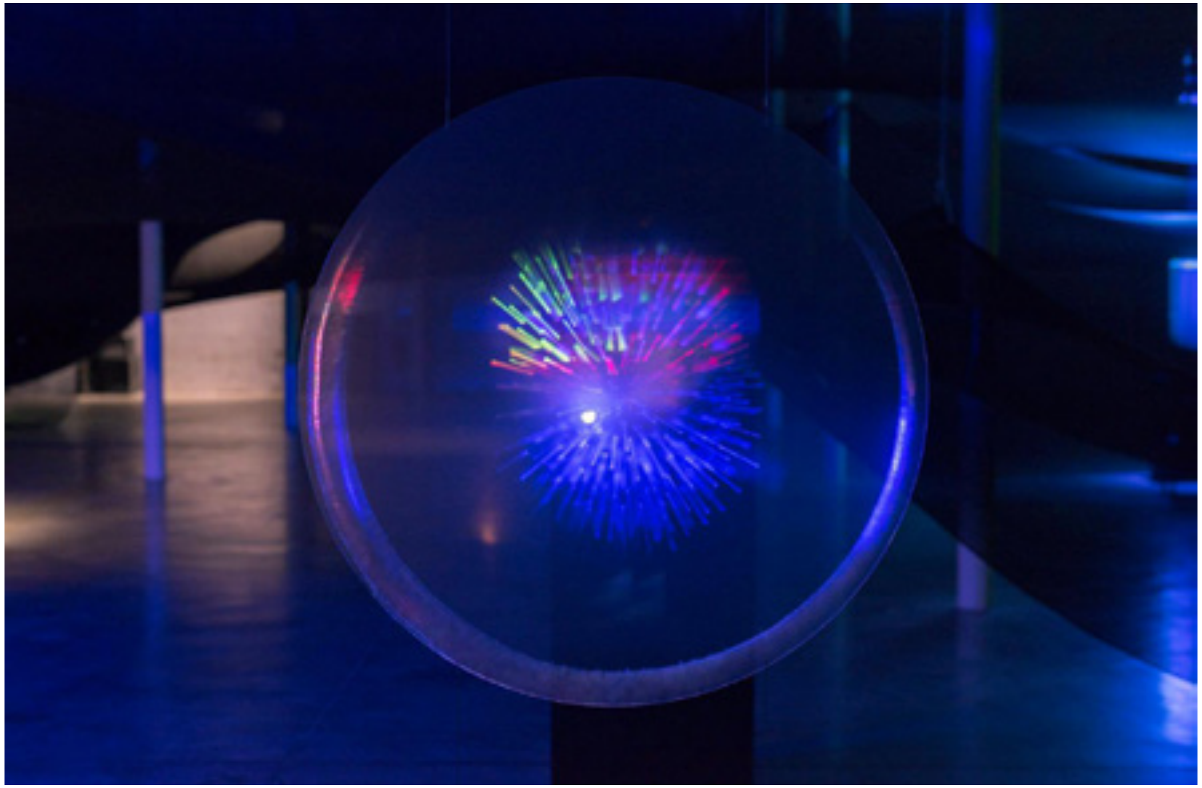
ION HOLE, EVELINA DOMNITCH & DMITRY GELFAND

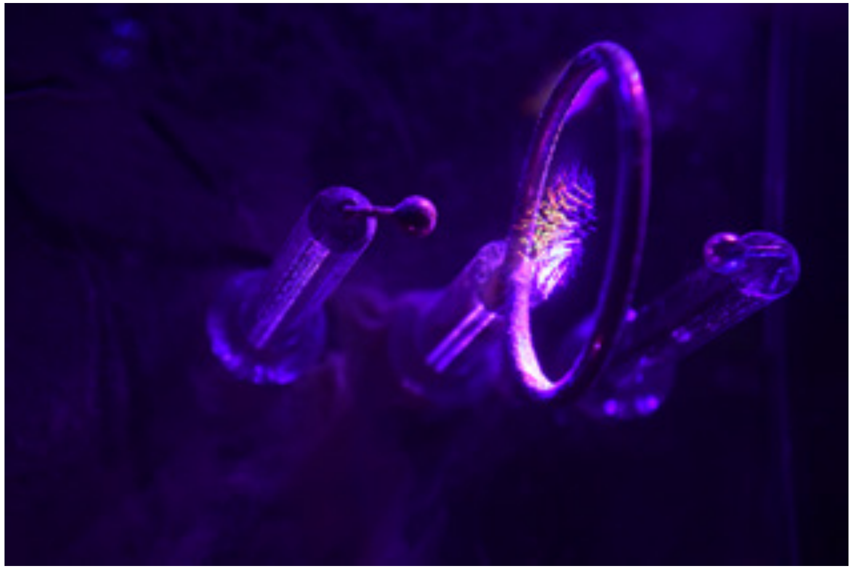
1/ THE *ION HOLE* INSTALLATION

2/ THE TECHNICAL SET UP - DISPOSITIF

1/ THE *ION HOLE* INSTALLATION



The circular screen showing an enlarged image of the oscillating lycopodium spores (installation at Le Lieu Unique, Nantes, 2016, image Martin Argyroglo for Le Lieu Unique)



Close up of the Paul trap with lycopodium spores (Image Dmitry Gelfand)

Ion Hole is an installation that shows to the naked eye extremely small particles that normally are not perceptible to our senses. By so doing, it echoes and reflects upon current research in quantum physics in which individual atoms are manipulated and even made visible.

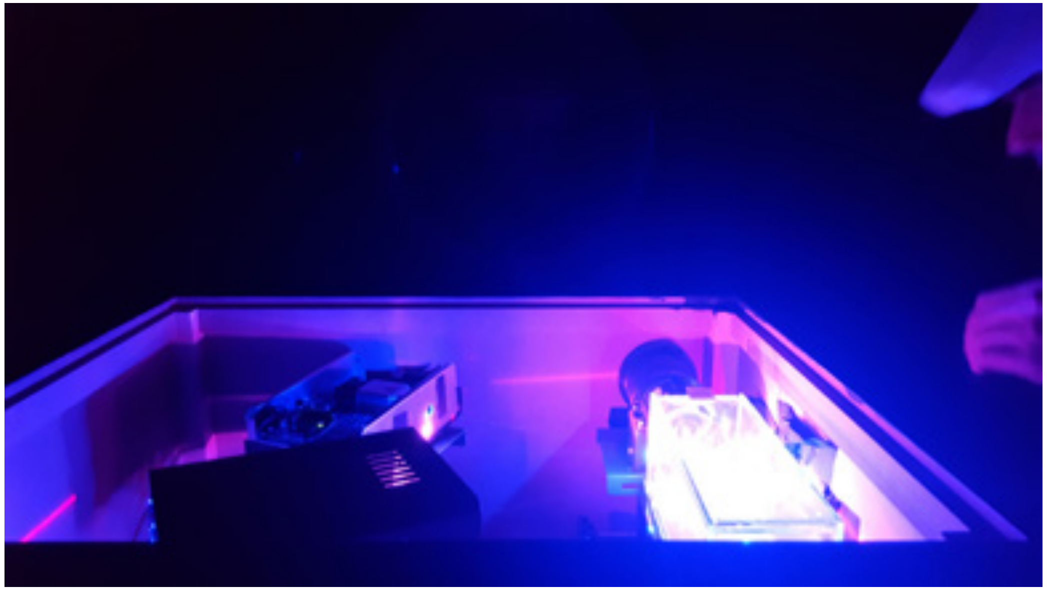
At the core of the installation is a scientific device called a «Paul trap» where lycopodium spores are captured by electric fields that cause the charged spores to oscillate. Lit by a laser light they become visible to the human eye and reveal the electric field.

The 2-centimeter ring at the center of the trap is blown up into a meter-sized optical projection onto a circular semi-transparent screen, hence symbolically connecting matter from its microscopic to its macroscopic cosmic scale.

THE TECHNICAL SET UP : DISPOSITIF OF *ION HOLE*

The elements composing *Ion Hole* are laid in a wooden box (72 x 60 x 37 cm).

On the right of the image, one can see a closed glass box (27 x 10 x 10 cm) hosting the Paul trap and the lycopodium spores when the work is activated. In the alignment of this box there is a projection lens that allows for the tiny device to be blown up onto a bigger screen (round screen or round projection on a regular screen).
On the left of the image, in the back, one can see the laser beaming its light onto the trap and the «captured» spores. On the left, in the front, is the voltage transformer.



