Entangled Visions

Exploring Quantum Visualizations in Culture, Dissemination, and the Arts

Oslo, Norway
2–5 December 2025

Entangled Visions

Exploring Quantum Visualizations in Culture, Dissemination, and the Arts

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OSLOMET HUB
The OsloMet Quantum Hub

Welcome

The OsloMet Quantum Hub is delighted to announce an interdisciplinary workshop exploring the rich intersections of quantum science, philosophy, dissemination, and the arts. The event will take place at Oslo Metropolitan University (OsloMet), Pilestredet campus, from 2nd to 5th December 2025.

The year 2025 has been declared the International Year of Quantum Science and Technology by the United Nations General Assembly, marking the centenary of quantum mechanics and promoting global collaboration in this transformative field. Our goal at the OsloMet Quantum Hub is to bring together individuals passionate about quantum science and technology—and to reach beyond traditional academic boundaries to share the beauty and significance of quantum science with a wider audience. This workshop will feature presentations by leading researchers and artists on the role of visualization in quantum physics and its connections to philosophy, dissemination, and the arts, as well as its influence on popular culture.

Talks include visually striking scientific results and illustrations, but will assume little to no prior knowledge of formal quantum theory. Topics include:

- Philosophical questions that remain unresolved within the axioms of quantum physics
- Effective dissemination of quantum science to students and the public, with a focus on visualization
- Quantum physics and technology in art and popular culture

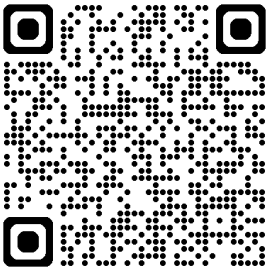
We wish you very welcome to this event and hope you will be joining us for an inspiring dialogue at the crossroads of science and creativity during the whole week!

Contents

Practicalities

Schedule

See the workshop's website:



https://uni.oslomet.no/quantum/entangled-visions/

Venue

The workshop will be held at the Pilestredet campus of OsloMet. We will be changing buildings from day to day, hopefully letting you get to know our urban campus without getting lost along the way. An overview of the campus can be seen in Figure 1.1 which contains a snapshot from MazeMap. This interactive map can be found here. The schedule contains links to MazeMap directions to all the various locations used throughout the workshop.

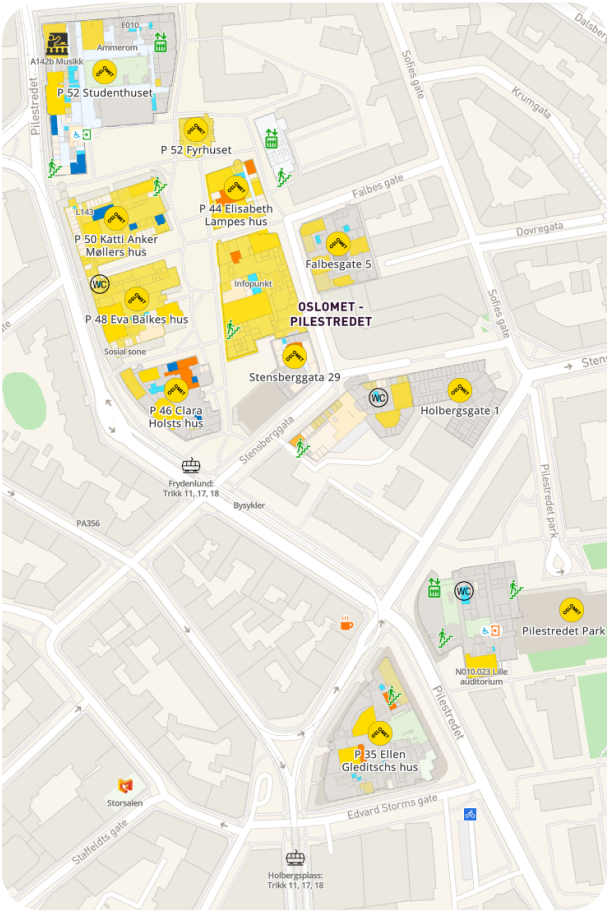


Figure 1.1: Snapshot of a MazeMap overview of campus Pilestredet which can be found here.

Directions

The campus is centrally located and can be reached by train, tram, or bus. From the airport, we recommend taking the train. Both the regular trains (Vy) and the airport express (Flytoget) take less than 25 minutes to the city centre. Public transport within the city is managed by Ruter.

- **Train:** Exit at *Nationaltheatret station*. This is the stop after Oslo Central Station (Oslo S) when travelling from the airport. The campus is only a 10-minute walk away, see Figure 1.2.
- **Subway (T-bane):** The closest station is *Nationaltheatret station*, see Figure 1.2
- **Bus:** The closest stop is *Holbergs plass*.
- **Tram:** The closest stops are *Holbergs plass* for building P35 and *Frydenlund* for the other buildings we will be using. Both can be seen in Figure 1.1.

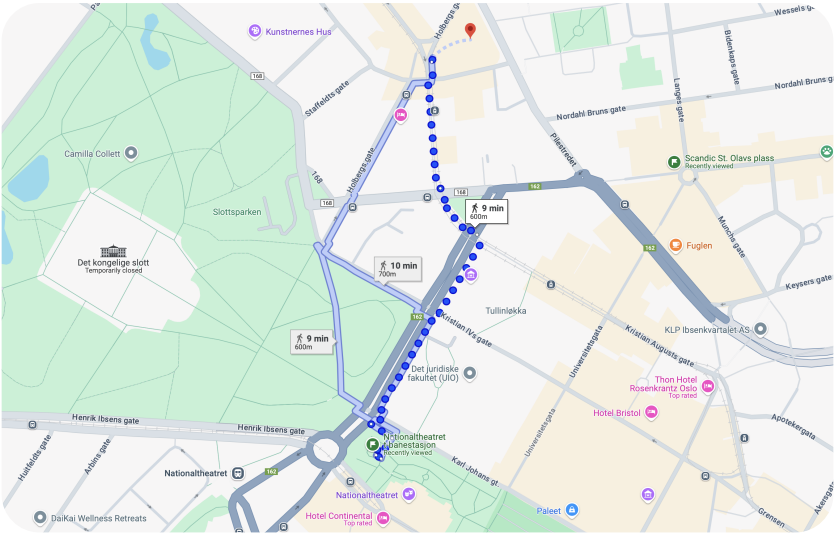


Figure 1.2: Directions from *Nationaltheateret station* (train and subway) to *Ellen Gleditschs Hus* (building P35). On foot it takes less than 10 minutes. (Map by Google)

