# NEWSLETTER N.16, March 2022

The participants of the "Mini-Symposium Quantum Boundaries: Gravity-Related Collapse Models", Frascati (IT), December 2022.

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## UPDATE OF WORK DONE

### Mini-Symposium Quantum Boundaries: Gravity-Related Collapse Models

With the support of John Templeton Foundation, the FQXi Foundational Questions Institute and TEQ, Catalina Curceanu, partner and Press Officer of the TEQ Consortium, organized and chaired the "Mini-Symposium Quantum Boundaries: Gravity-Related Collapse Models". The event, that took place in December 2021 at the INFN premises in Frascati aimed at discussing collapse models proposed as a solution of the measurement problem in quantum mechanics. In particular, gravity-related collapse models were discussed, together with experimental signatures, such as (but not only) the spontaneous radiation predicted by these models.

The program of the event was as follows:

10:00 - 10:20 **Catalina Curceanu**: Welcome to quantum physics and collapse models (poor Schrodinger cat!)

10:20 - 10:50 **Lajos Diosi**: Introduction to gravity related collapse models

10:50 - 11:10 **Sandro Donadi**: Radiation emission in the CSL and the DP models

11:10 - 11:30 **Maaneli Derakhshani**: Comments on gravitational cat states.

11:30 - 12:00 Coffee Break

12:00 - 12:30 **Kristian Piscicchia**: Experimental search for collapse signals at Gran Sasso

12:30 - 13:00 **Round table** - discussion and future plans

More info on the event at
Mini-Symposium Quantum Boundaries: Gravity-Related Collapse Models (22 December 2021): Scientific Programme · Agenda (infn.it)

### Progression on TEQ experiment

To focus all partner's effort for the ultimate TEQ experiment at UoS and at low temperature (300 mK), experimental partners have weekly meetings (Tuesdays at 11 am UK time for 60 minutes duration) to update on electronics, Paul trap and adaptation to cryostat, as well as on the detection mode for the final experiment (based on state estimation and quantum Fisher information metrology tools) based on theoretical expertise within the TEQ consortium. The meeting do regular updats on the following topics:

1. Configuration of Paul blade trap at UCL with low-noise electronic, at UHV conditions and at room temperature.
2. Preparation of the cryostat at UoS to receive the Paul trap.
3. Magnetic levitation experiments at UoS to reach the TEQ objective to test CSL.

4. Develop and apply to data a single trajectory based detection scheme for the TEQ experiment to avoid the long timescales of thermalization of the particle motion to the environment by QUB.

Comment on progression speed of experiments: Progress with setting up experiments and testing of components is still affected by Covid infection of team members, by global shortages and delay in delivery of electrical and mechanical components. A further significant factor reducing the pace of progression is the shortage of helium (liquid and gas) in the UK, which reduces the number of low temperature experiments which we can perform at UoS at the moment.

Location: online via Zoom.

Meeting dates: 11/01/2022, 18/01/2022, 25/01/2022, 01/02/2022, 08/02/2022, 15/02/2022, 08/03/2022, 22/03/2022, 29/03/2022.

Participants: Catalina Curceanu, Michael Drewsen, Peter Barker, Thomas Penny, Jonthan Gosling, Massimiliano Bazzi, Chistopher Timberlake, Antonio Pontin, Andrea Vinante, Matteo Carlesso, Mauro Paternostro, Hendrik Ulbricht.

## PUBLICATIONS

| Authors | Title | Journal | Volume | Pages | Year |
|---|---|---|---|---|---|
| Sgroi, Pierpaolo, and Mauro Paternostro | Modeling mechanical equilibration processes of closed quantum systems: A case study | Phys. Rev. E | 105 | 014127 | 2022 |
| Giannelli, Luigi, Pierpaolo Sgroi, Jonathon Brown, Gheorghe Sorin Paraoanu, Mauro Paternostro, Elisabetta Paladino, and Giuseppe Falci | A tutorial on optimal control and reinforcement learning methods for quantum technologies | Physics Letters A | 434 | 128054 | 2022 |
| Wu, Qiongyuan, Luca Mancino, Matteo Carlesso, Mario A. Ciampini, Lorenzo Magrini, Nikolai Kiesel, and Mauro Paternostro | Nonequilibrium Quantum Thermodynamics of a Particle Trapped in a Controllable Time-Varying Potential | PRX Quantum | 3 | 010322 | 2022 |
| Rubino, Giulia, Lee A. Rozema, Francesco Massa, Mateus Araújo, Magdalena Zych, Časlav Brukner, and Philip Walther | Experimental entanglement of temporal order | Quantum | 6 | 621 | 2022 |