Close up of the Paul trap in its glass chamber (27 x 10 x 10 cm) with the 2 cm ring electrode and two 1 mm sphere electrodes.

DISPOSITIF

The basis of *Ion Hole* is a scientific experiment that enables electrodynamic levitation.

Unlike the ion trap experiments in physics labs, this one does not involve a high vacuum at low temperatures – it takes place under normal atmospheric pressure. And instead of single atoms as are customarily trapped in quantum optics and quantum simulation research, the artwork levitates lycopodium moss spores, often used in fireworks, around 20 microns in size.

However, the principle, the techniques and the physics are the same and allow the audience to witness through their naked senses otherwise invisible particles and, as they oscillate, the electric field suspending them.

ION HOLE, EVELINA DOMNITCH & DMITRY GELFAND

1/ ART SCIENCE AND PHILOSOPHY

The Artistic and Intellectual Ground behind *Ion Hole* and Domnitch-Gelfand Creations

2/ BRINGING BACK THE SENSES

1/ ART SCIENCE AND PHILOSOPHY : THE ARTISTIC AND INTELLECTUAL GROUND BEHIND *ION HOLE* AND DOMNITCH-GELFAND CREATIONS

Ion Hole, like most of the works created by Domnitch and Gelfand, embeds a complex mesh of references.

Nourished by Malevich and suprematism, the ultimate goal of the artists is —no more, no less— to understand the fabric of the world that we are made of. In this quest, they fuse art, science and philosophy in installations and performances that carry scientific knowledge and experiments out of the labs and into the artistic visual and sound realms.

Based on cutting-edge scientific research, their philosophical and aesthetic choices for their creations are grounded in observation, perception and phenomenology, pushing the boundaries of what can be perceived from the invisible and the immaterial to reconsider matter.

Having dismissed the use of solid, fixed or recording media, their work is ephemeral, each time needing to be re-staged and exist as ever-transforming phenomena offered for observation. Dmitry Gelfand says "We abandoned solid state artistic practices in favour of directly experiencing the fluid and often weightless state of quantum physicality" (quoted by Giuseppe Saija in his article from January 26th 2017, http://www.youris.com/Society/Gallery/The-Shape-Of-The-Invisible.kl).

Reflecting upon their practice and more specifically their work with quantum physics, they write in their Leonardo article «Although our methods originate from the phenomenological crossroads of science and philosophy, our path has led to a purely non-verbal phenomenological art of observation, eventually stripped of both measurements and metaphors».

2/ BRINGING BACK THE SENSES

Dmitry Gelfand explains the duo's artistic approach and the challenge of dealing with the counterintuitive quantum world.

https://www.youtube.com/watch?time_continue=4&v=MuL_S6HfYKI

ION HOLE, EVELINA DOMNITCH & DMITRY GELFAND

1/ THE RESEARCH GOAL OF THE RYSQ CONSORTIUM

The goal of the research of RySQ explained by the scientist Robert Spreeuw, University of Amsterdam

https://www.youtube.com/watch?v=VMJ8R_6V5mE

2/ RYSQ, RYDBERG QUANTUM SIMULATORS : A QUANTUM PHYSICS FET OPEN PROJECT

From the RySQ documents
http://cordis.europa.eu/project/rcn/193719_en.html

QUANTUM SIMULATION
In modern times, quantum technologies, that translate unique properties of quantum mechanics into practical applications, play a crucial role in pushing forward the development of our society. The key aspect in realizing new quantum technologies is to understand the underlying fundamental physics of quantum mechanics through various models. This task becomes difficult at the current study of interacting many-body systems due to the lack of methods: analytical models are very rare at this level and all numerical methods running on conventional computers have their own drawbacks. The essential reason is that the resource needed for a classical method to simulate a quantum system/process increases exponentially with the number of the components.

It is possible to overcome this difficulty using quantum simulation, i.e. applying some controllable quantum systems to mimic the dynamics of the to-be-studied models.
This process is called quantum simulation and the controllable quantum systems are called quantum simulators (QS).