Lunches & Dinners

The Pilestredet campus is located centrally in Oslo and there is a variety of options for both lunch and dinner. There will be no organised lunches or dinners during the workshop, and all participants are free to explore the local restaurants and cafeterias. Please note that restaurants in Norway generally close a bit earlier than in other European countries. It is not uncommon that the kitchen closes as early as 21:00, but this might vary.

In addition to restaurants, there are a few options for lunch on campus. These are the *SiO* cafeterias in P32, P35 (a smaller one), and P52 which offer a variety of warm dishes, salads, baguettes etc. In addition, *Union167 Fyrhuset* offers a selection of baked goods, sandwiches and freshly baked pizzas. An overview of all of them can be found here.

Figure 1.3: Credit Benjamin A. Ward/OsloMet.

Abstracts

Tuesday 2 December

Quantum iconoclasm:
quantum interpretations and the pictures they break
Anders Kvellestad

Something is strange about our quantum world, on that point most physicists and philosophers agree. But, after a century of quantum physics we still can't seem to agree on precisely *how* the quantum breaks the classical view of the world. In this talk I will give a brief introduction to the question of the interpretation of quantum mechanics and highlight how different interpretations challenge different assumptions about the world. Coming from the perspective of a researcher in particle physics, I will focus in particular on a *participatory realism* view of quantum mechanics and discuss how this view has impacted how I talk, think and feel about physics and what it tells us about reality.

Quantum Mechanics and Avant-Garde Music: Shadows of the Void

Dr Rakhat-Bi Abdyssagin

The presentation covers different connections between quantum physics and contemporary music – ranging from interrelations in chronological perspective to metaphoric correlations between fundamental phenomena in quantum mechanics such as Heisenberg's uncertainty principle, the Pauli exclusion principle, quantum entanglement etc. and their reflection in the structure of selected music compositions by Karlheinz Stockhausen, John Cage, Arnold Schönberg and others, as well as in the specific extended techniques of performance. The presentation will tell about the place that classical music occupied in the lives and work of great scientists such as Albert Einstein, Max Planck, Max Born, Werner Heisenberg and others. Philosophical aspects of quantum theory and relativity will also be considered.

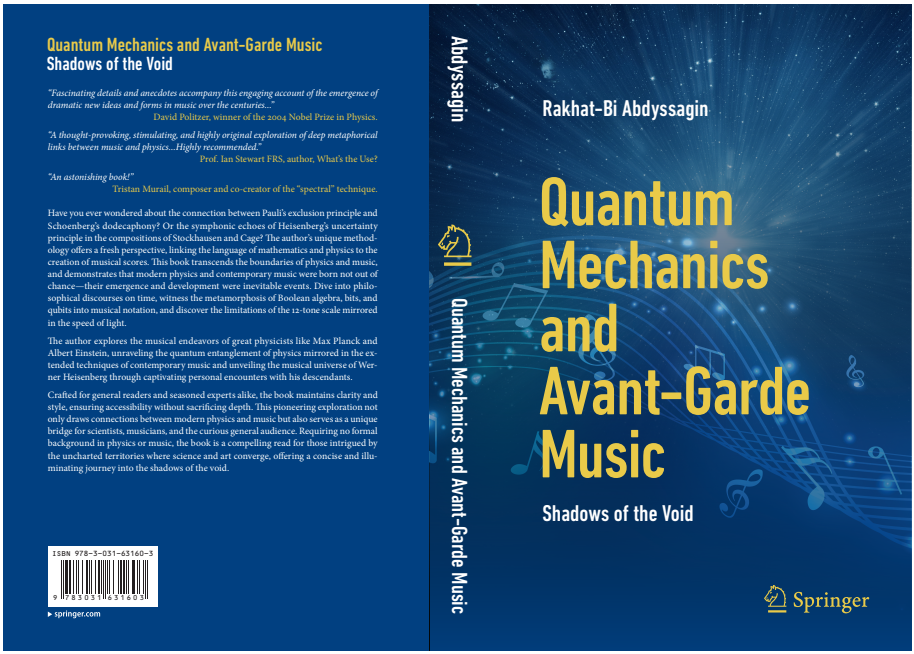


Figure 2.1

Concerning the Quantum in Art

Paul Thomas

This presentation will offer an artist's perspective on the intriguing relationship between quantum physics and art, particularly focusing on the role of probability, chance, and uncertainty. Instead of approaching quantum mechanics from a scientific perspective, the presentation explores how quantum phenomena concepts shape perception and creative expression. Through metaphors, signs, and serendipitous experiences, it questions how language and imagery of quantum mechanics have historically and synchronistically intersected with human culture. I will use my own practice-led artworks to demonstrate the often-contradictory nature of artistic practice, highlighting the challenges of visualising the invisible and ineffable latent beauty and significance of quantum phenomena.

