

NEWSLETTER N.4, September 2024



A screenshot of a moment in the QuCoM video published in May 2024.

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Update of work done

Regular scientific meetings

QuCoM experimentalists hold regular online meetings every second Tuesday per month. They discuss progress on experimental realisations of gravity and quantum experiments. At both experiment sites, Leiden and Southampton, there are setups which are used to detect gravity with levitated masses. These experiments are cryogenic and involved advanced vibration isolation techniques. The discussions are typically about improvements of particle trap designs to reach high quality factors for levitated particle, pick up the motion of particles in the trap with directional sensitivity, materials science issues with traps and particles as well as preparation procedures of traps.

As for the CAT...models and interpretations of quantum mechanics

A century after its birth, quantum mechanics continues to collect extraordinary successes. Nevertheless, there are still open problems at its FOUNDATIONS. Specifically, the quantum measurement problem, exemplified by the famous Schrödinger cat paradox, poses several questions still lacking an answer. Why a cat cannot be prepared in a quantum superposition? What is the real meaning of the wavefunction? How one can interpret or modify the quantum theory to solve the MEASUREMENT problem?

The workshop, held in Trieste on May 10, 2024, gave a glimpse into some of the open questions in the foundations of quantum mechanics from different perspectives. The discussions tackled the ontology of the wavefunction, the quantum measurement problem, the spontaneous collapse models, the Bohm mechanics and the many world interpretation of quantum mechanics.

A look at the interface between gravity and quantum theory – 2024 edition

The workshop, held in San Vito di Cadore from 2nd to 4th July 2024, gathered young researchers working on topics at the interface between gravity and quantum mechanics. The topics ranged from models describing non-standard coupling between gravity and matter, to recent proposals of experimental setups for studying the nature of gravity via table-top experiments. PhD students and PostDocs were given the opportunity to present their research activity and interact with their colleagues, and share motivations, techniques and perspectives, in a friendly and informal environment. A great amount of time has been dedicated to discussions and perspectives.

Fundamental Problems in Quantum Physics 2024

The fourth school on quantum foundations dedicated to Prof. GianCarlo Ghirardi was held in Trieste from 10th to 12th September 2024.

Quantum Mechanics is extremely successful in predicting experimental results and has a vast range of applications. Nonetheless, many unanswered questions remain. The school introduced Master and PhD students to the still outstanding problems in our understanding of quantum foundations. To give a deep look into the foundations of quantum mechanics, lectures were given by experts in the field. An extensive time was dedicated to selected contributed talks.

Here the list of speakers:

Davide Giordano Ario Altamura (University of Trieste) – Non-interferometric rotational test of the Continuous Spontaneous Localisation model

Oliviero Angeli (University of Trieste) – A fundamental ambiguity in Open Quantum Systems

Marion Cromb (University of Southampton) – Quantum Physics in Rotating Frames

Michael Drewsen (Aarhus University) – Search for bosons beyond the Standard Model through precise isotope shift measurements of the electronic structure in atomic ions

Laria Figurato (University of Trieste) – On the effectiveness of the collapse in the Diósi-Penrose model

José Luis Gaona Reyes (University of Trieste) – Can we incorporate spontaneous collapse in the Wheeler-DeWitt equation?

Trinidad Lantaño (Universität Ulm) – Entanglement of Rotational States as Evidence for Quantum Gravity

Emanuele Panella (University College London) – Hybrid classical-quantum gravity and cosmological implications

Nicolò Piccione (University of Trieste) – Extending the CSL Model by means of Generalized Mass Dependence

Kyrylo Simonov (University of Vienna) – Quantum theory with indefinite causal order and time direction

Michael Suleymanov (Bar-Ilan University) – Uncertainties and covariances in the framework of spatiotemporal quantum reference frames

Chris Timberlake (University of Southampton) – Magnetic levitation: A platform for testing fundamental physics

Marko Toroš (University College London) – Generating quantum non-local entanglement with mechanical rotations

Bassano Vacchini (University of Milan) – Jumps, collapses and reduced dynamics

Qiongyuan Wu (Queen's University Belfast) – Squeezing below the ground state of motion of a continuously monitored levitating nanoparticle

