NEWSLETTER N.14, September 2021

The cover of the German magazine Geo presenting the topic of quantum research and our perception of reality that is the core of the article citing TEQ and three partners (issue October 2021).

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UPDATE OF WORK DONE

TEQ Junior Workshop II

TEQ has organized the second TEQ Junior Workshop on July 5th, 2021 to follow up on the latest scientific developments of the project and enhance discussion on the next months of research of TEQ. The workshop was held on Zoom and counted a total of 15 participants.

Agenda

15:00 – 15:10	Welcome and intro
15:10 – 15:30	Alessio Belenchia (QUB): *An Optomechanical Platform for Quantum Hypothesis Testing for Collapse Models*
15:30 – 15:50	Luis Cortes Barbado (OEAW): *Advances in Quantum Reference Frames*
15:50 – 16:10	Jence Mulder (TUD): *Increasing the photoluminescence quantum yield of Yb:YLF4 nanocrystals. Towards optical refrigeration of nanocrystals*
16:10 – 16:30	Steffen Meyer (AU): *Complex molecular Ions for Testing the Large Scale Limits of Quantum Mechanics?*
16:30 – 16:50	Fabrizio Napolitano (INFN): *Low-noise electronics for TEQ experiments*
16:50 – 17:10	Antonio Pontin (UCL): *Latest developments in the TEQ programme at UCL*
17:10 – 17:30	Chris Timberlake (UoS): *Magnetic trapping for testing CSL at Southampton*
17:30 – 18:00	Q&A – general discussion

The Booklet of Abstracts can be found here: Booklet of Abstracts TEQ Junior Workshop II July 2021.pdf (tequantum.eu)

TEQ Steering Committee Meeting

TEQ Steering Committee members have met remotely on July 13th to discuss the latest progresses and the general performance trend of the project and to effectively plan the next 12 months of activities considering the 6-month project extension.

15:00 – 15:10	Welcome and intro

15:00 – 15:15	Welcome by the SC chair and adoption of agenda
15:15 – 15:30	Recap of activities in the last 12 months
15:30 – 15:45	Amendment to GA – 6-month extension
15:45 – 16:15	New Deliverable and Milestones plan
16:15 – 16:45	Scientific programme for the next 12 months
16:45 – 17:00	AOB
17:00	Closing

Participants:

- UNITS: Angelo Bassi, Irene Spagnul
- INFN: Catalina Curceanu
- QUB: Mauro Paternostro
- OEAW: Caslav Brukner
- AU: Michael Drewsen
- UCL: Peter Barker
- Southampton: Hendrik Ulbricht
- MSquared: James Bain
- TUD: Arjan Houtepen

PUBLICATIONS

Authors	Title	Journal	Volume	Pages	Year
Guérin, Philippe Allard, Veronika Baumann, Flavio Del Santo, and Časlav Brukner	A no-go theorem for the persistent reality of Wigner's friend's perception	Commun. Phys.	4	93	2021
G., Giulio, A. Belenchia, M. Carlesso, S. Donadi, A. Bassi, R. Kaltenbaek, M. Paternostro, and H. Ulbricht	Testing the foundation of quantum physics in space via Interferometric and non-interferometric experiments with mesoscopic nanoparticles	Commun. Phys.	4	155	2021

A. Belenchia, M. Carlesso, S. Donadi, G. Gasbarri, H. Ulbricht , A. Bassi & M. Paternostro	Test quantum mechanics in space — invest US$1 billion	Nature (Comment)			2021
A. Gundhi, J. L. Gaona-Reyes, M. Carlesso, and A. Bassi	Impact of Dynamical Collapse Models on Inflationary Cosmology	Phys. Rev. Lett.	127	091302	2021
A. Vinante, C. Timberlake, D. Budker, D. F. Jackson Kimball, A. O. Sushkov, and H. Ulbricht	Surpassing the Energy Resolution Limit with Ferromagnetic Torque Sensors	Phys. Rev. Lett.	127	070801	2021
V. Baumann, F. Del Santo, A. R. H. Smith, F. Giacomini, E. Castro-Ruiz, and C. Brukner	Generalized probability rules from a timeless formulation of Wigner's friend scenarios	Quantum	5	524	2021
Lucas F. Streiter, Flaminia Giacomini, and Časlav Brukner	Relativistic Bell Test within Quantum Reference Frames	Phys. Rev. Lett.	126	230403	2021
Anirudh Gundhi, Sergei V. Ketov, and Christian F. Steinwachs	Primordial black hole dark matter in dilaton-extended two-field Starobinsky inflation	Phys. Rev. D	103	083518	2021
Anirudh Gundhi & Christian F. Steinwachs	Scalaron–Higgs inflation reloaded: Higgs-dependent scalaron mass and primordial black hole dark matter	The European Physical Journal C	81	460	2021
S. Donadi, K. Piscicchia, R. Del Grande, C. Curceanu, M. Laubenstein & A. Bassi	Novel CSL bounds from the noise-induced radiation emission from atoms	The European Physical Journal C	81	773	2021

To explore the latest publications, visit Publications | TeQuantum.