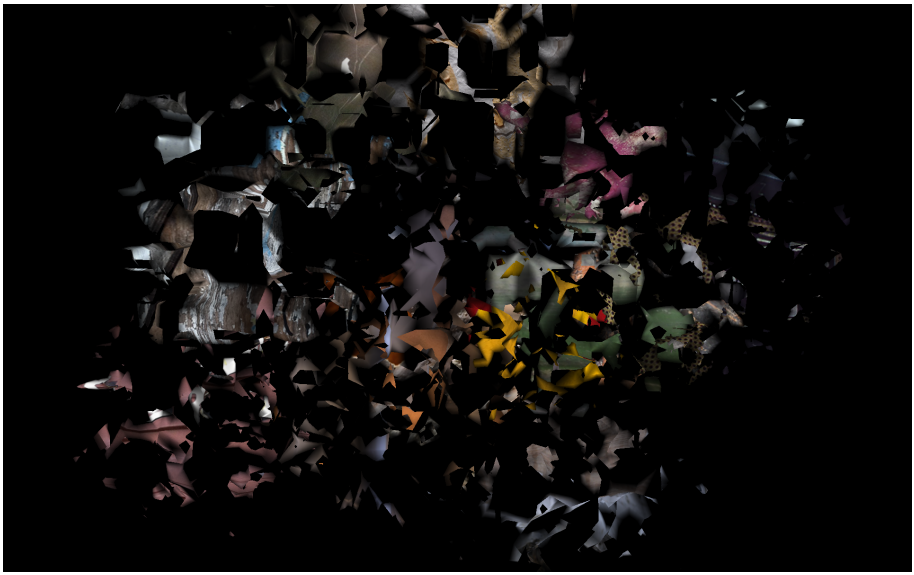


Figure 2.2: Screen capture from the digital artwork QuantumConsciousness.

Quantum Drawing Workshop: The Role of the Observer

Paul Thomas

The workshop will give a practical demonstration of how the role of the observer in art and quantum mechanics plays parallel roles. The workshop will invite participants to draw (conceptually and physically) to find analogous relationships with probability and uncertainty. A set of tools that explore the role of the observer influencing what is seen and experienced, whilst measuring the world through responsive mark making. Complex subjects such as counterfactual definitiveness, delayed choice quantum erasure, probability, indeterminacy, entanglement, superposition, and the classical-quantum divide will be explored through the traditional act of mark-making.

Figure 2.3: Paul Thomas, 'Johnny Numonic' Graphite, Gouache on paper.

Wednesday 3 December

Many Worlds, Many Stories
Chad Orzel

A handful of ideas from quantum foundations have taken hold in the broader culture, perhaps none more powerfully than the "Many Worlds Interpretation" developed by Hugh Everett III and popularized by Bryce DeWitt, which posits the existence of a nearly infinite number of parallel universes corresponding to the different possible outcomes of quantum measurements. This is an idea rife with possibilities for fictional narratives, and as such has been enthusiastically taken up by any number of authors. In this talk I will discuss what the Everett interpretation actually is, how it differs from the popular conception of the MWI, and some of its more successful uses in science fiction.

Learning about Quantum Technologies using Games: Interactive visualizations and the role of AI

Stefan Küchemann

Concepts in quantum technologies are often difficult to understand for learners because of their abstract nature and absence of everyday phenomena. However, applications based on quantum technologies are expected to determine our daily life in the near future, which leads to a tremendous growth in their market potential over the next 10 years. This change demands a basic understanding of aquatic technologies for everyone and a training of a workforce that is able to drive a shift from classical to quantum technologies.

In this presentation, we demonstrate how digital games can be used to engage learners in interacting with quantum technologies and creating an intuitive understanding of the underlying concepts. Together with quantum physicists, we created an interactive and authentic environment in which students learn about quantum technologies without requiring prior knowledge. Typical visualizations of quantum technologies provide a low entrance barrier and a non-player character based on AI supports learners and engages them in her story.

This presentation demonstrates the effectiveness of such a collaborative learning environment and discusses the potential and limitations of game-based learning approach for studying abstract concepts.

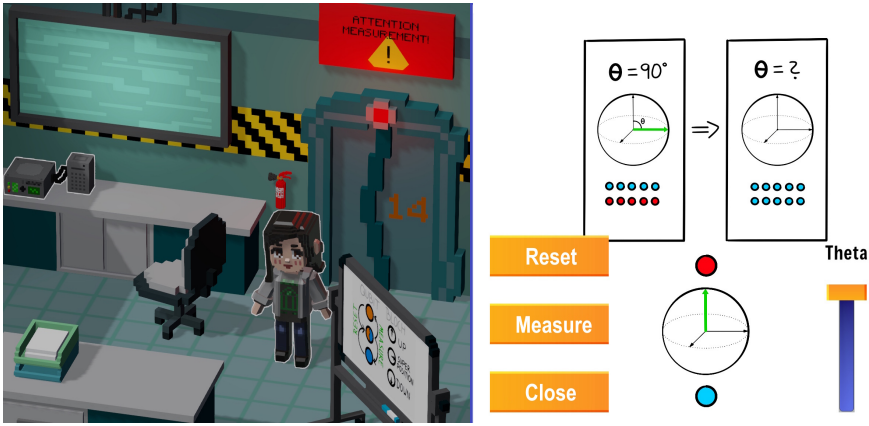


Figure 2.4: To learn about quantum technologies, an AI character engages the learner in different challenges and an exciting story.

Quantum Loops, Broken Symmetries: The Science Behind the Music

Eduardo Reck Miranda

Artificial Intelligence (AI) is revolutionising music creation and performance. AI-powered tools can now compose, analyse, enhance production quality, and curate personalised playlists, allowing musicians and listeners to explore new horizons.

However, the advent of quantum computers promises to push these boundaries even further. Quantum computers leverage phenomena such as superposition and entanglement to perform computations in fundamentally different ways from classical computers.

Practical quantum computers are still experimental. Building stable, low-error qubits is a challenging task. But the industry is progressing fast and there is growing interest in exploring quantum computing for a wide range of tasks. Artistic exploration, including music composition and performance, is a natural part of this process. Hence, the emerging field of Quantum Computer Music.