[...]
The main objective of the RYSQ project is to use Rydberg atoms for quantum simulations because their outstanding versatility will allow to perform a great variety of useful quantum simulations, by exploiting different aspects of the same experimental and theoretical tools. By implementing not only one but a whole family of Rydberg Quantum Simulators, the project will address both the coherent and incoherent dissipative dynamics of many-body quantum systems.
[...]
The long-term technological vision of QS is twofold: on the one hand, to create computational

devices that can be used for the exploration of otherwise unsolvable scientific questions, some of which possibly yet to be asked; and on the other hand to exploit the answers thus obtained in order to build technologies, beyond information and communication technologies (ICT), that can address societal challenges of global significance like energy production and transport.

Ultra-cold atoms and trapped ions are two appealing candidates for the physical realization of QS owing to their controllability over large number of interacting particles and strong interactions, respectively. RySQ offer the stimulating possibility of combining both advantages, by manipulating large numbers of strongly interacting particles (ultra-cold atoms excited to Rydberg levels), such that the thermal fluctuations originating from the non-zero temperature of atoms can be effectively neglected.

3/ PAUL TRAP

A Paul trap is an electrodynamic ion trap – named after Wolfgang Paul, the Nobel Prize winning scientist who invented it – that allowed scientists for the first time to observe isolated atoms – a new stage in the understanding of quantum physics, which until the invention of such tools could only be theorised or understood.

Among the ongoing philosophical problems in theoretical physics is the inability to describe a quantum system in terms of classical physics. The only way to precisely understand and manipulate quantum phenomena is on their own terms: by means of a quantum simulator - a rapidly evolving methodology initially proposed by Richard Feynman in 1981. Nearly a decade later, in 1989, Wolfgang Paul was awarded the Nobel Prize for having invented the electrodynamic quadrupole ion trap, which enabled physicists to observe for the first time the quantum nature of an individual atom. Finally, instead of measurements comprising averaged statistical values of large ensembles of atoms, an isolated singular atom could be directly probed.

The former approach was based on the classical assumption that all atoms behave in exactly the same way as an average of their statistical behavior. The Paul trap proceeded to become an ideal environment for quantum simulation. Furthermore, the trap's ability to address individual atoms opened a tangible route towards quantum computation: designing logic gates not with bulk matter but rather with discrete properties, such as a single atom's spin, to perform logic operations at unfathomable speeds. The Paul trap has also become a valuable tool in numerous domains besides experimental physics, including chemical analysis, atmospheric science, and aerobiology.

FEAT
A JOURNEY THROUGH ART SCIENCE PROJECTS

ION HOLE, EVELINA DOMNITCH & DMITRY GELFAND

1/ FROM THE RESIDENCY: BUILDING THE ION TRAP, KNOWLEDGE AND CONVERSATIONS

(Compiled from Evelina Domnitch & Dmitry Gelfand's report)

APRIL 2016

After the match-making process between the artists and the scientists that took place in Amsterdam, Domnitch and Gelfand went to the Johannes Gutenberg University in Mainz, part of the RySQ consortium, where they met with quantum pioneer, Ferdinand Schmidt-Kaler. Under his guidance, they constructed what is known as a Paul trap - an electrodynamic ion trap named after Wolfgang Paul, who won the 1989 Nobel Prize in physics for this invention.

Afterwards in their studio in Amsterdam, in order to magnify the subtle micro-motion of trapped particles, they started developing a purely optical (non-digital) laser projection system.

