



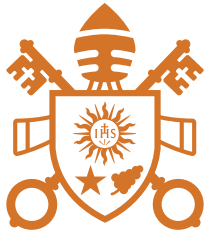
THE PONTIFICAL  
ACADEMY OF SCIENCES

WORKSHOP ON

# Quantum Science and Technology: Recent Advances and New Perspectives



30 November - 2 December 2023  
Casina Pio IV, Vatican City



*I believe that, in our time, support for pure science must be defended and, if possible, increased. Indeed, without prejudice to applied science, pure science should be recognized as a public good, whose contributions are to be placed at the service of the common good. Your Society can surely accomplish much in this regard.*

Greetings of His Holiness Pope Francis to a delegation of the Max Planck Society, Thursday, 23 February 2023

## Concept note

One century ago, scientists like Niels Bohr, Luis de Broglie, Erwin Schrödinger, Werner Heisenberg, and others created the theory of Quantum Mechanics (QM). This Workshop of the Pontifical Academy of Sciences is convened in part to recognize that historic achievement, especially in view of the fact that some of the founders of Quantum Mechanics were members of the PAS. More importantly, we gather to examine the current state of QM and the prospects for its future in science and technology. QM gave birth to a revolution in both science and technology. It gave us a theoretical framework for understanding the physical world at the sub-microscopic level of atoms, molecules, and their constituents. And, QM changed the way we think about reality, introducing fundamental limits on what can be known, even in principle, about a physical system, limits that were inconceivable to pre-quantum thinkers.

Through its influence on science and technology, the quantum revolution has touched nearly all aspects of modern life. Quantum-based electronics have progressed to the point that consumer devices like computers, watches, and mobile phones are in-

dispensable in most industrialized countries. Even our standards of measurement—our modern metric system—is based upon quantum principles.

Many have identified a second quantum revolution, one in whose midst we now see amazing new developments in science and technology. This second revolution has elevated the strangest aspects of QM, superposition and entanglement, to technological status. Quantum information, with its promise of quantum computers able to perform calculations beyond the capabilities of any imaginable classical computer; quantum communication whose security is guaranteed by the laws of physics; quantum measurement with sensitivity that defies the usual limits to precision; and quantum simulations that promise new understanding and design opportunities for materials and medicines are part of the second quantum revolution.

We welcome you to this Workshop on Quantum Science and Technology: Recent Advances and New Perspectives, where we will remember the past, explore the present, and imagine the future.

# Programme

## DAY 0 | WEDNESDAY 29 NOVEMBER 2023 (Reception – Extra Activity – Casina Pio IV)

- 17.30 Arrival – Registration  
Secretariat
- 
- 18.00-19.30 Welcoming Session: Special presentation about the PAS, history and goals. Followed by reception  
Speakers: Chancellor **Card. Peter K.A. Turkson** and Organizing Academicians
- 
- 19:30-21:00 **Dinner**
- 

## DAY 1 – THURSDAY 30 NOVEMBER 2023

- 09.00-09.40 **Cardinal Peter K.A. Turkson** *Welcome to the PAS*  
**Joachim von Braun** *Opening of the Workshop*  
**Cardinal Pietro Parolin** *Opening Speech*  
  