In this talk, I will begin by presenting the basics of Quantum Computer Music. Then I will introduce the technology I developed at the University of Plymouth in collaboration with partners for the compositions of the Entangled Visions concert "Quantum Loops, Broken Symmetries" (December 3, 2025, at 18:00, Salen, ZEB, Oslo). These include generative systems based on quantum cellular automata, quantum random walks, quantum machine learning, and Q1Synth, a quantum simulation sound synthesiser.

Figure 2.5: Miranda on stage at The House, Plymouth, UK.

Qubits and Quartets:
memory, CubeHarmonic, neural activity, and voice

Maria Mannone

A quartet of physics, computer science, neurology, and music: we present some of their possible intersections through to the mathematical framework of quantum mechanics.

Case one is an adaptation to the music of the concept of memory measurement in quantum states. The idea leads to the definition of a criterion of Musical non-Markovianity, that is presented and then applied to orchestral musical pieces.

Case two concerns the quantum-computing implementation of a truth table, adopted to choose moves on the 4D CubeHarmonic (the HyperCubeHarmonic), a musical instrument derived from the Rubik's cube, increasing harmonic variety.

Case three is the core concept of the quantum vocal theory of sound, where quantum computing is applied to vocal sound signal processing.

Case four is a reference to the quantum-based simulation of brain activity, from human EEG data. As an inverse of case one, we end the presentation with a sonification of density matrices obtained from simulations of quantum robotic swarm.

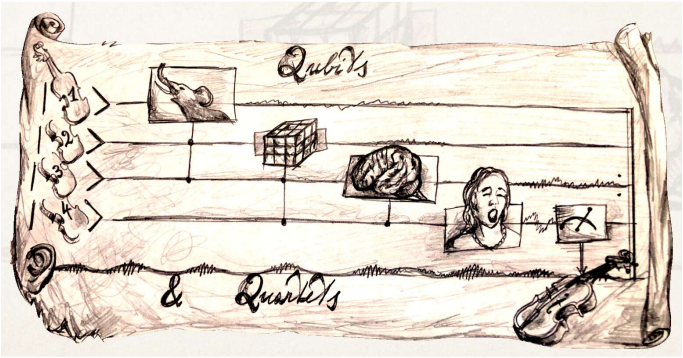


Figure 2.6: Drawing by Maria Mannone showing a pictorial circuit with four qubits, where each qubit is represented as a schematic violin. The classic qubit is represented as an ear, representing the information that will be listened to. The gates contain images representing the four parts of the presentation: an elephant for the memory, a Rubik's cube for the CubeHarmonic, a brain for the neural activity, and an opera singer for the voice. Finally, the measurement operation leads to some cello music.

Dhvāni/Atomspheres/Datafiction

Budhaditya Chattopadhyay

Dhvāni means "resonance" in Sanskrit. Contingent resonances between sounding objects and between people are the starting point for the self-regulating aleatory installation Dhvāni. In its exhibition, a biomimic web is stretched with hundreds of South Asian ceremonial bells and other tuned objects and instruments, such as wind chimes and ghungroos. By means of a self-built artificial intelligence system based on randomness and unpredictability, this resounding network responds to human presence: footsteps, voices, hand clapping. Through machine learning, the interconnected system improves its performance creating a beyond-human resonant organism. Atomspheres is a series of participatory performances that engage with the macro-scale crises of the climate and ecology in a planetary context and bridges its entanglements with micro-level coping strategies to the crises in a regenerative gathering. The performances resonate with the tradition of free improvisation and communal and participatory sonic gatherings for affective and discursive engagement with crises and conflict, ingrained in many Global Souths cultures. The performances involve field recordings of climate variables like wind, water, and woods, comprovised by chance generative processes, accompanied by radio interferences transducing situated weather patterns, weaved together by meditative instrumental interventions of traditional instruments, as well as live electronics and algorithmic interpretation of data and assemblages embracing free improvisational techniques and an ethos of chance and randomness. The project is inspired by the quantum-level entanglements of humans, beyond-humans, and other life forms in a survival context, as well as the possibility of healing through humble acceptance and letting go of control. It explores sensory transduction and quantum amalgamation of environments to speculate how to make them post-immersive and attuning experiences in an open, circular, collaborative setting as sonic-social gathering. These two projects are discussed in the talk in the light of Quantum concepts, chance, emergence, and randomness.

Can you touch a wavefunction?

Audun Skau Hansen

Orbitals and quantum states sit at the heart of modern chemistry and quantum technologies, yet most students only ever meet them as flat textbook images or opaque algebra. At the same time, the emerging quantum technology workforce will need not only formal competence, but also robust intuition for many-body quantum physics.

In this talk, I'll probe the question "Can you touch a wavefunction?" and explore what happens when we quite literally step *inside* quantum states using virtual reality. I'll show how modern web and VR technologies make it easy to move from theoretical, textbook-native representations toward fully interactive, tangible, and immersive experiences.

My aim is to demonstrate that VR experiences grounded in computational thinking are not just a gimmick, but a concrete didactic tool for linking Hilbert space to human perception–helping prepare a broader community to think and work quantum.