DISSEMINATION ACTIVITIES

In the third quarter of 2021, TEQ members delivered seminars and talks to over 6.300 people in audience!

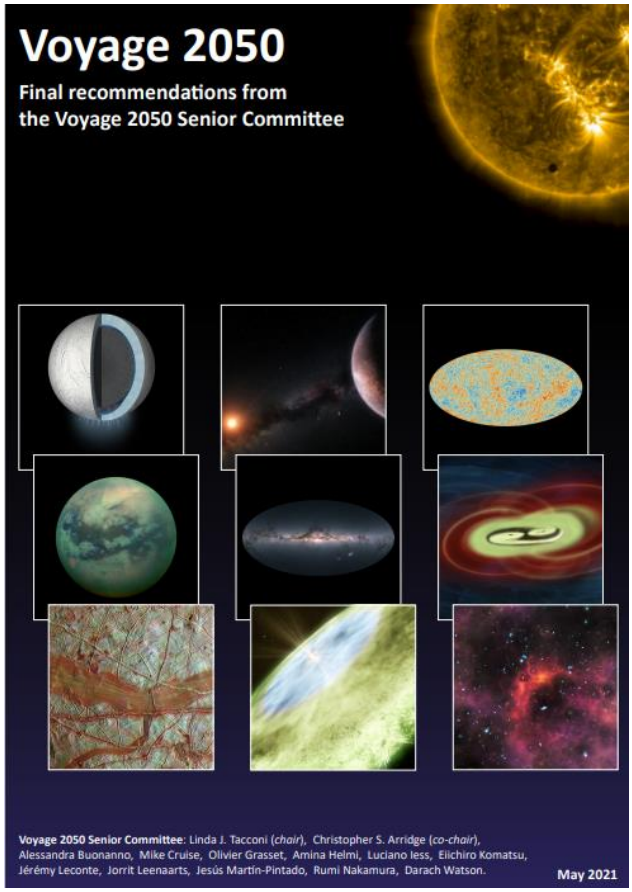
Who	What	Where	When
Caslav Brukner	*Quantum reference frames and Einstein's equivalence principle*	Workshop on Quantum Foundations, Gravity, and Causal Order	June, 2021
Angelo Bassi	*Quantum Mechanics: What is it about?*	Round table on Physics and Technology	June, 2021
Angelo Bassi	*Il mondo dei Quanti*	Seminar	June, 2021
Hendrik Ulbricht	*Probing gravity of quantum systems in the paradigm of levitated mechanics*	Challenges for witnessing quantum aspects of gravity	June, 2021
C. Curceanu, A. Porcelli	*La quantistica in laboratorio*	Cronache del Silenzio	June, 2021
C. Curceanu	*De la stele la pisica lui Schroedinger*	public online talk	June, 2021
Caslav Brukner	*Quantum reference frames for space and space-time*	Conference "Quantizing Time"	June, 2021
Caslav Brukner	*Quantum superposition of entropic times*	Complex Systems and Biological Physics Seminar	June, 2021
C. Curceanu	*Dall'incredibile gatto di Schrödinger alle tecnologie quantistiche*	Online event	June, 2021
Caslav Brukner	*Quantum reference frames and Einstein's equivalence principle*	Workshop on Quantum Foundations, Gravity, and Causal Order	June, 2021
Caslav Brukner	*Quantum reference frames for space and space-time*	Conference "Quantizing Time"	June, 2021
Luis C. Barbado	*Transformation of Spin in Quantum Reference Frames*	Quantum Information Seminar	June, 2021
Caslav Brukner	*Quantum superposition of entropic times*	Complex Systems and Biological Physics Seminar	June, 2021

