Deutsche Physikalische Gesellschaft DPG

International Workshop Opportunities and Risks of Quantum Technologies:

International Relations, Civil Society Consequences and Possible Restraint

October 20 - 21, 2025, Physik-Zentrum, Bad Honnef
Hauptstr. 5, 53604 Bad Honnef, Germany

Quantum technologies enable completely new applications in many areas of society, both nationally and internationally. Enormous investments and research programmes are being made by leading countries and industry in the field of quantum innovations. These are regarded as strategic techno-logies in international competition. Current and future research not only harbours great economic opportunities, but also potential risks, which are being discussed internationally, particularly in the areas of international relations, security policy and geopolitics. This is particularly evident in potential applications in the field of quantum communication (cryptography), quantum sensors and quantum navigation. However, problems in civil society are also foreseeable, for example in relation to privacy and data protection, diversity and fairness or misinformation. Even if many developments are not always foreseeable today, their social and security policy risks should be discussed in advance. On the one hand, particularly security-relevant fields will be identified and mechanisms for risk reduction examined, while on the other hand, experience from the areas of risk technologies, arms export control or preventive arms control should be applied to future destabilising applications.

Four questions arise in particular: Where are new, critical application possibilities with destabilising consequences? Which players, research programmes and application goals are known? What control and ethical containment options are there and what experiences have been made so far? Which national and international forums are discussing comparable developments, applications and possible limitation options?

Organisation: DPG – WG Physics and Disarmament (AGA), WG Industry and Economy (AIW), Physics of Socio-Economic Systems Division (SOE)

Sponsored by: Wilhelm and Else Heraeus-Foundation

DPG Programme Committee. Jürgen Altmann (AGA), Götz Neuneck (AGA), Achim Grunwald (ITAS), Hans-Georg Grothues (AIW), Steve Fetter (U of Maryland), Philipp Hövel (SOE), Dieter Meschede (Bonn).

Link: https://www.quantum2025.de/veranstaltungen/chancen-und-risiken-von-quantentechnologien

The **final seminar program** is available at the seminar website:
https://www.dpg-physik.de/veranstaltungen/2025/opportunities-and-risks-of-quantum-technologies

Conference venue:
The address of the **Physikzentrum Bad Honnef** is Hauptstrasse 5, 53604 Bad Honnef, Germany

INTERNATIONAL YEAR OF Quantum Science and Technology

2025 Quantum2025

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Phone during office hours: +49 (0) 2224 9010-113 or -114 or -117
Phone during the conference: +49 (0) 2224 9010-120
Travel hints: On the website you will find a detailed city map of Bad Honnef, showing the location of the Physikzentrum. Special railway fares for travelling within Germany to Bad Honnef are available here. If no taxi is available at the railway station in Bad Honnef or Rhöndorf please dial +49 (0) 2224 2222 to order one.

SUNDAY, October 19th, 2025

- Arrival and registration
- 18:30 Supper, Social Gathering: Lichtenberg-Keller

MONDAY, October 20th, 2025

*** Breakfast at 7:30-9:00 ***

Welcome (DPG Official, Organizers)

1. **Overview on Current Quantum Research and Development** 9:10-10:30

Moderator: Dieter Meschede

- **Frank Wilhelm-Mauch,** Saarland University/FZ Jülich**:**
  Quantum Computing – State of Play and Expectations
- **Christopher Monroe**, Duke University:
  Quantum Computers for Research, Government, and Industry

*** Coffee Break 10:30-11:00 ***

Research Areas

2. **Quantum Computing and Simulation** 11:00-12.30

Moderator: Joachim Ulrich

- **Peter Orth,** Saarland University:
  The Future of Computation? Unlocking the Power of Quantum Computing
- **Wolfgang Mauerer**, Ostbayerische Hochschule Regensburg, Lab. for Digitalization:
  Status and Future of Quantum Algorithm

*** Lunch 12:30-14:00 ***

3. **Quantum Sensing and Navigation** 14:00-15:30

Moderator: Hans-Georg Grothues

- **Alberto Comin, Airbus:**

"Navigating the Quantum Future: An Aerospace End-User's Perspective"

- **Thomas Strohm,** Chief Expert for Quantum Technologies, Bosch Research & President of the European Quantum Industry Consortium (QuIC)
  Quantum Magnetometers and Quantum Computing Applications in Material Research and the Aspects of industrialization at Bosch

*** Coffee Break 15:30-16:00 ***

4. Quantum Communication and Cryptography 16:00-17:30

Moderator: Philipp Hövel

- **Oliver de Vries,** Quantum Optics Jena: *Data Security in the Age of Disruptive Technologies: Quantum Encryption from a User Perspective*
- **Nico Döttling,** CISPA Helmholtz Center:
  Quantum Cryptography beyond Quantum Key Distribution