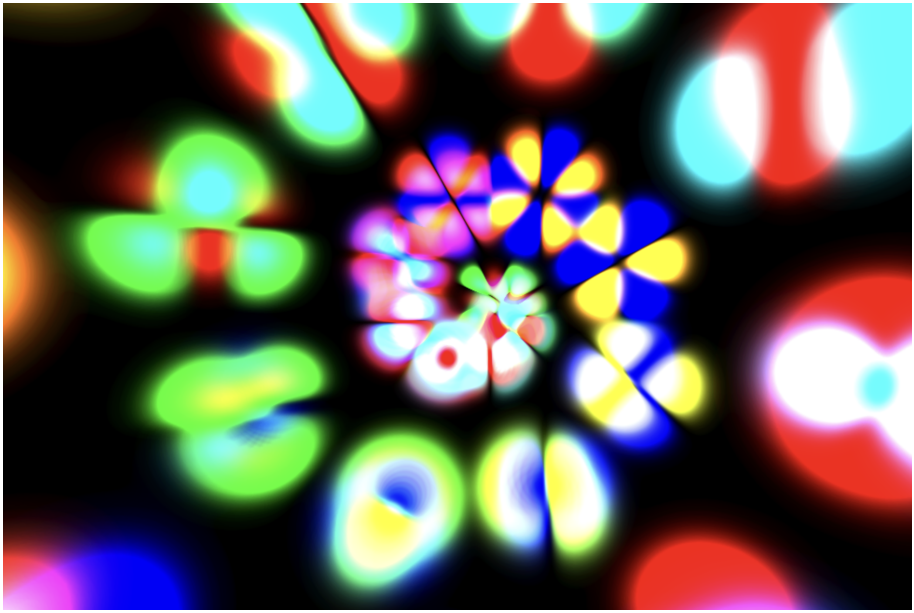


Figure 2.7

Curating art-science collaborations for creative innovation

Caterina Benincasa

Art-science collaborations are a powerful way to rethink what we know. They can make us experience knowledge differently, allowing us to explore and re-imagine assumptions, connections and opportunities. Informed by research on art-science collaborations, and drawing on my experience with the JRC SciArt programme, this talk explores curatorial practice as a form of transdisciplinary navigation, where bringing together different ways of knowing and doing can provide important engagement with ontological, epistemological and ethical dimensions of research.

Working across art and science can challenge habits of thought, invite new lines of inquiry and offer unexpected insights into each participant's own research. What matters is not only what such collaborations produce (an artwork, a paper, a participatory workshop, a presentation), but rather the process of how they develop: the slow work of building trust, understanding each other's motivations and creating conditions in which mutual curiosity can thrive. Curators play a crucial role in enabling these processes, mediating expectations, bridging cultures and languages, and designing the 'spaces of possibility' where friction becomes productive.

In this talk, I will share some of the lessons learned from curating these projects: managing expectations, facilitating fruitful misunderstandings, navigating liminal spaces, and fostering reflective dialogue. Through concrete examples from JRC SciArt, we will see how transdisciplinary encounters, when provided with the necessary conditions, methodological sensitivity and support (including institutional support), can help ferment new insights and dialogue, and produce knowledge and impact.

Archetypes of Entanglement: Alchemical Imaginaries and Spiritualism in Quantum Theory and Art

Aurora Del Rio

This talk explores entangled imaginaries between quantum theory, psychology and artistic research. The concept of archetype is examined as it was explored in the vision of pioneer of quantum theory Wolfgang Pauli and psychologist Carl Gustav Jung, in the context of a re-emergence of alchemical theories and the spiritualist movement. In their research, the archetype was intended as a symbolic bridge between psyche and matter, as an attempt to define a new ontology based on quantum physics, or a new model of reality that could overcome the Newtonian paradigm of the universe as a clockwork.

In the early 20th century, when radioactivity was discovered, alchemical transmutation was considered to be finally possible to achieve through the new scientific discoveries. Currently, the nuclear industry uses concepts borrowed from mythology and alchemy, such as the idea of transmutation in relation to radioactive waste. Drawing on artistic research, this talk presents different approaches to quantum theory and nuclear imaginaries from the arts, suggesting that art can serve as a way of providing a form of embodied knowledge, while posing existential questions about the nature of reality and the sustainability of our technical achievements.

Figure 2.8: Aurora Del Rio “Rituals of Inheritance” 2024, still image from video.

Thursday 4 December

Visualizing the Quantum Ecology: Sensing across Sights, Imaginations, and Design by *Stefano Calzati*

This talk weaves together cognition, perception, and expression to explore quantum-inspired and quantum-derived links across sights, imaginations, and visualizations. I will do so by discussing the "quantum ecology" (Calzati & de Kerckhove 2024) as an onto-epistemological framework and a technological paradigm. Both the framework and the paradigm pivot around an understanding of being as sensing: this latter is not a faculty applied to a pre-given world, but the ongoing modulation of the I-world coevolution. In other words (and more radically), being is technics: an embodied, emergent information symmetry breaking that is always from within and open-ended, enacting complementary auto/sympoietic dynamics.

I begin with contrasting sight as a technologically prosthetic mode of experience and imagination as a discontinuous, insight-driven mode of experience. These two modes of actualizing reality (i.e., "world-sensing") are always co-present, yet partially incommensurable, and resist any framing, which is rather an ex-post analytical operation.

From here, the talk examines how different world-sensing ecologies emerge as/through embodied being as technics: language (and writing systems) stabilize meaning as a form of shared phenomenological sensing of sensing; mathematics, as a signification system, also operates as a sensing of sensing, by abstracting from perceptual experience in favor of a cognitive apprehension of reality; digital computation formats the sensible into binary logic, eschewing (anthropological) meaning altogether; and quantum information technologies as dispositif introduce new forms of synthetic sensing, exposing and refracting entanglement, uncertainty, and non-locality into the societal fabric.

Most importantly, these ecologies do not form discrete domains but co-emerge through continual tension, alignment, and differentiation. Put differently, I advance the idea that ecologies can be best understood as fractal holograms: nested onto-epistemological world-sensing whose intermingling become thinkable and designable through/as always-partial, open-ended onto-epistemological configurations. So how to visualize ecologies as fractal holograms to yield new insights into reality as an emergent affair?

The talk discusses how some of these tenets can be applied in practice. Notably, I present the design and teaching of a course – "Ethics for the Data-Driven City" (TU Delft 2022-2024) – based on an original "problem-opening" approach that leverages and operationalizes quantum ecology's emphasis on uncertainty and entanglement to reveal the value-laden irreducibility of data practices and to design artefacts that expose the inevitable ethical tensions and un/intended consequences emerging from the computation of cities as complex systems.