Angelo Bassi	*Fundamental Tests of Quantum Mechanics*	Perspectives on Quantum Sensing and Computation for Particle Physics	July, 2021
C. Curceanu	*Quantum mechanics tests in the Gran Sasso undergroud laboratory: collapse models and spin-statistics*	16th Marcel Grossmann Meeting	July, 2021
Hendrik Ulbricht	*'How to build a research network'*	UniKORN event	July, 2021
Luis C. Barbado	*Unruh effect for detectors in superposition of accelerations*	Joint Annual Meeting of ÖPG and SPS 2021	August, 2021
Angelo Bassi	*La Meccanica Quantistica*	Stage on Physics for High School Students	August, 2021
Hendrik Ulbricht	*Probing new physics by levitated mechanical systems*	90th birthday of Roger Penrose	August, 2021
Luis C. Barbado	*Quantum computation and communication technologies*	FFG Sommerpraktikum	August, 2021
Luis C. Barbado	*Unruh effect for detectors in superposition of accelerations*	Vienna Quantum Foundations Conference	September, 2021
Angelo Bassi	*Present and future precision tests of spontaneous wave function collapse models*	Statistical and Quantum Mechanics: reconsidering their foundations in the light of new cutting edge experiments	September, 2021
C. Curceanu	*La scienza che ci cura, ci coccola e ci diverte*	European Researchers' Night	September, 2021
C. Curceanu	*L'essenziale è invisibile agli occhi...ma non alle nostre menti*	European Researchers' Night	September, 2021
Caslav Brukner	*Quantum superposition of entropic times*	ETH Workshop: Time in Quantum Theory: from mathematical foundations to operational characterization	September, 2021
C. Curceanu	*La Scienza dei Supereroi*	European Researchers' Night	September, 2021

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

ANY OTHER RELEVANT INFORMATION

TEQ warms up for space



The European Space Agency has recently released a report called Voyage 2050 that outlines the plan for the ESA Space Science Programme up to 2050. This is a new long-term plan that sets the European priorities in space science for the next decades.
For the first time in this framework, the foundations of quantum mechanics are included into the discussion of Space scientific priorities; specifically, possible experiments of the quantum superposition principle and of the quantum mechanical wave function collapse for different mass test particles are envisaged to be done is Space.
The TEQ project already operates in these area, developing new theoretical models and implementing tests of the quantum superposition principle on more and more macroscopic objects to establish the ultimate bounds to the validity of the quantum framework. However, these experiments, being carried out on Earth, are intrinsically limited by the dimensions of the objects whose quantum properties have to be tested.
That's where the Space comes in the picture. In fact, Space offers a potentially attractive arena for creating and verifying quantum properties of macroscopic objects beyond current Earth-based capabilities.
TEQ partners A. Bassi (UniTs), H. Ulbricht (UoS), M. Carlesso (UniTs) and M. Paternostro (QUB) have recently developed a feasibility study focusing on the efforts to test the boundaries of quantum physics in Space.
The study called "*Testing the foundation of quantum physics in space via Interferometric and non-interferometric experiments with mesoscopic nanoparticles*" is published today July 7, 2021, by Natures' Communication Physics at this link: Testing the foundation of quantum physics in space via Interferometric and non-interferometric experiments with mesoscopic nanoparticles | Communications Physics (nature.com)

Testing quantum mechanics in Space

On 2nd August 2021, the journal Nature published a Comment by TEQ partners Angelo Bassi, Mauro Paternostro, Hendrik Ulbricht alongside other colleagues titled "Test quantum mechanics in space". The article brings to the attention of the scientific community the need to invest resources in research aimed at testing the limits of quantum physics through experiments in Space. Unlike experiments on Earth, Space offers conditions (primarily the almost absolute absence of gravity) that allow physical systems to develop freely for much longer time.

These are experiments that will take decades to carry out, given their complexity. Verifying the limits of quantum mechanics will consolidate or revolutionize the approach to quantum technologies, for example with regard to the development of increasingly powerful quantum computers.
Read the article here: Test quantum mechanics in space — invest US$1 billion (nature.com)