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|---|---|---|---|---|---|
| Giacomini, Flaminia, and Časlav Brukner | Quantum superposition of spacetimes obeys Einstein's equivalence principle | AVS Quantum Sci. | 4 | 015601 | 2022 |
| Baumann, Veronika, Marius Krumm, Philippe Allard Guérin, and Časlav Brukner | Noncausal Page-Wootters circuits | Phys. Rev. Research | 4 | 013180 | 2022 |
| Carlesso, Matteo, Sandro Donadi, Luca Ferialdi, Mauro Paternostro, Hendrik Ulbricht, and Angelo Bassi | Present status and future challenges of non-interferometric tests of collapse models | Nature Physics | 18 | 243–250 | 2022 |
| Belenchia, Alessio | Quantum physics in space | Physics Reports | 951 | 1-70 | 2022 |

To explore the latest publications, visit Publications | TeQuantum.

## DISSEMINATION ACTIVITIES

In the last 3 months, TEQ members delivered seminars and talks to over 4.250 people in audience!

| Who | What | Where | When |
|---|---|---|---|
| Arjan Houtepen | Finding the weakest link – surface electrochemistry of nanomaterials | CHAINS | December, 2021 |
| Jence Mulder | Electrochemical p-doping of CsPbBr3 nanocrystals | CHAINS | December, 2021 |
| Hendrik Ulbricht | Experiment demonstration of levitated optomechanics | No title | December, 2021 |
| Hendrik Ulbricht | 'Quantum Experiments in space' | SPRINT events | December, 2021 |
| Sandro Donadi | Radiation emission in the CSL and the DP models | Mini-Symposium Quantum Boundaries: Gravity Related Collapse Models | December, 2021 |
| Caslav Brukner | Das Monatsmagazin: Warum die Zeit in der Quantenphysik vor und zurück laufen kann | Ö1 Radio program | December, 2021 |
| Catalina Curceanu | Quantum Physics: Minunatii Cuantice | OctogonHUB talks | December, 2021 |

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| Hendrik Ulbricht | Experiment demonstration of levitated optomechanics | No title | January, 2022 |
| Barker Peter | Cavity cooling by quadratic coupling in a levitated optomechanical system | Optical and Quantum Sensing and Precision Metrology II | January, 2022 |
| Hendrik Ulbricht | Experiment demonstration of levitated optomechanics | No title | February, 2022 |
| Catalina Curceanu | La relatività: da Einstein ai raggi cosmici e acceleratori di particelle | AIF – Associazione per Insegnamento della Fisica talks | February, 2022 |
| Catalina Curceanu | Science in quantum and nuclear physics | Associazione Luca Coscioni per Giornata internazionale delle donne e delle ragazze in scienza | February, 2022 |
| Angelo Bassi | Infrastrutture quantistiche | Sfide e prospettive del sistema portuale del Mare Adriatico Orientale nella transizione digitale ed ecologica | March, 2022 |
| Catalina Curceanu | Dal gatto di Schroedinger al computer quantistico | Visioni scientifiche sul futuro dell'umanità | March, 2022 |

A detailed list of all talks can be found at Talks | TeQuantum.

## ANY OTHER RELEVANT INFORMATION

### TEQ experimental success leads to new project

New projects rise from the successes of TEQ. Specifically, the experimental success with levitated magnets has recently brought partners to win a 1m€ QuantERA 2021 Grant.
The project, called LEMAQUME (LEvitated MAgnets for QUantum MEtrology) is led by Dr. Andrea Vinante (CNR / Istituto di Fotonica e Nanotecnologie (IFN) – Trento, Italy) former TEQ member. The project will start in April 2022 and will last 36 months. It has 11 partners from Italy, France, Germany, UK, USA, Israel, and Latvia.
The QuantERA Call 2021, launched by 36 funding organisations from 27 countries, attracted 128 international research teams applying for over 132 M EUR. At the second stage of the Call, 91 full proposals were proceeded and reviewed, of which 39 proposals have been recommended for funding by the Call Steering Committee.