*** Conference Dinner 18:30-20:00 ***

Evening Talk: Thomas Lengauer, Leopoldina: 20:00-21:30

Science With an Ethical Compass in the "Zeitenwende"

Moderator: Götz Neuneck

Social Gathering: Lichtenberg-Keller

TUESDAY, October 21st, 2025

*** Breakfast at 7:30-9:00 ***

Application Areas

5. Domestic Security: Critical Infrastructures, Cyber-Security 9:00-10:15

Moderator: Hans-Georg Grothues

- **Andrés Barreneche García,** OECD, Paris:
  Towards International Principles for the Responsible Development and Use of Quantum Technologies
  Silvio Dragone, IBM Research, Zürich:
  Cybersecurity in the Era of Quantum Computing: Risks, Adaptation, and Infrastructure Challenges

*** Coffee Break 10:15-10:45 ***

6. International Security, Defence Research and Arms Control 10:45-12:00

Moderator: Jürgen Altmann

- **Michal Krelina,** Stockholm International Peace Research Institute (SIPRI**)** / Czech Technical University, Prague:
  Quantum Technology in the Military – Introduction and Trends
- **Lukas Weymann,** Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe)**:**
  Quantum Technologies in the Military Context – Evaluation of Potential Applications and International Activities
- **Lindsay Rand**, Center for International Security and Cooperation, Stanford University:
  Detecting Submarines: Technical Feasibility and Strategic Stability Implications

7. Ethical Question, International Relations 12:00-13:15

Moderator: Armin Grunwald

- **Mira L. Wolf-Bauwens,** Geneva Science and Diplomacy Anticipator, Geneva:
  Why the Era of Quantum Utility must be the Era of Responsible Quantum Computing
- **Matthias C. Kettemann**, Harvard University/Innsbruck Quantum Ethics Lab, Department of Theory and Future of Law, University of Innsbruck:
  Quantum Technologies as a Common Good? The Work of UNESCO's Science Ethics Committee and the Limits and Potentials of a Normative Approach to the Ethics and Governance of Quantum Computing

Closing Remarks 13:15-13:30

*** Small Lunch 13.30-14.00 ***

Abstracts

1. Overview on Current Quantum Research and Development

Prof. Dr. Frank Wilhelm-Mauch, Saarland University/FZ Jülich: *Quantum Computing – State of Play and Expectations*

Quantum computing is currently omnipresent in the media hype cycle. The field has made tremendously advances, yet, some claims are even bigger than the progress. This talk will give an overview of the current status, next steps, and long-term goals as well as put some of the current hype into context. It will focus on the perspective of a user and observer rather than that of a quantum engineer.

Prof. Dr. Christopher Monroe, Duke University: *Quantum Computers for Research, Government, and Industry*

Quantum computers exploit the bizarre features of quantum physics -- uncertainty, entanglement, and measurement -- to perform tasks that are impossible using conventional means. These may include the computing and optimizing over ungodly amounts of data; breaking encryption standards; simulating models of chemistry and materials; and communicating securely via quantum teleportation. While the quantum hype is deafening, solving certain types of problems will likely require quantum computers. The speaker will discuss the state-of-the-art in the pursuit of quantum computers, led by an uneasy coalition of scientists and engineers from academia, industry and government.

2. Quantum Computing and Simulation

Prof. Dr. Peter P. Orth, Saarland University: *The Future of Computation? Unlocking the Power of Quantum Computing*

The prospects of constructing a quantum computer are tantalizing. Such a machine is expected to solve a selected number of important problems much faster than any classical computer. One important example is the factoring of large integers into their prime factors using Shor's quantum algorithm, which could be used to break commonly used cryptography schemes. Another one is the simulation of a quantum system's dynamics with potential applications in the discovery of new materials or drugs. While the current technology is potentially decades away from being able to run Shor's algorithm for significantly large integers, the past few years have brought tremendous progress in our efforts of building and reliably operating a quantum computer, including recent breakthroughs in realizing beyond classical simulations and of quantum error correction. Several recent quantum experiments have unearthed a new form of "quantum-centric supercomputing". This makes near-term applications such as quantum simulation an immediate and realistic goal. The speaker will introduce quantum computing and explain the underlying concepts that enable the tremendous speedups for selected problems that are anticipated and what is required to reach a "practical quantum advantage". He will also discuss where the technology stands now, what are potential near-term applications, focusing on quantum simulations, and what are future goals in our quest towards the realization of a full-fledged quantum computer.