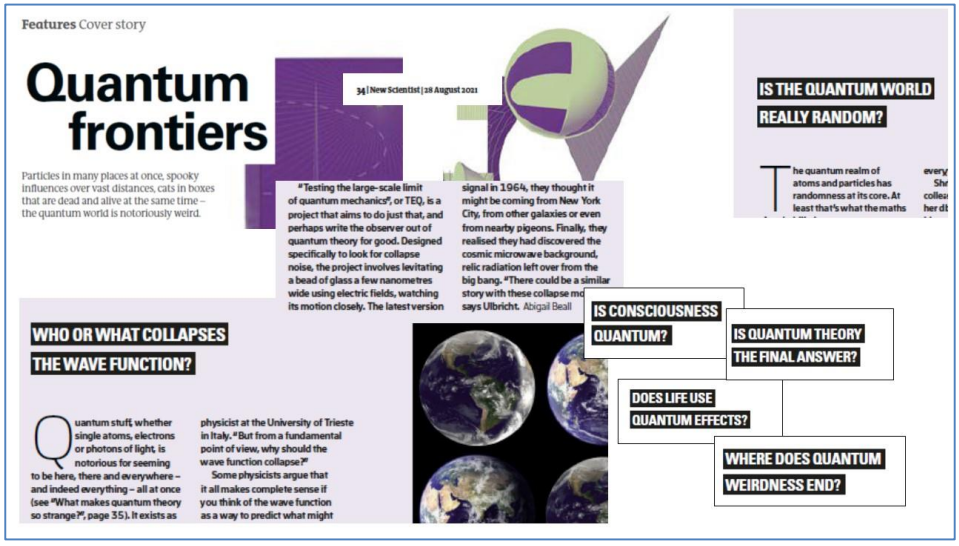
TEQ on the cover of Geo magazine

On the October issue 2021, TEQ was featured in a long cover article on the German magazine Geo. The article covers recent views on quantum mechanics through some of the most prominent scientists in the field. The article features interviews to three of TEQ partners: Angelo Bassi (PI) from the University of Trieste, Caslav Brukner from the Austrian Academy of Sciences (IQOQI) and Hendrik Ulbricht from the University of Southampton.
The author visited the labs at the University of Southampton where Ulbricht has assembled the TEQ final experiments and has run the first tests in summer 2021. "To have relevant results we have to wait for more tests", he says. "I think it's important to explore whether quantum mechanics is valid at all levels" says Brukner. He doesn't think quantum mechanics is the final version of our understanding of the physical world. "The quantum theory is young, it is less than 100 years old", says Bassi in closure of the article, "The history of science shows us that this nothing, we have to be patient to find a new theory beyond quantum mechanics that explains quantum and classical phenomena".

With 2.3 million readers in 2020, Geo Magazin is an educational monthly magazine known for its detailed reportages, in-depth interviews and impactful pictures. This article represents a big success for the TEQ project as its scientific efforts are translated into a science popularization language and delivered to a large general public.
Link to the article: Physik: Was ist noch real? Die Quantenforschung stellt unser Weltbild infrage | GEO+

New Scientist chooses TEQ for a cover story

"Particles in many places at once, spooky influences over vast distances, cats in boxes that are dead and alive at the same time – the quantum world is notoriously weird. Things get most baffling with the questions quantum theory raises about the nature of reality. These are frontiers of our understanding, beyond which lies a wilderness of interpretation where physics begins to blend into philosophy."


Features Cover story

Quantum frontiers

Particles in many places at once, spooky influences over vast distances, cats in boxes that are dead and alive at the same time – the quantum world is notoriously weird.

34 | New Scientist | 28 August 2021

"Testing the large-scale limit of quantum mechanics", or TEQ, is a project that aims to do just that, and perhaps write the observer out of quantum theory for good. Designed specifically to look for collapse noise, the project involves levitating a bead of glass a few nanometres wide using electric fields, watching its motion closely. The latest version

signal in 1964, they thought it might be coming from New York City, from other galaxies or even from nearby pigeons. Finally, they realised they had discovered the cosmic microwave background, relic radiation left over from the big bang. "There could be a similar story with these collapse mo

says Ulbricht. Abigail Beall

IS THE QUANTUM WORLD REALLY RANDOM?

The quantum realm of atoms and particles has randomness at its core. At least that's what the maths

WHO OR WHAT COLLAPSES THE WAVE FUNCTION?

Quantum stuff, whether single atoms, electrons or photons of light, is notorious for seeming to be here, there and everywhere – and indeed everything – all at once (see "What makes quantum theory so strange?", page 35). It exists as

physicist at the University of Trieste in Italy. "But from a fundamental point of view, why should the wave function collapse?"

Some physicists argue that it all makes complete sense if you think of the wave function as a way to predict what might

IS CONSCIOUSNESS QUANTUM?

IS QUANTUM THEORY THE FINAL ANSWER?

DOES LIFE USE QUANTUM EFFECTS?

WHERE DOES QUANTUM WEIRDNESS END?

In over 10 pages of the August 2021 issue, New Scientist's authors explore the most fascinating questions about quantum mechanics: what makes quantum theory so strange? Who or what collapses the wave function? Why aren't big things quantum? Is the quantum world really random?

"From a practical point of view, [quantum mechanics] it works perfectly," says Angelo Bassi, TEQ's PI interviewed for this article, "But from a fundamental point of view, why should the wave function collapse?"

"Designed specifically to look for collapse noise, the [TEQ] project involves levitating a bead of glass a few nanometers wide using electric fields, watching its motion closely", writes Abigail Beall, author of the article. Further on, another TEQ partner takes the floor. Hendrik Ulbricht, who is leading the experiment, expects relevant results within a year. "We are all very excited," he says.

New Scientist is one of the best known science magazines and an extremely high brand reach: 5.2 million actively engaged weekly users across all its platforms, 6 million social media following, 4 million monthly website visits and 120.675 weekly circulation (*source:* https://experience.newscientist.com/advertise/).

This article is another 2021 success for the TEQ project, together with the article on Geo magazine, as its scientific efforts are translated into a science popularization language and delivered to a large general public.

Link to the article: This is what makes the quantum world so strange and confusing | New Scientist