The Limits of Causality: A Research through Artistic Practice

María Castellanos & Alberto Valverde

The Causality of the Impossible is an art installation that explores the relationship between determinism, chance, and causality. It stems from the idea that we are connected to our past not only through memory or genetics, but also through the unending chain of events that has led us to the present moment. While classical physics proposes a universe governed by determinism, quantum mechanics introduces a fracture: at the core of matter, certainty dissolves into probability.

This talk offers an overview of Alberto Valverde's artistic practice, using The Causality of the Impossible as a point of departure to examine how his work engages with the tension between science, perception, and event. However, the discussion will not focus solely on this piece: a broader selection of projects will be presented to show how Valverde transforms physical phenomena–such as the cosmic microwave background and quantum fluctuations–into sensitive experiences that challenge traditional notions of causality and make the seemingly impossible perceptible.

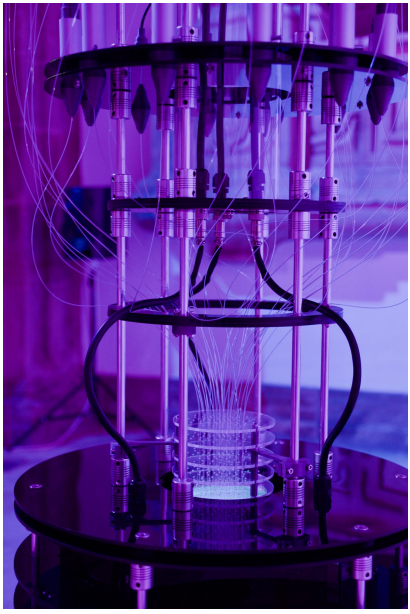


Figure 2.9: Detail of the artwork The Causality of the Impossible, by Alberto Valverde 2020.

Art as Gateway: Quantum Beyond Expertise

David Young

Quantum computing's development risks being confined to technical experts because of how strange and counterintuitive the technology is, perpetuating the very binary thinking that quantum mechanics itself fundamentally challenges. Making art with quantum computing, I employ an "intentionally non-expert approach" that embraces uncertainty, intuition, and creative misunderstanding as valid forms of technological engagement. I will present my process and visual works that function as "Trojan Horses"–carrying quantum concepts to broader audiences. These works serve as gateways that spark curiosity among non-experts while developing my own intuition of quantum phenomena and inspire others to do the same. By dissolving the expert-novice binary, this approach shows that meaningful engagement with technology doesn't require expertise, creating space for more diverse voices in shaping our technological future.

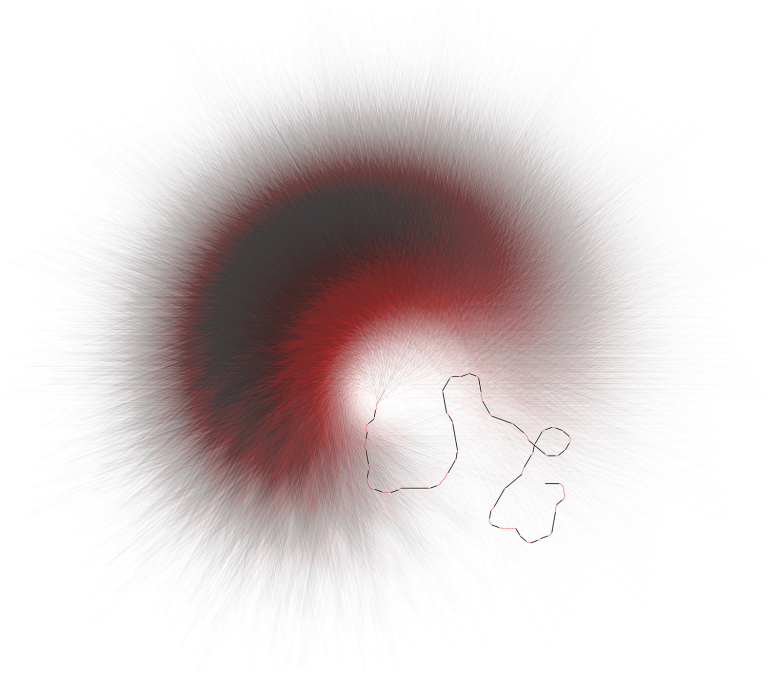


Figure 2.10: "Q 192".

Aesthetics in quantum physics: Motivation, meaning and education

Henrik Zinkernagel

Physicists often invoke aesthetic language. They use terms such as beauty, harmony and wonder – not only to describe their finished theories and explanations, but also to express their motivations and passionate involvement in the scientific process. This talk is about some important ways aesthetics influenced the historical development of quantum mechanics and its philosophical interpretation. I aim first to clarify the notion of aesthetics and to show that – far from being merely a question of subjective or personal taste – it is closely related to widely shared beliefs about scientific understanding. I then discuss how aesthetic considerations – e.g. regarding beauty, visualization, the sublime and the limitations of the new theory – played an important role for the quantum physics pioneers, focusing particularly on Niels Bohr. I conclude by considering how aesthetics in science is also relevant for science education and the public understanding of science.

Figure 2.11: Quantum visions in Niels Bohr's living room?
Photo © The Niels Bohr Archive, Copenhagen.

Quantum Music and Networks: From Algorithms to Art

Khrystyna Gnatenko

Features of quantum programming will be presented as an introduction. Networks in music will be discussed, along with original methods for studying the properties of these networks using quantum programming [1–3]. These methods are based on constructing graphs that describe melody or harmony in a musical score, building the corresponding multiqubit entangled states, and investigating their properties with quantum algorithms. Among these properties are entanglement distance, the velocity of quantum evolution, and quantum correlations. Basic methods for creating quantum music will also be discussed and demonstrated.

In addition, the specific features of the bachelor's educational program Quantum Computers and Quantum Programming, launched at Ivan Franko National University of Lviv, Ukraine, in 2020, will be presented.

[1] Gnatenko, Kh. P. *Entanglement of multi-qubit states representing directed networks and its detection with quantum computing.* Phys. Lett. A. — 2024. — Vol. 521. — Art. 129815. — 5 p.