Giorgio Zicari (Queen's University Belfast) – Critical quantum metrology for fundamental physics



QuCoM project meeting in Trieste

On 9th September 2024, a QuCoM scientific meeting took place in Trieste with the aim of updating on progress and defining next steps and new collaborations to achieve the objectives of the project. The following talks were given:

- *Enhancing the deviations from Quantum Mechanics due to Schrödinger-Newton dynamics* (Davide Giordano Ario Altamura – Trieste)
- *Squeezing below the ground state of motion of a continuously monitored levitating nanoparticle* (Wu Qiongyuan - Belfast)
- *Quantum Metrology for Levitated Dynamics* (Francis Headley - Tübingen)
- *Softening the soft spring* (Gertjan van Baarle - Leiden)
- *Progress and future changes, since the paper on the Zeppelin as a gravity detector* (Dennis Uitenbroek – Leiden)
- *Passively levitated Graphite for gravitational sensing* (Elliot Simcox - Southampton)
- An overview on recent activities in Leiden cryogenics (Salim Erfanifan - Leiden).

A total of 20 participants from all 7 project partners attended the meeting.

QuCoM Steering Committee in Trieste

On 10th September 2024, a QuCoM Steering Committee took place among the PIs of QuCoM partner organization to discuss the development of upcoming deliverables and milestones. The participants also discussed the outcomes of the dissemination strategy and adjustment of the collection of information. The partners viewed the project video that was created by the group of the University of Southampton and published in late May 2024. The partners discussed the possibility to meet in person in the spring 2025 to discuss project progresses and results in view of the project end in September 2025. The overall evaluation of scientific progresses is positive while the management continues to work smoothly.

QuCoM video

The Consortium produced a video explaining the QuCoM project, aimed at the general public with a basic knowledge of science and physics; the scientific community interested in understanding the project; and funding agencies potentially interested in financing further research connected to QuCoM.

The work on creating the video began in early 2024 when the group at Southampton started brainstorming about the realization of the QuCoM video. The idea was to create a short stop-motion video illustrating the project's ideas in an accessible and fun way. The video was produced in-house by Dr. Cromb, who had previous experience in movie-making and a passion for science communication.

The video aims to illustrate and communicate that QuCoM is a project testing gravity in a new way. It also explains why gravity needs to be tested and that gravity is not well understood on the small/quantum scale. Additionally, it highlights QuCoM's approach of using levitated particles and explains the rationale behind this method.

The final product is available for all project teams to distribute and disseminate through their channels as a project presentation and can be viewed on the QuCoM website's homepage and on Youtube [Gravity in QuCoM \(youtube.com\)](#).

Publications

Authors	Title	Journal	Volume	Pages	Year
Kristian Piscicchia, Sandro Donadi, Simone Manti, Angelo Bassi, Maaneli Derakhshani, Lajos Diósi, and Catalina Curceanu	X-Ray Emission from Atomic Systems Can Distinguish between Prevailing Dynamical Wave-Function Collapse Models	<i>Phys. Rev. Lett.</i>	132	250203	2024
Davide Giordano Ario Altamura, Matteo Carlesso, Sandro Donadi, and Angelo Bassi	Noninterferometric rotational test of the continuous spontaneous localization model: Enhancement of the collapse noise through shape optimization	<i>Phys. Rev. A</i>	109	062212	2024
Q Wu, D A Chisholm, R Muffato, T Georgescu, J Homans, H Ulbricht, M Carlesso and M Paternostro	Squeezing below the ground state of motion of a continuously monitored levitating nanoparticle	<i>Quantum Sci. Technol.</i>	9	045038	2024
S. Sgroi, G. Zicari, A. Imperato & M. Paternostro	Efficient excitation-transfer across fully connected networks via local-energy optimization	EPJ Quantum Technology	11	Art. n. 29	2024

Dissemination activities

In the last 6 months, QuCoM members delivered seminars and talks as follows.