*Group Photo*
- 09.40-11.00 **SESSION 1: GENERAL AND HISTORICAL ASPECTS**  
Chair: **Vanderlei S. Bagnato**  
JQI Fellow - Joint Quantum Institute / IFSC - University of São Paulo and Texas A&M University
- 09.40-10.00 **Daniel Kleppner** *Professor emeritus - Massachusetts Institute of Technology*  
*Otto Stern's Magical Decade*
- 
- 10.00-10.20 **Eugene S. Polzik** *Professor - University of Copenhagen*  
*Quantum Limits of Knowledge*
- 
- 10.20-10.40 **Marlan O. Scully** *Director in Institute for Quantum Science and Engineering; Texas A&M University*  
*Unruh and Hawking Radiation from a Quantum Optical Perspective*
- 
- 10.40-11.00 **Discussion – Q&A**
- 
- 11.00-11.30 **Coffee Break**
- 11.30-13.10 **SESSION 2: SIMULATION AND INFORMATION**  
Chair: **Massimo Inguscio** *University of Florence - Italy*
- 11.30-11.50 **Randall G. Hulet** *Fayez Sarofim Professor of Physics - Rice University*  
*Quantum Simulation with Ultra-Cold Atoms*
- 
- 11.50-12.10 **John M. Martinis** *Professor of Physics - University of California, Santa Barbara*  
*Demonstrating Quantum Mechanics at a Petascale Computational Space*
- 
- 12.10-12.30 **Immanuel Bloch** *Scientific Director - Max Planck Institute of Quantum Optics*  
*Large Scale Quantum Simulations Using Ultracold Atoms*
- 
- 12.30-12.50 **Maciej Lewenstein** *Group Leader - ICFO and ICREA*  
*The Coming Decades of Quantum Simulations*
-

12.50-13.10	<b>Discussion – Q&amp;A</b>
13.10-14.30	<b>Lunch</b>
14.30-16.10	<b>SESSION 3: GENERAL QUANTUM SCIENCE</b> Chair: <b>Immanuel Bloch</b>
14.30-14.50	<b>Kees Joesse</b> Taiwan Semiconductor Manufacturing Company, Director Business Development EMEA <i>TSMC and it's Role in the Semiconductor Industry</i>
14.50-15.10	<b>Aleksey Akimov</b> Principal Investigator - Russian Quantum Centre <i>Toward Quantum Simulations with Thulium Atom</i>
15.10-15.30	<b>José N. Onuchic</b> Professor, Rice University <i>When is Quantum Mechanics Important in Biology?</i>
15.30-15.50	<b>Carl Williams</b> Principal - CJW Quantum Consulting LLC <i>The Quantum Ecosystem: Where We Are and Where We May Be Going</i>
15.50-16.10	<b>Discussion – Q&amp;A</b>
16.10-16.40	Coffee Break
16.40-19.00	<b>SESSION 4: QUANTUM METROLOGY</b> Chair: <b>Carl Williams</b>
16.40-17.00	<b>William D. Phillips</b> JQI Fellow - Joint Quantum Institute <i>Quantum Metrology and the Quantum Reform of the Metric System</i>
17.00-17.20	<b>Mikhail Lukin</b> Harvard University - USA <i>Exploring Quantum Error Correction Frontier Using Programmable Atom Arrays</i>
17.20-17.40	<b>Jun Ye</b> Physicist - NIST/JILA/University of Colorado <i>Quantum Science and Atomic Clocks</i>
17.40-18.00	<b>Philippe Bouyer</b> Professor - Univ. of Amsterdam and Technical Univ. Eindhoven <i>Quantum Sensors from Fundamental Physics to Applications</i>
18.00-18.20	<b>Luiz Davidovich</b> Research Professor - Texas A&M University <i>Quantum Sensing: Beyond the Classical Limits of Precision</i>
18.20-18.40	<b>Discussion – Q&amp;A</b>
19.00-20.30	<b>Dinner (for those that sign up for it)</b>

## DAY 2 | FRIDAY 1 DECEMBER 2023

09.00-11.00	<b>SESSION 5: INTERACTING QUANTUM SYSTEMS</b> Chair: <b>Vanderlei S. Bagnato</b>
09.00-09.20	<b>Martin Zwierlein</b> Professor of Physics - Massachusetts Institute of Technology <i>Strongly Interacting Quantum Gases</i>
09.20-09.40	<b>Jean Dalibard</b> Laboratoire Kastler Brossel - France <i>Matter Waves, a Unique Platform for the Exploration of Soliton Physics</i>

