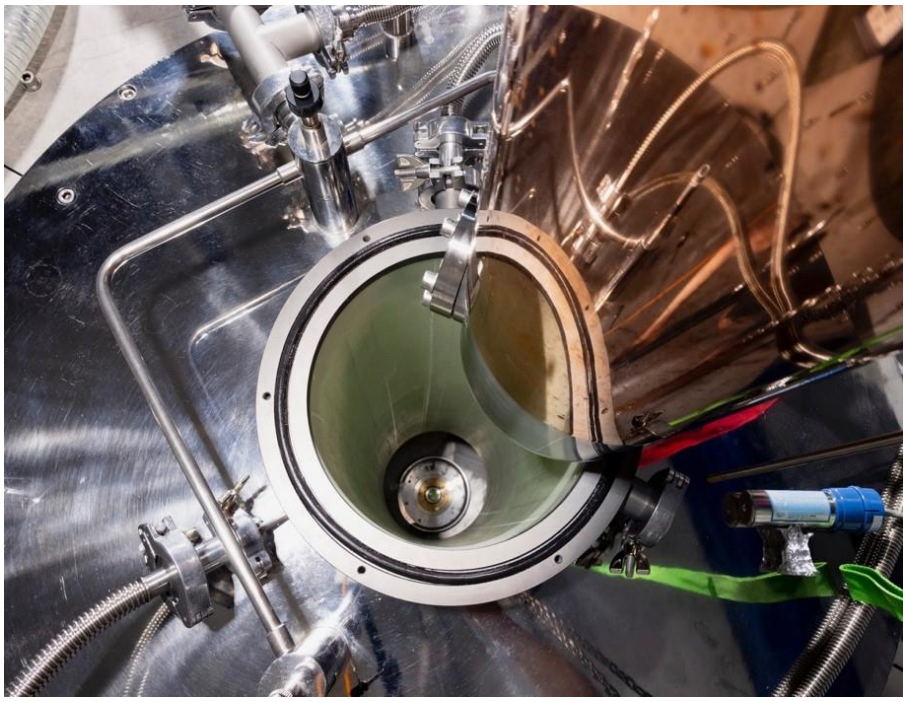
# NEWSLETTER N.1, March 2023



## Sommario

## Update of work done

### Launch of the project

The Consortium launched the project in October 2022 with a tailor-made press release. This document represents one of the most important points in the dissemination plan of the Project. It aims to extend the awareness of the Project in the general public. The Press Release broadcasts the ideas on which the Consortium is built and underlines the European Commission's investments in the Project mission.

The press release was developed in the first half of October 2022 after the kick-off meeting of the project and sent out to the partner and for distribution to the press of the respective countries. The partners were invited to share it with respective press offices for posting on institutional websites and social media accounts.

The press release was picked up by many media services as documented below:

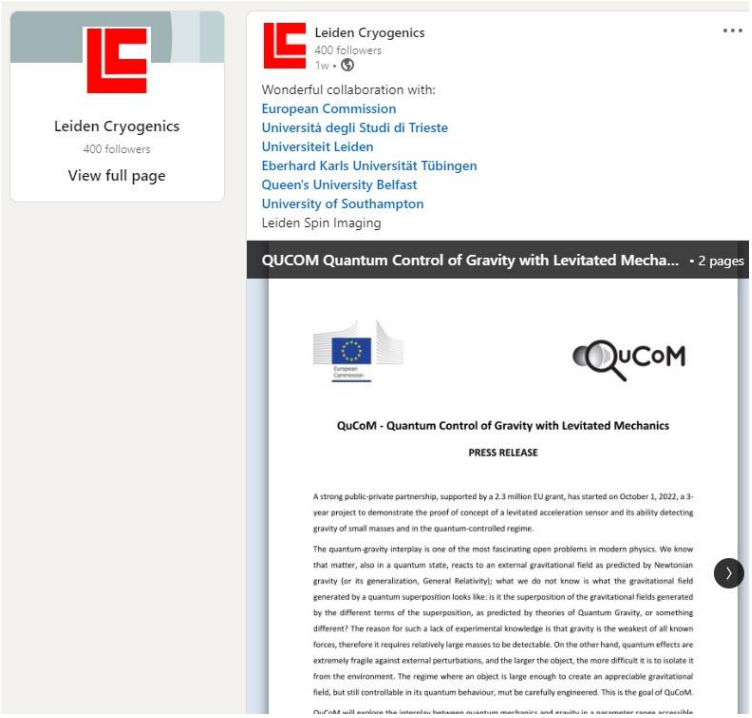
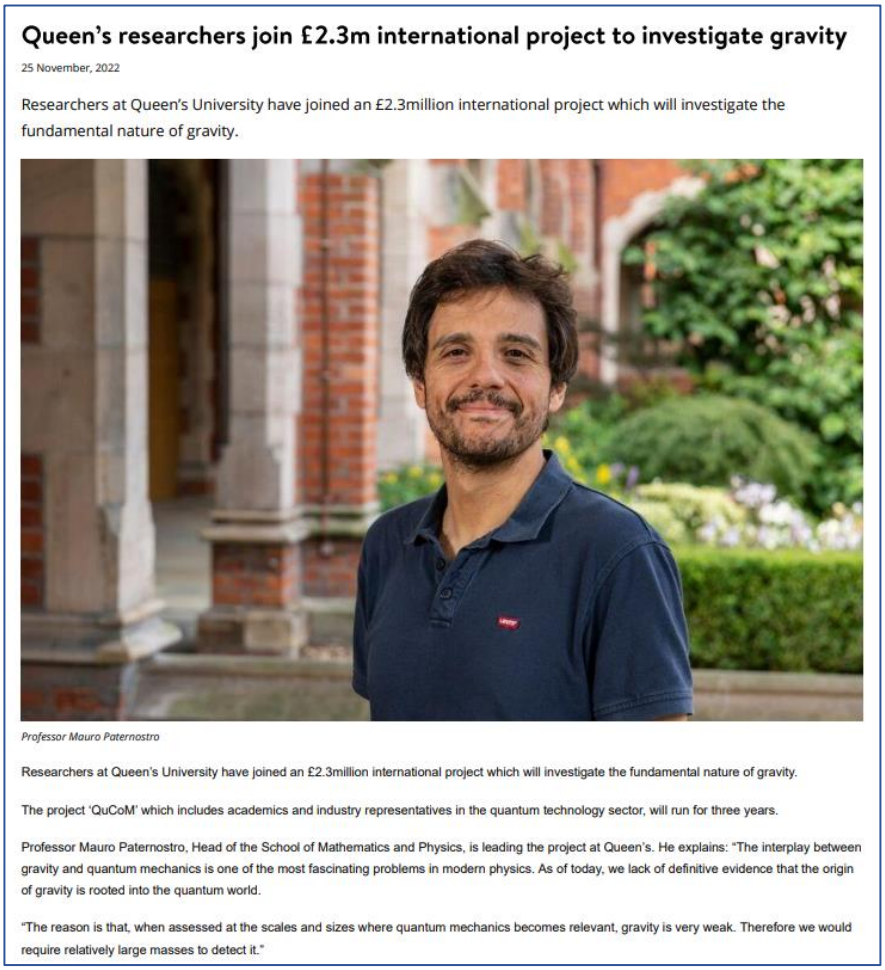



*Fig. 1 The press released shared on the LinkedIn account of Leiden Cryogenics*



**Queen's researchers join £2.3m international project to investigate gravity**

25 November, 2022

Researchers at Queen's University have joined an £2.3million international project which will investigate the fundamental nature of gravity.

*Professor Mauro Paternostro*

Researchers at Queen's University have joined an £2.3million international project which will investigate the fundamental nature of gravity.

The project 'QuCoM' which includes academics and industry representatives in the quantum technology sector, will run for three years.

Professor Mauro Paternostro, Head of the School of Mathematics and Physics, is leading the project at Queen's. He explains: "The interplay between gravity and quantum mechanics is one of the most fascinating problems in modern physics. As of today, we lack of definitive evidence that the origin of gravity is rooted into the quantum world.

"The reason is that, when assessed at the scales and sizes where quantum mechanics becomes relevant, gravity is very weak. Therefore we would require relatively large masses to detect it."