3. Quantum Sensing and Navigation

Alberto Comin, Airbus Ottobrunn: *"Navigating the Quantum Future: An Aerospace End-User's Perspective"*

As a key industrial end-user, Airbus regards quantum technologies as strategic assets that require careful navigation of both their opportunities and risks. This talk presents our perspective on the practical applications and challenges of these dual-use technologies. To improve guidance and resilience, we are developing quantum sensing and navigation solutions that mitigate the risks of satellite dependency, including quantum inertial navigation and quantum-enhanced magnetic anomaly navigation. We address the direct threat that quantum computers pose to data security by contributing to the European Quantum Communication Infrastructure (EuroQCI), a project combining terrestrial and satellite networks. Finally, while quantum computing is still maturing, we explore its potential to solve intractable, NP-hard problems. Our use cases include applying quantum simulation to fuel cell modelling and using quantum optimization for logistical challenges like aircraft loading and flight path optimization.

Dr. Thomas Strohm, Robert Bosch GmbH: *Quantum Magnetometers and Quantum Computing Applications in Material Research and the Aspects of industrialization at Bosch*

We present the technical background of two quantum technology activities at Bosch: the quantum magnetometer and quantum computing applications in the field of materials research. In addition, some general aspects of the industrialisation of these technologies are addressed.

4. Quantum Communication and Cryptography

Dr. Nico Döttling, CISPA Saarbrücken: *Quantum Cryptography beyond Quantum Key Distribution*

Quantum cryptography, initiated by the works of Wiesner, and Bennett and Brassard, offers the prospect of unconditional security: While all of classical public key cryptography necessarily relies on computational hardness, keys generated with a quantum key distribution cannot be compromised using any amount of computational power. However, the hope of realizing cryptographic tasks beyond quantum key distribution with unconditional security was shattered by the work of Mayers, who showed that not even the minimal notion bit commitments can be realized with unconditional security in the quantum setting. Recently, cryptographers started considering the more modest notion of “everlasting security”, which guarantees that any successful attack against such a protocol must succeed during the runtime of the protocol, i.e. security cannot be compromised after the fact via a "store now, decrypt later” approach. We will discuss recent lines of work aiming to achieve this goal, as well how post-quantum cryptography can be used to securely realize distributed quantum computation.

Dr. Oliver de Vries, Quantum Optics Jena: *Data Security in the Age of Disruptive Technologies: Quantum Encryption from a User Perspective*

The increasing networking and digitalization of the economy and society place ever higher demands on the security of our data. At the same time, disruptive technological developments, particularly progress in the field of quantum computers, threaten established encryption methods. In this context, quantum key distribution (QKD) becomes increasingly

important. But why is QKD so relevant right now? Recent advances in quantum technology are bringing the possibility of a powerful quantum computer within reach – a milestone that could make traditional asymmetric key distribution methods obsolete. At the same time, society is becoming increasingly aware of cybersecurity risks caused by artificial intelligence and, in general, by rapidly scaling computing power. What QKD can do (and what it can't) will be explained in this lecture.

Evening Talk Prof. Dr. Thomas Lengauer, Leopoldina: *Science With an Ethical Compass in the "Zeitenwende"*

Over the last century, an ethical compass for science and research has gained increasing relevance in liberal democracies, among them Germany. The development of nuclear weapons was probably one of the central seeds of the topic. From the 1950s onwards, the topic was also increasingly discussed in the fields of chemistry, pharmaceutics and medicine. In the 2000s, information technology increasingly gave rise to ethical issues. Around the same time, controversial gain-of-function experiments in virus research led to the establishment of the "Joint Committee on the Handling of Security-relevant Research" of DFG and Leopoldina. The committee is one of the national focal points of ethical self-regulation of the sciences. Its major task is raising awareness for and mitigating possible misuse of research results. The major instruments for this purpose are the so-called Committees for Ethics in Security-Relevant Research (KEFs) of which more than 100 have been established in German universities and research institutes. Additionally, the Joint Committee holds topical meetings and supports expanding the topic in university teaching. With the growing geopolitical polarization and the start of the Russian invasion of Ukraine as a signature event, the issue of the role and limitations of science in affording national security has initiated a broadening of the discussion. The talk will inform about the activities of the Joint Committee and address current challenges and dilemmas in this context.

5. Domestic Security: Critical Infrastructures, Cyber Security

Andrés Barreneche García, OECD, Paris: *Towards International Principles for the Responsible Development and Use of Quantum Technologies*

Quantum technologies represent a new paradigm with potentially ground-breaking implications for digital economies and society. These technologies promise significant advancements in innovation across various business sectors and could also help address societal challenges. At the same time, they raise digital, privacy, and national security risks. The OECD is working with government, science and industry experts to explore the policy opportunities and challenges for harnessing benefits while mitigating risks. This work is serving as a foundation for the OECD to build consensus around the principles guiding the responsible development and use of quantum technologies.