09.40-10.00	<b>Tilman Pfau</b> Institute Director - University of Stuttgart <i>Long Range Interacting Quantum Systems</i>
10.00-10.20	<b>Carlo F. Barenghi</b> Professor - Newcastle University (United Kingdom) <i>Quantum Turbulence: Classical and Non-Classical Aspects</i>
10.20-10.40	<b>Discussion – Q&amp;A</b>
10.40-11.10	<b>Coffee Break</b>
11.10-13.00	<b>SESSION 6: QUANTUM TECHNOLOGY AND APPLICATIONS 1</b> Chair: <b>C. Monroe</b>
11.10-11.30	<b>Martin B. Plenio</b> Ulm University <i>Quantum Technologies for the Life Sciences</i>
11.30-11.50	<b>Irfan Siddiqi</b> Professor and Chair, Department of Physics - UC Berkeley <i>Quantum Information: Harnessing the Unseen</i>
11.50-12.10	<b>Oliver Dial</b> CTO - IBM Quantum <i>Quantum Utility in Advance of Fault Tolerance</i>
12.10-12.30	<b>Christophe Jurczak</b> CEO - Quantonion <i>Investing in the Quantum Future – State of Play and Way Forward for Quantum Venture Capital</i>
12.30-12.50	<b>Discussion – Q&amp;A</b>
13.00-14.30	<b>Lunch</b>
14.30-16.10	<b>SESSION 7: QUANTUM TECHNOLOGY AND APPLICATIONS 2</b> Chair: <b>Donna Strickland</b>
14.30-14.50	<b>Andrew Steane</b> Professor of Physics - University of Oxford <i>Quantum Computing, the Church-Turing Thesis and the Babel Fallacy</i>
14.50-15.10	<b>Christopher R. Monroe</b> Professor - Duke University <i>Full-Stack Quantum Computer System</i>
15.10-15.30	<b>Peter Zoller</b> Professor/Group Leader - University of Innsbruck and IQOQI (Austrian Academy of Sciences) <i>Programmable Quantum Simulators and Quantum Sensors with Atomic Platforms</i>
15.30-15.50	<b>Robert Sutor</b> Vice President and Chief Quantum Advocate - Infleqtion <i>Crossing the Quantum Chasm: Moving from Little Quantum Computers to Practical Networked Quantum Systems</i>
15.50-16.10	<b>Discussion – Q&amp;A</b>
16.10-16.40	<b>Coffee Break</b>
16.40-18.20	<b>SESSION 8: QUANTUM TECHNOLOGY AND APPLICATION 3</b> Chair: <b>Christiane Morais Smith</b>
16.40-17.00	<b>Sergio Boixo</b> Principal Scientist, Quantum Computing - Google <i>Recent Progress in Experimental Quantum Computing</i>
17.00-17.20	<b>Matthias Troyer</b> CVP, Technical Fellow - Microsoft <i>Unlocking the Quantum Promise: Transformative Application of Quantum Computing</i>

17.20-17.40	<b>Robert Schoelkopf</b> Professor - Yale University <i>Error Detection and Error Correction with Superconducting Qubits: The Microwave Dual Rail</i>
17.40-18.00	<b>Ignacio Cirac</b> Director of Theory Division - Max Planck Institute of Quantum Optics <i>Quantum Computing and Simulation</i>
18:00-18:20	<b>Celso Jorge Villas Boas</b> Full Professor, Federal University of São Carlos <i>Development of Second Generation Quantum Solutions for Industries and Services Segments in Brazil</i>
18.20-18.40	<b>Discussion – Q&amp;A</b>
19.00-20.30	<b>Dinner</b>