*Fig. 2 The press release pick up by the Queen's University Belfast website*

**New QuCoM website on line**

Effective communications is at the core of QuCoM and involves the Consortium as a whole in many ways. We work to maximize the impact that QuCoM has on the communities working on foundations of quantum mechanics, quantum optics and quantum technologies, both theoretically and experimentally. We also work to communicate to specific audiences, including other researchers, industry general public and policy makers. To do so we have developed a new project website at https://qucom.eu/.

The website gives information on the specific scientific objectives of the project, offers an overview of the people working in the different research teams, and contains information on dissemination activities like talks, newsletters, press releases and press articles. Moreover, one can find useful info on upcoming and past events organized in the frame of the project, news and a complete list of publications produced by the members of the consortium.

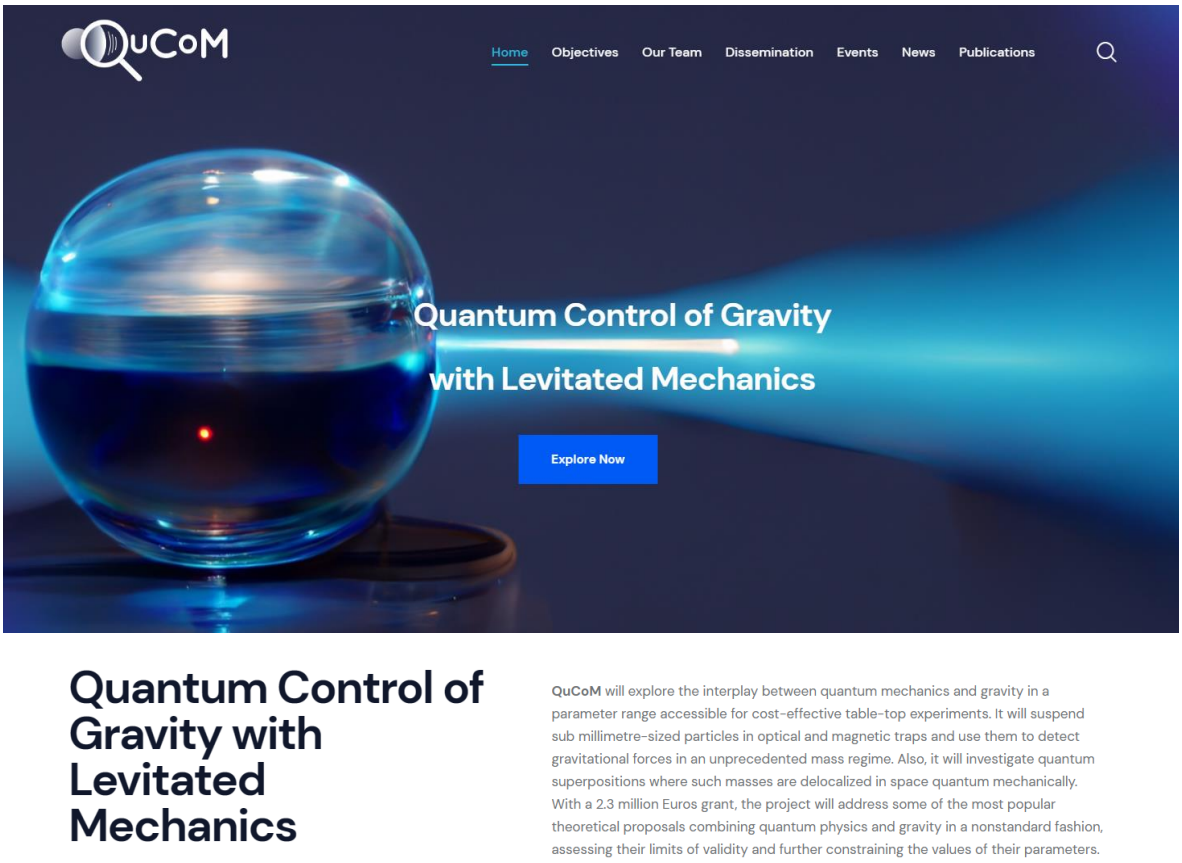



*Fig. 3 A screenshot of the upper part of the project website's homepage*

**Series of seminars "Optomechanical systems for tests of fundamental physics"**

The partner UniTs promoted a series of seminars titled "Optomechanical systems for tests of fundamental physics" on Friday 25th and Tuesday 29th November 2022, Monday 5th, Wednesday 7th and Friday 9th December 2022 at the University of Trieste. The speaker was Matteo Carlesso, PostDoc at The Queen's University Belfast.

