditional hard-law models, providing agile and responsible pathways in rapidly evolving technological landscapes.

Our inquiries also extend across disciplinary frontiers. We explore the interface of quantum technologies with artificial intelligence (QAI), decision-making, and neuroscience. We also address forward-looking themes such as the relationship between quantum technologies and consciousness, investigating how quantum algorithms might mirror cognitive abilities or open new avenues for understanding mind and awareness. Additional areas of exploration include the regulatory and energy implications of quantum systems, as well as their geopolitical impact as second-generation quantum technologies emerge.



# Publications

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The Quantum Social Lab's key publications showcase our commitment to anticipatory governance and interdisciplinary research. Building on this foundational work, QSL refines and applies frameworks and tools in practice — uncovering sector-specific challenges and opportunities, and shaping responsible pathways for the future of quantum technologies.

**Español, G. A., & Marco, F.** (2025, October). Quantum sandboxes for the majority world: A dual governance approach to innovation and regulation. T20 South Africa.

Aboy, M., **Gasser, U.**, Cohen, I. G., & Kop, M. (2025). *Quantum technology governance: A standards-first approach*. Science, 389(6760), 575-578.

**Gasser, U., & Marco, F.** (2025, May 9). *Cracking the quantum future of finance*. Duckbucks. <https://duckbucks.com/a/cracking-the-quantum-future-of-finance>

**Gasser, U.**, De Jong, E., Kop, M. (2024). *A call for responsible quantum technology*. Nature Physics, 9 Apr 2024, Vol 20, 525-527.

Kop, M., Aboy, M., De Jong, E., **Gasser, U.**, Minssen, T., Cohen, I. G., ... & Laflamme, R. (2024). *Ten principles for responsible quantum innovation*. Quantum Science and Technology, 9(3), 035013.

**Marco, F.** (2024, July 19). *Advancing the quantum innovation paradigm: Using AI governance frameworks to identify gaps within quantum governance strategies and their narratives*. Paper presented at the EASST-4S 2024 Conference, Amsterdam, Netherlands. URL: <https://nomadit.co.uk/conference/easst-4s2024/paper/85866>

Kop, M., Aboy, M., De Jong, E., **Gasser, U.**, Minssen, T., Cohen, I. G., ... & Laflamme, R. (2024). *Towards responsible quantum technology: safeguarding, engaging and advancing quantum R&D*. UC L. Sci. & Tech. J., 15, 63.

# Education

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*“Education is not the learning of facts, but the training of the mind to think.” - Albert Einstein*

The Quantum Social Lab offers a wide range of educational programs. Our university courses are designed to foster an interdisciplinary understanding of quantum technologies, with a focus on Quantum Governance. These include courses like *Quantum Computing for Future Policy Shapers*, *Quantum Technologies in Theory and Praxis*, and *Quantum Social Lab: Mapping Challenges and Opportunities of Quantum-Based Technologies*. Students from all disciplines can also dive into the foundations with courses such as *Mathematical, Physical and algorithmic basics of Quantum Technologies* and *Quantencomputing für Politikwissenschaftler:innen*.

Our curriculum also explores the intersection of art and quantum technologies, often taught in collaboration with our artists-in-residence through courses like *Generative Design Studio: Responsible Quantum Innovation and Art-Driven Innovation with Quantum Technologies*. Our courses are open to all TUM students and are taught with state-of-the-art methods, often resulting in real-world applications, artworks, or academic publications.

To specifically foster interdisciplinarity, our most promising students can apply for the Young Quantum Social Scientists (YQSS) scholarship. This program promotes cross-disciplinary education, skills and research training, and challenge-based problem solving.

Our educational efforts extend beyond the university. The QSL also focuses on the education of policymakers and the wider public, specifically through the development of the QuantWorld learning platform.



# YQSS - Fostering Interdisciplinary Talents

*We offer a variety of courses for university students around Munich, and a unique junior researcher program: the Young Quantum Social Scientists.*

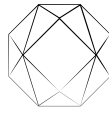
The Young Quantum Social Scientists (YQSS) program is a one-year scholarship designed to educate and empower the next generation of scholars at the intersection of quantum technologies, politics, and society. The program blends research, education, and hands-on engagement, bringing together students from diverse backgrounds.

YQSS participants contribute directly to QSL's projects, support partners, and pursue their own research. They are also integrated into initiatives such as the QuantWorld Learning Platform, and they take courses on quantum foundations, governance, and ethics to provide them with an innovative, cross-disciplinary perspective.