[2] Gnatenko, Kh. P. *Relation of curvature and torsion of weighted graph states with graph properties and its studies on a quantum computer.* Eur. Phys. J. Plus. — 2025. — Vol. 140, No. 3. — Art. 241. — 7 p.

[3] Gnatenko, Kh. P. *Studies of properties of bipartite graphs with quantum programming.* arXiv:2507.16653 to appear in Phys. Lett. A.

"Let me be the Bride of Science"

Renate C.-Z.-Quehenberger

This quote from Ada Lovelace aptly characterizes my approach to quantum visualization. Within the framework of the interdisciplinary project "Quantum Cinema – a Digital Vision", at the University of applied arts Vienna, we developed a hyper-Euclidean, 3D animated geometry to visualize the 5- or 10-dimensional space in motion, which could serve as an ontological foundation for quantum mechanics. Its construction is based on my (re)discovery of the 3D representation of the Penrose Kites & Darts tiling, named epitahedra ($E\pm$).

I will present some visualization examples of geometrical contextuality proofs, such as the 3D representation of Mermin's magic pentagram as a Boolean intersection of two epitahedra ($E\pm$) serving as spin simplices. Moreover I'll introduce my (otherwise still unknown) hypersphere model and approaches to extend the Bloch sphere for visualizing quantum states in higher dimensions – highlighting the importance of digital arts as a tool for quantum visualization.

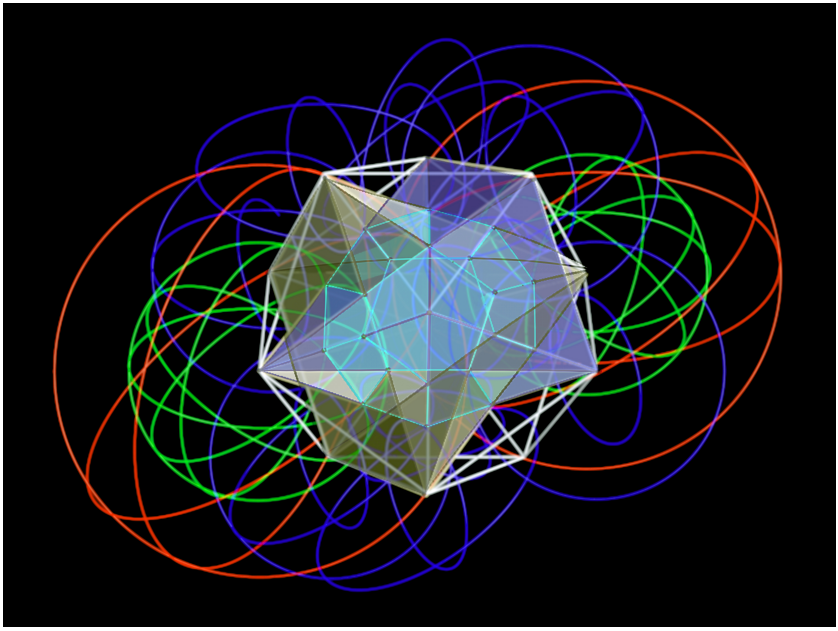


Figure 2.12: Two unit cells of 5-dimensional space c.f. spin-simplices, with circular decoration of the Penrose tiles in motion forming a dodecahedron; (image: Quantum Cinema 2012 © Renate Quehenberger, Bildrecht Vienna 2025)

Fundamental problems and possible approaches to teaching and learning quantum physics

Berit Bungum & Ellen K. Henriksen

Fascination and frustrations in learning quantum physics in schools and university

Berit Bungum

Quantum physics breaks fundamentally with classical physics and how we experience the world and thus brings fascination as well as frustration for learners. This talk presents empirical results on young students' challenges in learning basic aspects of quantum physics, including superposition, wave-particle duality and the role of measurements. We discuss how these challenges relate to philosophical stances and interpretations of quantum physics.

Approaches to quantum literacy in the age of quantum computing

Ellen K. Henriksen

The invisible and non-intuitive nature of quantum physics calls for different approaches to teaching than classical physics. Based on experiences from upper secondary physics education, we discuss the concept of 'quantum objects' and various forms of visualizations that may contribute to 'quantum literacy', which has increasing relevance in light of quantum computing technologies.

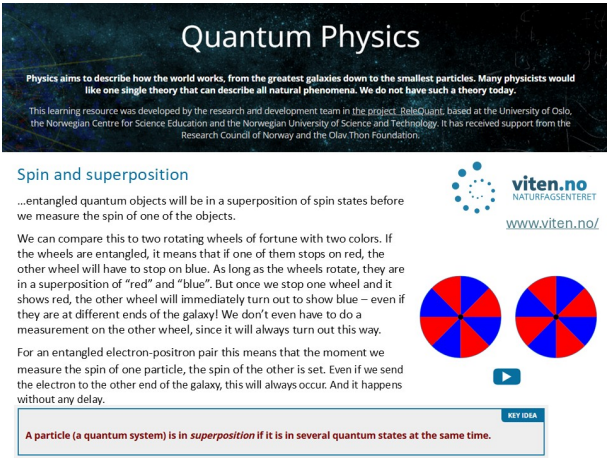


Figure 2.13: Excerpt from an online learning resource on www.viten.no, aimed at upper secondary physics students. Entangled quantum objects are compared with spinning wheels of fortune: If you stop one of them and it shows red, the other one will show blue.

Friday 5 December

Building for Quantum
Marina Otero Verzier

Building for Quantum is a film directed by Manuel Correa, Marina Otero, Manu Sancho, and Emil Olsen, recently featured in the official selection of the 2025 Venice Architecture Biennale. The film follows the construction of the Basque Quantum (BasQ) headquarters in Donostia, a facility that hosts one of the world's most powerful quantum computers. Through the making of this building, the film examines the imaginaries, political agendas, and aspirations surrounding the arrival of this transformative technology. As quantum computing begins to redefine the boundaries of knowledge, Building for Quantum explores how architecture is mobilized to materialize a new computational paradigm.