The field of optomechanics studies the coupled dynamics of a mechanical resonator and the light field that is shed on it. The mass and the frequency of the mechanical resonator span several orders of magnitude, thus making optomechanical system a perfect testbed for various aspects of fundamental physics. Among these, LIGO is certainly the most celebrated one. In this series of seminars, I will introduce the working principles of optomechanical systems and how one can exploit them to probe fundamental science.

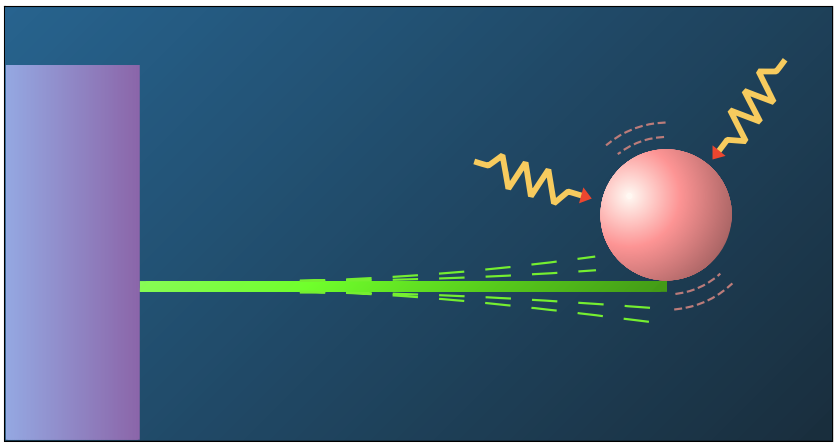


*Fig.4 The image used on the poster to promote the seminars.*

**Progression on QuCoM experiments**

Important experimental update on two mass measurements was achieved with a paper, at the stage of pre-print at the moment: "Magnetic Zeppelin: Detection of gravitational drive in the Hz regime" by Tim M. Fuchs, Dennis Uitenbroek, Jaimy Plugge, Noud van Halteren, Andrea Vinante, Hendrik Ulbricht, Tjerk H. Oosterkamp.

Extremely isolated mechanical resonators are excellent probes for small scale forces and quantum mechanical effects. Furthermore, such systems operating at low frequencies and appericiable mass are well suited to measure both quantum mechanical effects, and gravitational effect, whose exact descriptions have yet to be unified. In this paper we demonstrate a sub-millimeter scale magnetic particle, levitated inside a type-I superconducting trap. At a frequency of 26.7 Hz, a mass of 0.4 mg and showing Q-factors in excess of 107, we obtained a force noise of 0.5 fNHz−−−√. This force sensitivity was then validated by driving the magnetic particle using a time varying gravitational gradient supplied by brass masses on an electric wheel positioned underneath the cryostat, paving the way for future experiments gravitationally coupling small test and source masses. We measured a signal at 3/8 of the expected Newtonian gravitational force at the location of the magnetic particle. We attribute this difference to the effect of the gravitational drive on the mass spring system from which the trap was suspended. This work provides a stepping stone towards mesoscopic probes of gravity and the quantum nature of gravity, and can find application in magnetometry and magnetic resonance force microscopy.