To broaden their impact, students present their work on international stages such as Xpanse (Abu Dhabi), SONAR, and Quantum Effects, ensuring their voices shape both academic and public debates on quantum innovation.



# QuantWorld



*The QuantWorld flagship project explores the future of quantum technologies within specific areas such as banking, medicine, and mobility.*



QuantWorld is supported by the Federal Ministry of Research, Space, and Technology with 1.9m Euros. Coordinated by the Technical University of Munich (TUM) in cooperation with Fraunhofer AISEC and the TUM University Clinics, it explores how second-generation quantum technologies (QT 2.0) may shape key sectors such as medicine, banking, and mobility. It takes a human-centered approach, placing citizens at its core to build trust in quantum technologies and make them tangible.

The project's core is the QuantWorld Learning Platform, a modular, digital environment with open-access materials and certification options. Rather than beginning with physics or mathematics, it starts from people's everyday needs and experiences.

QuantWorld also includes challenges, where Artists-in-Residence and Extended Reality (XR) interventions make societal opportunities and risks of quantum technologies accessible to experts, students, professionals, and engaged citizens alike. In the long term, all modules will culminate in a free *Quantum Basics* course, modeled after *Elements of AI*, to create a shared societal knowledge base.

# QuantWorld Learning Platform

*A learning platform for everyone interested in the world of quantum technologies.*

The QuantWorld Learning Platform (launching February 2026) combines modern design with a unique learning approach. It begins by exploring the technology's potential impact on people's lives within "living worlds," allowing users to then dive deeper into the basics of quantum mechanics. From there, users can also zoom out to explore the world of quantum governance, RRI (Responsible Research and Innovation) applied to quantum technologies, or discover future scenarios.



# Artistic Interventions

## When Quantum Meets Arts

*Artistic interventions bring a unique perspective to the abstract world of quantum technologies.*

One of the Quantum Social Lab's unique lines of exploration is its sustained engagement with the arts. From the outset, we have treated artistic interventions not as peripheral but as integral to our research, education, and community-building. While the arts are often overlooked in discussions of science and innovation, we believe a holistic approach to quantum technologies requires the full spectrum of human creativity and expression.

This commitment was demonstrated at the International Quantum Forum, where artistic performances — including those by Ila Khamagaran — showcased how art can expand the conversation around quantum technologies, offering new ways of sensing, interpreting, and experiencing their societal relevance. Such interventions do not merely illustrate scientific concepts; they challenge established perspectives, stimulate dialogue, and open imaginative horizons.

Through initiatives like the QuantWorld Project and the YQSS network, we collaborate with artists to create experiential encounters with quantum ideas. These works make abstract concepts tangible, spark public imagination, and cultivate broader societal reflection.

By integrating artistic perspectives, we aim to move beyond disciplinary silos and foster a genuinely interdisciplinary dialogue — one that embraces science, philosophy, law, and art as coequal partners in shaping the future of quantum technology.



# Artistic Perspectives

## Patrik Hübner

*To me, art can act as a mediator and translator of complex technological concepts into comprehensible, engaging experiences that can be more easily digested by both individuals and the society as a whole. [...]*



## Anne Kristin Kristiansen

*[...] Second generation quantum technologies are extremely interesting to me because of the state of "fragile coherence" they depend on, and the transformative potential that can ensue from such seeming fragility.*



## Solimán López

*[...] I am deeply fascinated by the concepts underlying the quantum world, and I also believe that a better and more profound understanding of this technology will aid humanity in comprehending the origins of our species and ourselves. However, we must be mindful to "curate" how society utilizes this powerful tool. [...]*



## Benjamin Nott

*That space between technology and the user is one of the most exciting and daunting places to be. Do you approach it with a tech mindset, or do you approach it with a end-users mindset? I feel the arts have always allowed us to bridge this gap.*



# Outreach and Events

*From academic symposia to science slams, QSL brings research to life through diverse and engaging events.*

To bridge the gap between academia and the public, including policymakers, the Quantum Social Lab engages in a variety of events and formats. We not only host our own key events but also collaborate with partners to co-create forums, workshops, and other spaces for public engagement. Examples include:

**The Transatlantic Quantum Forum (2022):** The QSL hosted a first open academic conference – hybrid together with the Arizona State and Yale University, where more than 40 researchers presented their ongoing work.



**PuzzleX (2023):** Together with our partner Matter Inc. we created a Quantum Cipher Garden – a 20-square-meter presentation of Quantum Encryption.