At the core of the project lies the Quantum System Two–the first modular quantum architecture–designed to enable the interconnection of multiple quantum computers into systems capable of addressing problems far beyond the reach of today's classical supercomputers. The film navigates the intersection of the physical and the philosophical within quantum architecture, juxtaposing the tangible materials of brick and mortar with the meticulous precision required to sustain near-perfect vacuum chambers at temperatures colder than deep space.

Delving into the daily challenges of constructing this architecture, Building for Quantum goes behind the scenes to reveal the manipulation of matter and the technological, human, and labor efforts involved. The film dwells in the tension between the raw realities of construction, the surgical precision of machine processes, and the digital simulations that emerge within its circuits.

Figure 2.14: Installation view of Building for Quantum, main exhibition, Arsenale, Venice Architecture Biennale 2025. Photo: José Hevia.

Quantum Computing: Human Interactions at Every Layer

Maria Emine Nylund & Benedikt Mithassel

Quantum computers won't change the world by themselves, people will. As quantum technologies move from theory to practice on real-world problems, expert knowledge remains a bottleneck to use it in various domains. The central question becomes: what human interactions shape the field? In this talk, we take a tour through the human side of quantum computing: from human-to-human communication about quantum problems, to algorithm design workflows, to interaction with quantum machines. Using an HCI lens, we highlight the importance of moving between different abstraction levels in both visualizations and interactions. We discuss how insights from classical computing, design, and examples of visualisations in classical and quantum sensors can inform usable quantum tools.

Our message is simple: HCI + QC = True.

Framework Fundamentality

Michael Cuffaro

I will argue that theoretical frameworks, understood as structured sets of conceptual and methodological commitments underpinning models and theories, can enter into philosophically significant relations of relative fundamentality with one another in a way that provides insight into scientific change. Using quantum theory as a case study, I will compare two theoretical frameworks: the standard framework (ST), which privileges closed systems and unitary dynamics, and a generalized framework (GT) that takes open systems and non-unitary dynamics as basic. I will introduce three different concepts of framework fundamentality—ontic, epistemic, and explanatory—and argue that GT is more fundamental than ST in each sense. I will then propose a multi-dimensional generalization of the concept of fundamentality for which the conceptual and methodological integration that theoretical frameworks enable is not an accidental feature but the mark of a scientific worldview, providing the basis for comparisons between frameworks, and reorienting debates about what counts as fundamental in science. Based on joint work with Stephan Hartmann.

Quantum physics in superhero movies - who got it right?

Vidar Skogvoll

Filmmakers often use quantum mechanics to justify the impossible powers of superheroes. These uses range from surprisingly accurate to scientifically absurd. My podcast, "Under Kappa," has analyzed over 60 of these heroes from a physics perspecitve. In this presentation, I will show the best and worst of Hollywood's quantum theory.

Lists of Contributors

The following is a list of speakers in alphabetical order.

Alberto Valverde	Open University of Catalonia (Spain)
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The following is a list of contributors to the display session.

David Young	“Q 12”
	“Q 192”
Eivind Hauge Omtveit	“Bohm Trajectories”
Jonas Carlsen	“Antiproton Decelerator”
Karol Życzkowski	“Notes on quantum maps”
Paul Thomas	“Quantum Conciousness”
	“Nano Essence”
Renate C.-Z.-Quehenberger	“Epita Dodecahedron”
Sølve Selstø	“Landau-Zener Landscapes”

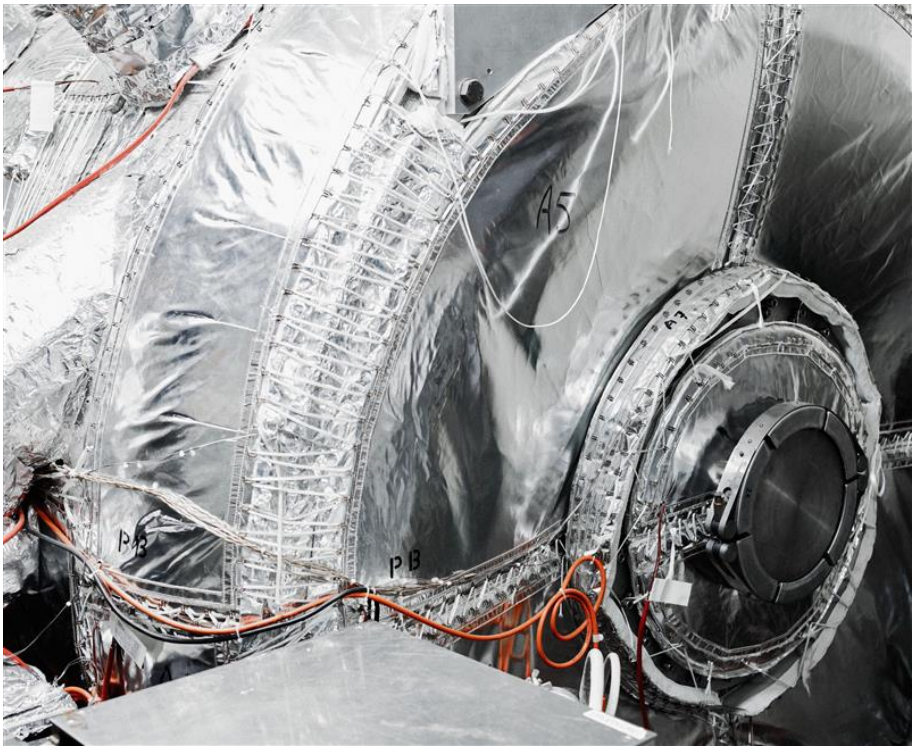

Figure 3.1: “Antiproton Decelerator” from Jonas Carlsen.

Notes