As a result of the Call Quantum Technologies research has a greater chance to be a large-scale transnational undertaking. The grantees will conduct projects focused on:

– Quantum Phenomena and Resources (QPR), where the goal is to lay the foundations for the QT of the future;

– Applied Quantum Science (AQS), aimed at taking known quantum effects and established concepts from quantum science, translating them into technological applications and developing new products.

While providing strong support to basic science, the QuantERA Co-funded Call 2021 aims also to give a boost to strategic applied research in quantum technologies.

More info at: https://quantera.eu/quantera-call-2021-39-european-excellent-projects-awarded-funding/

## UniTs coordinates newly granted MSCA Doctoral Networks project - MAWI

The University of Trieste has won, as coordinator, a MSCA Doctoral Networks project in the field of matter-wave interferometry for a total grant amount of 2,710,655.98 Euros. The consortium has a total of 9 partners.

This type of action implements doctoral programmes, by partnerships of universities, research institutions and research infrastructures, businesses including SMEs, and other socio-economic actors from different countries across Europe and beyond.

The field of matter-wave interferometry is emerging as a highly-promising interdisciplinary field, at the interface between fundamental science and quantum technologies/photonics/semiconductor European industry and has strong links with TEQ research.

The primary goals of the project "MAWI" are to use the exquisite control of ultracold quantum matter to implement guided matter-wave interferometers and to train young researchers in the emerging fields of matter-wave interferometry and quantum sensors based on interferometric schemes. The remit of MAWI is in the area of novel quantum sensing devices, with potential sensitivity enhancement of several orders of magnitude with respect to existing devices. Achieving this goal requires training the next generation of "quantum interferometry researchers" to a broad range of topics from fundamental to applied science, including both experimental developments and modelling, with strong connections to industry and emerging technological trends. The training network focuses on the combination of optimal preparation of initial ultracold atomic sources and potentials to control and guide the atoms; their combination to build integrated guided atom interferometers for precision measurements, e.g., of rotations and accelerations; and technological advances towards their miniaturisation. The end goal of a fully-integrated cold atom quantum device could become a major commercial tool in the coming decade, complementing, or potentially even hybridising with, parallel developments in the photonics and semiconductor industries.

## UniTs research group wins Leonardo challenge

Leonardo S.p.a. has announced the winners of the first challenges promoted on Solvers Wanted, the innovation scouting platform. Thus Leonardo expands its ecosystem for encouraging research and innovation processes with Open Innovation initiatives, involving the academic world and start-ups, enlarging the network of organisations sharing the same vision.

Leonardo selected three of the many projects received for these first challenges, among them, the UniTs Bassi research group with the proposal "Noisy quantum algorithms". The winners were awarded a contract of collaboration with Leonardo to implement their respective solutions, and they will have the chance to join the Leonardo Team for Innovation network, adding the network brand to their logos.

"Collaboration with research centres, universities and start-ups is an accelerator driving innovation and the company's competitiveness", emphasised Franco Ongaro, Chief Technology & Innovation Officer of Leonardo. "Solvers Wanted is a further tool supporting Leonardo's open innovation strategy to fuel the innovation supply chain in Italy".

The purpose of the project, based on the researches and findings of TEQ, is to generalize the Noise-Gate approach also to measurement-based quantum computing. The mathematical formalism remains the same but will be adapted to the case of photonic platforms.

Leonardo S.p.a. develops multi-domain capabilities in the Aerospace, Defence and Security sector. The company plays a prominent role in major international strategic programmes and is a trusted technological partner of governments, defence agencies, institutions and enterprises. Innovation, continuous research, digital manufacturing and sustainability are the cornerstones of Leonardo's business worldwide.