**2<sup>nd</sup> Annual Stanford Responsible Quantum Technology Conference (2024):** Urs Gasser and Constanze Albrecht represented the common project collaboration “Building Global Capacity for Responsible Quantum Technologies.”



**XPanse (2024):** The Young Quantum Social Scientists presented a Quantum Medical Wonderland, a 50-square-meter installation in Abu Dhabi showcasing their work on the future of medicine. The event featured keynotes from Urs Gasser and Fabienne Marco, complementing the students' own presentations and highlighting the Quantum Social Lab's interdisciplinary research for a global audience.

### **International Quantum Forum (2025):**

The QSL and its partners hosted a two-day International Quantum Forum in Munich. It brought together academic discussions, a Science Slam, and a grand finale – the Quantum Arts Gala at the HP8, creating a unique space for interdisciplinary engagement.



# Community

## *Bridging Research and Society Through Community*

Quantum technologies are more than scientific breakthroughs — they carry the potential to transform our societies. Ensuring this transformation is inclusive, responsible, and aligned with human values is central to our mission. The Quantum Social Lab builds a vibrant community that unites scientists, industry, policymakers, students, and the public, forging the connections needed to shape a quantum ecosystem for the future we want to build.

**Academia:** Embedded in the TUM ecosystem and connected to universities worldwide — including Chulalongkorn University, the University of Amsterdam, the University of Oxford, and Harvard University — the QSL collaborates with leading researchers on joint projects and fosters student mobility to strengthen international exchange.



**Economy:** The development of quantum technologies is accelerating, driven by academia, industry, and governments alike. Today, private-sector investment already surpasses that of governments, underscoring the central role of industry in advancing the field. The QSL engages with companies such as Quandela, Strangeworks, Terra Quantum, and IBM — remaining independent in its research while offering students unique opportunities to experiment with real quantum devices and connect with diverse career paths early on.

**Decision-Makers:** Supported by the *Bavarian Ministry of Science and the Arts* and recognized as a *TUM Flagship Project*, QSL provides strategic insights for stakeholders across policy, academia, and industry. Participation in review processes such as *UNESCO's COMEST* and endorsement of the *UN Year of Quantum Science and Technologies* highlight its role in a wider community of NGOs, policymakers, and public institutions shaping responsible quantum governance. Further partners include GESDA and the OQI.



**The Public:** By opening events to the public and placing them in accessible venues, QSL maximizes its societal impact. Collaborations with partners such as the *SMÄK - Egyptian Museum Munich* and *TECH by Handelsblatt* bring quantum debates to broader audiences. Beyond academic publishing, QSL ensures that its community grows with exceptional diversity, making quantum technologies part of a shared public conversation.

**Students:** Students and young researchers are not passive recipients but core stakeholders in QSL's community. Integrated into projects and partnerships with associations such as *Girls in Quantum*, the *Austrian Quantum Society*, and *Push Quantum*, they contribute actively to research and outreach. Highlights include a Science Slam and a World Café during the *International Quantum Forum 2025*, showcasing the creativity and agency of the next generation.



# Policy and Impact

*For QSL, responsible innovation begins with dialogue; when decision-makers listen and knowledge flows freely, policies can truly shape inclusive futures.*

Over the past two years, we have advanced this mission through diverse initiatives:

**Policy Clinics:** First piloted in Thailand in the realm of AI, this innovative concept that translates principles into action is now being expanded by Urs Gasser and Fabienne Marco with the Global Network of Centers, evolving into grassroots policy clinics and sandboxes that foster dialogue and experimentation.

**Hosting Dialogues:** In collaboration with the TUM Think Tank, QSL has participated in and shaped formats for exchange and learning, bringing together thought leaders such as Alondra Nelson, Markus Blume, and Niklas Lundblad.

**Knowledge Sharing:** QSL actively contributes to conversations at major conferences and events, from physics to diplomacy. Highlights include the Geneva Science and Diplomacy Anticipation Summit, UNESCO Global Forum, TECH, GiTex Europe, the KI Big Bang Festival, and the Deutsche Physikalische Gesellschaft.

**Impact Building:** Our work is built on dialogue, but it is ultimately about creating impact. By connecting scientists, policymakers, industry leaders, and the public, the QSL ensures that quantum technologies are developed with societal needs in mind. Every policy clinic, forum, and public exchange strengthens the foundations for inclusive and responsible innovation, making QSL a catalyst for long-term transformation in the quantum ecosystem.



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