### DAY 3 | SATURDAY 2 DECEMBER 2023

09.00-11.20	<b>SESSION 9: PRESENT AND FUTURE PERSPECTIVES 1</b> Chair: <b>Peter Zoller</b>
09.00-09.20	<b>Susana Huelga</b> Ulm University <i>Nature's Quantum Blueprint: Unveiling Quantum Phenomena in Biological Processes</i>
09.20-09.40	<b>Sebastian Deffner</b> Associate Professor - UMBC <i>Introduction to the Thermodynamics of Quantum Information</i>
09.40-10.00	<b>Tommaso Calarco</b> Director of the Institute of Quantum Control, Forschungszentrum Jülich <i>Quantum Control and Quantum Technology</i>
10.00-10.20	<b>Luca Galantucci</b> Researcher - Istituto per le Applicazioni del Calcolo; Consiglio Nazionale delle Ricerche (IAC-CNR Roma) <i>Active Quantum Turbulence</i>
10.20-10.40	<b>Steven M. Girvin</b> Eugene Higgins Professor of Physics - Yale Quantum Institute <i>Control of Oscillators for Hardware-Efficient Quantum Simulations and Error Correction</i>
10.40-11.00	<b>Cristiane Morais Smith</b> Full Professor (Chair Condensed-Matter Physics) Utrecht University, ITP <i>Quantum Fractals</i>
11.00-11.20	<b>Discussion – Q&amp;A</b>
11.20-11.50	<b>Coffee Break</b>
11.50-13.50	<b>SESSION 10: PRESENT AND FUTURE PERSPECTIVES 2</b> Chair: <b>Susana Huelga</b>
11.50-12.10	<b>Wolf J. Singer</b> Senior Fellow - Ernst Struengmann Institute for Neuroscience <i>Computational Strategies Exploited by Natural Neuronal Networks: Similarities with Quantum Computing?</i>
12.10-12.30	<b>Paulo Nussenzvieg</b> Universidade de São Paulo <i>A Roadmap for Quantum Technologies in São Paulo, Brazil and Latin America</i>
12.30-12.50	<b>Vladislav Yakovlev</b> Full Professor - Texas A&M University, TX, USA <i>Quantum Mechanics for Biology and Medicine</i>
12.50-13.10	<b>David DeMille</b> Professor of Physics - University of Chicago <i>Tabletop Experiments and Quantum Methods to Probe New Fundamental Particles</i>

13.10-13.30	<b>Luis A. Orozco</b> Emeritus Professor, JQI, Physics, University of Maryland and NIST <i>Francium, From Its Discovery to Precision Measurements</i>
13.30-13.50	<b>Discussion – Q&amp;A</b>
13.50-15.00	<b>Lunch</b>
15.00-18.30	<b>SESSION 11: PRESENT AND FUTURE PERSPECTIVES 3</b> Chair: <b>William D. Phillips</b>
15.00-15.20	<b>William Hurley</b> Strange works - Founder and CEO <i>On the Arrogance of Man in the Age of Thinking Machines</i>
15.20-15.40	<b>Philip Bucksbaum</b> Professor – Stanford University <i>Ultrafast Quantum Dynamics in Atoms and Molecules</i>
15.40-16.00	<b>Salvador E. Venegas-Andraca</b> Professor - Tecnológico de Monterrey <i>From the Lab to the Market: A Roadmap to Turn Quantum Science and Engineering Into a Global Workforce</i>
16.00-16.20	<b>Arthur Ekert</b> Oxford University <i>From Curiosity to Security: Quantum Crypto, Quo Vadis?</i>
16.20-16.40	<b>Eric Lutz</b> University of Stuttgart - Director of the Institute for Theoretical Physics I <i>Converting Quantum Statistics Into Work</i>
16.40-17.00	<b>Coffee Break</b>
17.00-17.20	<b>Klaus von Klitzing</b> Director Emeritus - Max Planck Institute for Solid State Research <i>Quantum Standards in Metrology</i>
17.20-17.40	<b>Paola Cappellaro</b> Massachusetts Institute of Technology <i>Practical Quantum Advantage in Quantum Sensing</i>
17.40-18.00	<b>Antia Lamas-Linares</b> Amazon Principal Research Scientist <i>Quantum Communications at Scale – An Industry Perspective</i>
18.00-18.20	<b>Prof. Sandro Stringari</b> Professor, University of Trento, Italy <i>Supersolidity in Ultracold Atomic Gases</i>
18.20-18.40	<b>Discussion – Q&amp;A</b>
18.40-19.00	<b>SESSION 12: FINAL STATEMENT</b> Chair: <b>Joachim von Braun</b> and <b>Vanderlei S. Bagnato</b>
19.30-21.30	<b>Final Dinner</b>