Silvio Dragone, IBM Zürich*: Cybersecurity in the Era of Quantum Computing: Risks, Adaptation, and Infrastructure Challenges*

As quantum computing advances, it poses a significant threat to current cryptographic systems that underpin digital security. This presentation explores the looming risk quantum computers represent, particularly their ability to break encryption algorithms which are used in trillions of transactions on billions of devices. In the hands of cybercriminals, this capability could lead to

massive data breaches, decryption of previously secure communications, and unprecedented access to sensitive systems. Special attention is given to the direct implications for critical infrastructure where modernization challenges are compounded by legacy systems, limited budgets, and complex upgrade cycles. Attendees will gain insights into the urgency of adopting post-quantum cryptographic standards and the strategic planning required to safeguard critical infrastructure against this rapidly evolving threat landscape

6. International Security, Defence Research and Arms Control

Dr. Michal Krelina, Stockholm International Peace Research Institute (SIPRI) / Czech Technical University, Prague: *Quantum Technology in the Military – Introduction and Trends*

Quantum technology is going to gradually shape military capabilities, with advancements in communication, sensing, and computing. This presentation briefly introduces its practical applications, such as quantum cryptography for secure data transmission, quantum sensors for improved navigation and detection, and the potential role of quantum computing in defence. In addition to technological developments, I will also explore trends in the perception of quantum technology within military and strategic communities, addressing both its promises and current limitations.

Dr. Lukas Weymann, Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe: *Quantum Technologies in the Military Context – Evaluation of Potential Applications and International Activities*

Most quantum technologies have potential for both military and civilian applications. In a report for the Office of Technology Assessment at the German Bundestag (TAB), the potential and activities relating to quantum technologies in the military context were analyzed. From "Quantum Hype" to "Quantum Winter" – the expectations in the military sector cover a broad spectrum. This results in different strategies worldwide for the use of quantum technologies in this area.

Dr. Lindsay Rand, Center for International Security and Cooperation, Stanford University: *Detecting Submarines: Technical Feasibility and Strategic Stability Implications*

Nuclear-armed submarines strengthen a country's nuclear deterrent by ensuring a reliable second-strike capability, but only if they remain undetectable. Advances in quantum sensing, particularly magnetic anomaly detection, could potentially enhance long-range detection and tracking of submarines. In this presentation, I survey various quantum sensing techniques and their impact on submarine detectability. While these sensors may improve detection in specific, limited scenarios, they are unlikely to enable continuous and reliable tracking. I conclude by discussing the strategic stability implications of these findings.

7. Ethical Question and International Relations

Dr. Mira L. Wolf-Bauwens, Geneva Science and Diplomacy Anticipator, Geneva

: *Why the Era of Quantum Utility must be the Era of Responsible Quantum Computing*

The transition from theoretical quantum computing to practical applications necessitates a responsible approach to its development and deployment. As quantum systems gain utility, ensuring ethical standards, security, and societal benefit becomes critical. A framework for responsible quantum computing must prioritize transparency, inclusivity, and long-term sustainability while mitigating potential risks, such as cryptographic vulnerabilities. By embedding responsibility at the core of quantum research, the field can progress in a way that fosters trust, maximizes positive impact, and aligns with broader ethical and scientific standards.

Prof. Dr. Matthias C. Kettemann, LL.M., Harvard University/Innsbruck Quantum Ethics Lab, Department of Theory and Future of Law, University of Innsbruck: *Quantum Technologies as a Common Good? The Work of UNESCO's Science Ethics Committee and the Limits and Potentials of a Normative Approach to the Ethics and Governance of Quantum Computing*

Technologies are neither good nor bad, nor are they neutral. We give ethical guardrails – or don't. We provide a governance framework – or don't. Quantum computing has the potential to positively impact individual and collective rights and further international solidarity and intergenerational equity. It also carries risks for these global goods and values and can exacerbate global divides. As the United Nations General Assembly has called upon states to support the development of Quantum Technologies with a view to the progressive realization of the Sustainable Development Goals, the speaker argues – based on his work as rapporteur for Quantum Computing in UNESCO's Science and Technology Ethics Committee – that Quantum technologies need ethical safeguards and common standards to ensure responsible and anticipatory governance. Developments in quantum computing should benefit the whole world rather than concentrate quantum capabilities on a select few. Technological progress does not happen; it is shaped. While innovation should be supported, norms are necessary to ensure a future of quantum computing that is human rights-based, human security-sensitive, and human development-oriented.