Pre-print can be found at https://arxiv.org/abs/2303.03545

## Publications

| Authors | Title | Journal | Volume | Pages | Year |
|---|---|---|---|---|---|
| Andrea Vinante, Chris Timberlake, Hendrik Ulbricht | Levitated Micromagnets in Superconducting Traps: A New Platform for Tabletop Fundamental Physics Experiments | *Entropy* | 24 | 1642 | 2022 |
| Alessandro Laneve, Hannah McAleese, Mauro Paternostro | A scheme for multipartite entanglement distribution via separable carriers | *New J. Phys.* | 24 | 123003 | 2022 |
| Giorgio Zicari, Barış Çakmak, Özgür E Müstecaplıoğlu and Mauro Paternostro | On the role of initial coherence in the spin phase-space entropy production rate | *New J. Phys.* | 25 | 013030 | 2023 |
| Jonathon Brown, Mauro Paternostro and Alessandro Ferraro | Optimal quantum control via genetic algorithms for quantum state engineering in driven-resonator mediated networks | *Quantum Sci. Technol.* | 8 | 025004 | 2023 |
| Marta Maria Marchese, Alessio Belenchia and Mauro Paternostro | Optomechanics-Based Quantum Estimation Theory for Collapse Models | *Entropy* | 25 | 500 | 2023 |

## Dissemination activities

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

| Who | What | Where | When |
|---|---|---|---|
| Angelo Bassi | Spontaneous wave function collapse models: an update | Lisbon Philosophy of Physics Seminars | October, 2022 |
| Angelo Bassi | Spooky Action at a Distance | Presentazione premio Nobel Fisica 2022 agli studenti dell'Università di Trieste | October, 2022 |
| Angelo Bassi | Spontaneous wave function collapse models: an update | Seminar at the University of Marseille | October, 2022 |
| Angelo Bassi | Spontaneous wave function collapse models | The Complexity of the Cosmos | October, 2022 |
| Angelo Bassi | Dalla filosofia della fisica alle frontiere dell'entanglement quantistico | A proposito di Futuro. Dialoghi tra Treccani Futura e Human Technopole su scienza e immaginario | November, 2022 |
| Angelo Bassi | Noisy Gates for Quantum Computing | International Conference on Quantum Technologies for High-Energy Physics - CERN | November, 2022 |
| Angelo Bassi | Quantum Mechanics: foundations and applications | Fisica Teorica all'INFN tra passato, presente e futuro – Università La Sapienza ROMA | November, 2022 |
| Angelo Bassi | Gravity related collapse-models | Quantum Mechanics day – LNGS - Gran Sasso | November, 2022 |
| Angelo Bassi | Collapse models make particles jiggle… and emit photons | The Hitchhiker's Advanced Guide to Quantum Collapse Models and their impact in science, philosophy, technology and biology - LNF - Frascati | November, 2022 |
| Hendrik Ulbricht | Testing quantum and gravity | The Hitchhiker's Advanced Guide to Quantum Collapse Models and their impact in science, philosophy, technology and biology - LNF - Frascati | November 2022 |

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|---|---|---|---|
| Hendrik Ulbricht | Quantum Entanglement | 2022 Nobel prize in Physics talk to undergraduate students | December 2022 |
| Mauro Paternostro | Informational steady-state and entropy production in continuously monitored systems' | Colloquium at Koç University, Istanbul, Turkey | January, 2023 |
| Angelo Bassi | Precision tests of models of spontaneous wave function collapse | Quantum West 2023 | February, 2023 |
| Angelo Bassi | Spooky Action at a Distance - La nonlocalità quantistica | Seminar to high school students | February, 2023 |
| Mauro Paternostro | Quantum neouromorphic approach for efficient sensing of gravity0induced entanglement | KOBIT7 conference, Eskisehir, Turkey | February, 2023 |

## Any other relevant information

### New hires

In the Consortium there has been a few new hires since the beginning of the project in October 2022:

- University of Trieste: José Luis Gaona Reyes (PostDoc since October 2022)
- University of Trieste: Oliviero Angeli (PhD student since November 2022)
- University of Trieste: Anirudh Gundhi (PostDoc since March 2023)
- University of Tübingen: Francis Headley (PhD student since November 2022)
- University of Southampton: Elliot Simcox (PhD student since November 2022)
- Leiden University: Gerrit Tjalma (research assistant since February 2023)

### Outreach activities

Prof. Hendrik Ulbricht carried out an interesting outreach activity for 30 school students at his labs at the University of Southampton (UK) on February 18, 2023. Professor Ulbricht together with the members of his research group did a research lab demonstration of cooling in levitated optomechanics for the student group.