# List of Participants

**Prof. Dr. Joachim von Braun**  
President  
The Pontifical Academy of Sciences

**Cardinal Peter K.A. Turkson**  
Chancellor  
The Pontifical Academy of Sciences

**Dr. Aleksey Akimov**  
Principal Investigator  
Russian Quantum Center

**Prof. Vanderlei S. Bagnato**  
PAS Academician  
Professor  
University of São Paulo/Texas A&M

**Prof. Carlo F. Barenghi**  
Professor  
Newcastle University (United Kingdom)

**Prof. Immanuel Bloch**  
Scientific Director  
Max Planck Institute of Quantum Optics

**Dr. Sergio Boixo**  
Principal Scientist, Quantum Computing  
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**Prof. Philippe Bouyer**  
Professor  
Univ. of Amsterdam and Technical Univ. Eindhoven

**Prof. Philip Bucksbaum**  
Professor  
Stanford University

**Prof. Tommaso Calarco**  
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Forschungszentrum Jülich

**Prof. Paola Cappellaro**  
Massachusetts Institute of Technology

**Prof. Dr. Ignacio Cirac**  
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**Prof. Jean Dalibard**  
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**Prof. Artur Ekert**  
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**Prof. Kees Jooisse**  
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Director Business Development EMEA

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**Prof. Dr. Maciej Lewenstein**

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ICFO and ICREA

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Harvard University

**Prof. Dr. Eric Lutz**

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University of Stuttgart

**Dr. Lucas Madeira**

Researcher  
University of São Paulo

**Dr. John M. Martinis**

Professor of Physics  
University of California, Santa Barbara

**Prof. Christopher R. Monroe**

Professor  
Duke University

**Dr. Svetlana Monroe**

Professor  
Duke University

**Prof. Cristiane Morais Smith**

Full Professor (Chair Condensed-Matter Physics)  
Utrecht University, ITP

**Prof. Paulo Nussenzveig**

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University of Sao Paulo, Brazil

**Prof. José N. Onuchic**

PAS Academician  
Professor  
Rice University

**Lady Abigail Oppong**

Independent Researcher  
Ghana

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**Prof. Eugene S. Polzik**

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**Dr. Jun Ye**  
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NIST/JILA/University of Colorado