April – September 2024

Non-linear media in weakly curved spacetime: optical solitons and probe pulses for gravimetry

06/08/24

Event: Relativistic Quantum Information North Speaker: Daniel Braun Place: Charles University Prag, Prag Date: 06 August 2024

In cerca di un'immagine del mondo quantistico

25/07/24

Event: ScienzaNuova 2024 Speaker: Angelo Bassi Place: Accademia di Merano, Merano (IT) Date: 25 July 2024

Incorporation of a collapse mechanism in the Wheeler-DeWitt equation

18/07/24

Event: Emergence of Classically: New Perspectives on Measurements in Quantum Theory Speaker: José Luis Gaona Reyes Place: Trinity College, Dublin, Ireland Foundation - Erice Date: 18 July 2024

Incorporating a spontaneous collapse mechanism in a Wheeler-DeWitt equation

02/07/24

Event: A look at the interface between gravity and quantum theory - 2024 edition Speaker: José Luis Gaona Reyes Place: San Vito di Cadore, Italy Date: 2 July 2024

Foundations of Quantum Mechanics

24/06/24

Event: Quantum – NEST Speaker: Angelo Bassi Place: Ettore Majorana Foundation – Erice Date: 24–28 June 2024

Quantum Computers and the Quantum Revolution 2.0

04/06/24

Event: Popular scientific talk Speaker: Daniel Braun Place: Museumsgesellschaft Tübingen Date: 4 June 2024

Incorporating a spontaneous collapse mechanism in a Wheeler–DeWitt equation

04/06/24

Event: A Modern Odyssey: Quantum Gravity meets Quantum Collapse at Atomic and Nuclear physics energy scales in the Cosmic Silence Speaker: José Luis Gaona Reyes Place: ECT*, Trento, Italy Date: 4 June 2024

Entanglement le correlazioni quantistiche

21/05/24

Event: Public talk Speaker: Angelo Bassi Place: Alba Date: 21 May 2024

Collapse models as a solution to the measurement problem

10/05/24

Event: As for the CAT, models and interpretations of Quantum Mechanics Speaker: Matteo Carlesso Place: University of Trieste, Trieste Date: 10 May 2024

Introduzione alla Computazione Quantistica

09/05/24

Event: QuANtumDay Speaker: Angelo Bassi Place: Università Politecnica delle Marche, Ancona Date: 9 May 2024

A non-equilibrium route to the foundations of quantum mechanics

18/04/24

Event: Quantum Science & Technology: where we are, where we are headed Speaker: Daniel Braun Place: The Italian Academy 1161 Amsterdam Ave, NYC 10027 – New York Date: 18 April 2024

Quantum parameter estimation with many-body fermionic systems and application to the quantum Hall effect

03/04/24

Event: BW-Hungary Quantum Workshop Speaker: Daniel Braun Place: University Ulm Date: 3 April 2024

Non-linear media in weakly curved spacetime: optical solitons and probe pulses for gravimetry

05/06/24

Event: 55th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics Speaker: Dennis Rätzel and Alessio Belenchia Place: Fort Worth, Texas Date: 5 June 2024

Quantum metrology using levitated magnets

04/06/24

Event: 55th Annual Meeting of the APS Division of Atomic, Molecular and Optical Physics Speaker: Francis Headley Place: Fort Worth, Texas Date: 4 June 2024

Il progetto «Quantum FVG» di comunicazione quantistica

29/05/24

Event: Conferenza GARR 2024 Speaker: Angelo Bassi Place: Università di Brescia, Brescia Date: 29 May 2024

Do Wave Functions Jump?

20/05/24

Event: Philosophy of Spontaneous Collapse Speaker: Angelo Bassi Place: Università Italiana, Lugano Date: 20 May 2024

The quantum measurement problem

10/05/24

Event: As for the CAT, models and interpretations of Quantum Mechanics Speaker: Angelo Bassi Place: University of Trieste, Trieste Date: 10 May 2024

La Meccanica Quantistica

08/05/24

Event: Meeting with High School students Speaker: Angelo Bassi Place: University of Trieste, Trieste Date: 8 May 2024

The second quantum revolution and Quantum Computing

10/04/24

Event: INSPYRE 2024 Speaker: Angelo Bassi Place: LNF-INFN Frascati Date: 10 April 2024

The case for measuring the gravitational field of the LHC beam

27/03/24

Event: Physics beyond collider annual workshop Speaker: Daniel Braun Place: CERN, Geneva Date: 27 March 2024