**Prof. Anton Zeilinger**  
Senior Scientist (IQOQI Vienna);  
Professor Emeritus (University of Vienna)

**Prof. Dr. Peter Zoller**  
Professor/Group Leader  
University of Innsbruck and IQOQI  
(Austrian Academy of Sciences)

**Prof. Martin Zwierlein**  
Professor of Physics  
Massachusetts Institute of Technology

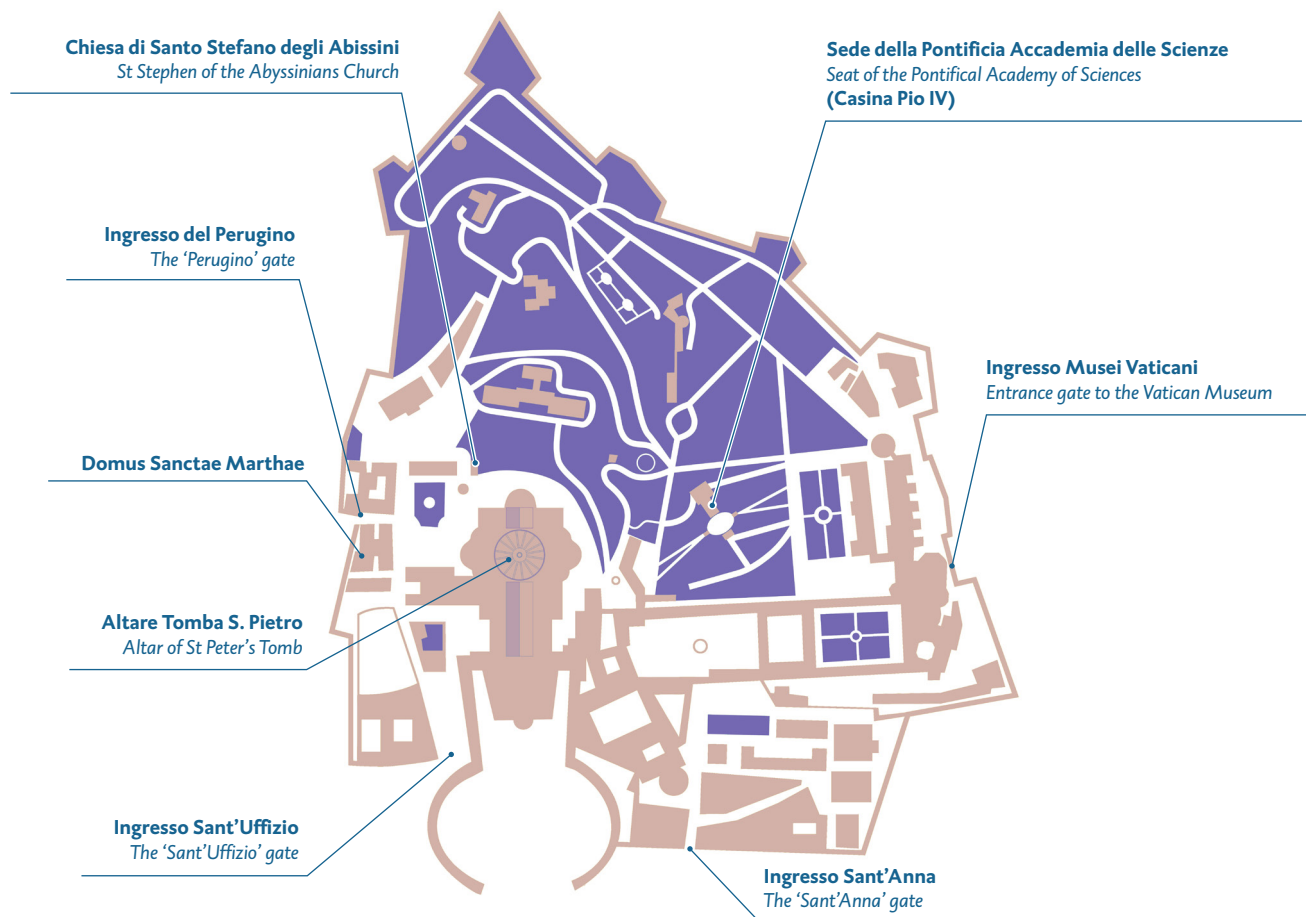
## Memorandum

### General information

- › Dress code is business attire.
- › Invites are strictly personal, but accompanying persons are invited to the lunch and dinner everyday (from 29 November evening to 2 December).
- › Please remember to bring a valid ID.
- › In case of any problems, please call the Academy on +39 0669883195 or +39 0669883451. On the travel days, the mobile phone number +393420026216 will be available.
- › Please refer to [www.pas.va](http://www.pas.va) for further information on the Academy, the Academicians, and current and past events.

### WI-FI

- › WI-FI network: academy-guest
- › Password: G@rdens1936



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