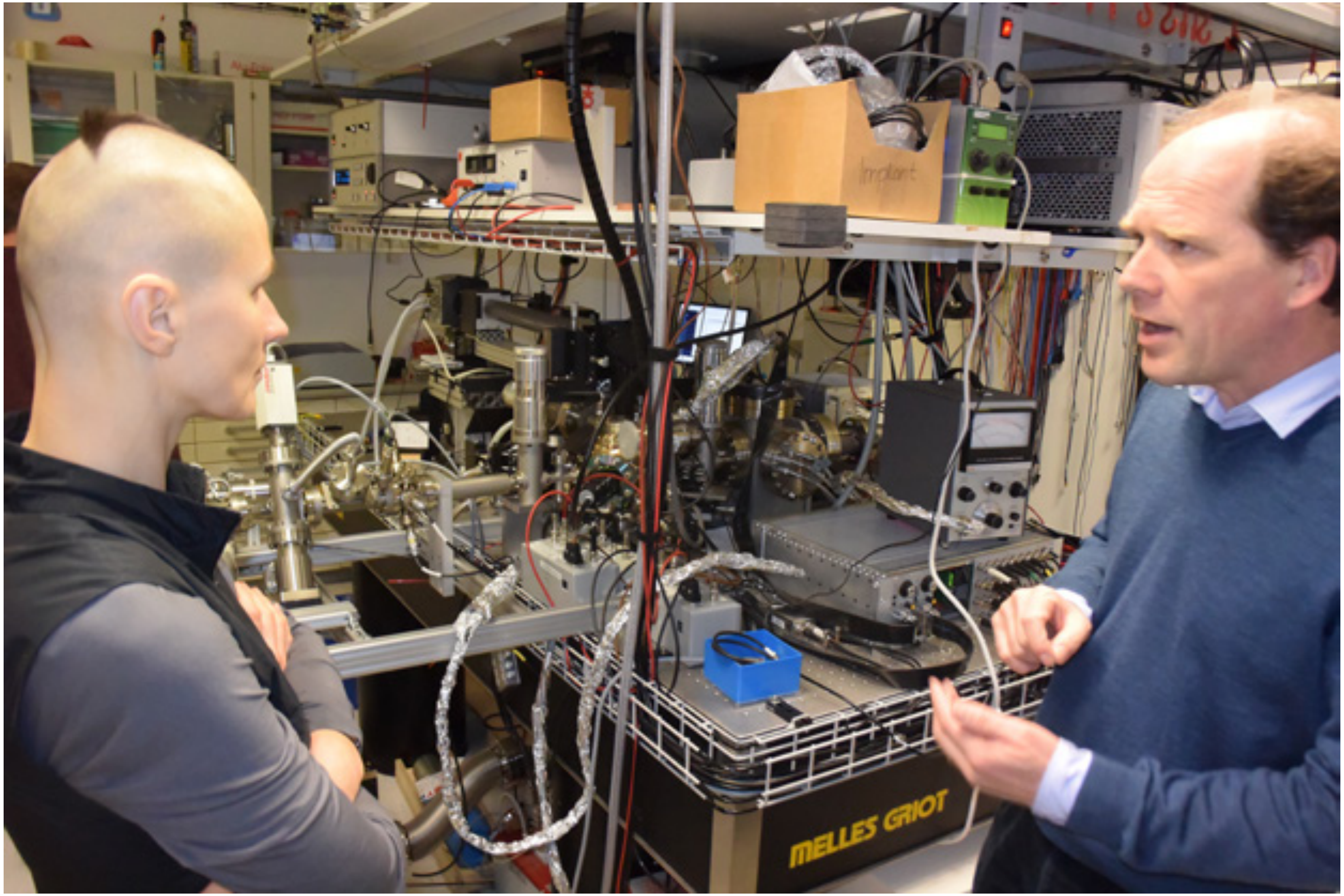
JULY 2016

After Mainz, Domnitch and Gelfand went to Ulm. At the Institute for Complex Quantum Systems of Ulm University they collaborated with the director of RySQ, theorist Tommaso Calarco, as well as with Ferdinand Schmidt-Kaler. On this occasion, they constructed a 30-centimeter long linear ion trap, which gives rise to completely different modes of particle behavior. Moving along square-shaped orbits that had never before been reported in quantum optics literature, hollow glass microspheres hovered back and forth through the trap. This would lead to another artwork *Quantum Lattice*.

Shortly afterward, they visited the lab of Robert Loew who researches quantum entangled Rydberg gases at the Physics Institute of Stuttgart University.

AUGUST 2016

In August, they participated in the midterm FET meeting of the RysQ consortium in Ercolano, Italy which led to multiple invitations: from Philippe Grangier, Director of Research at the Charles Fabry Laboratory of the Institute of Optics, CNRS; from theoretical physicist, Juan P. Garrahan, to visit the RysQ group at the University Nottingham, and from Matthias Weidemüller, Dean of the Department of Physics and Astronomy at the University of Heidelberg.

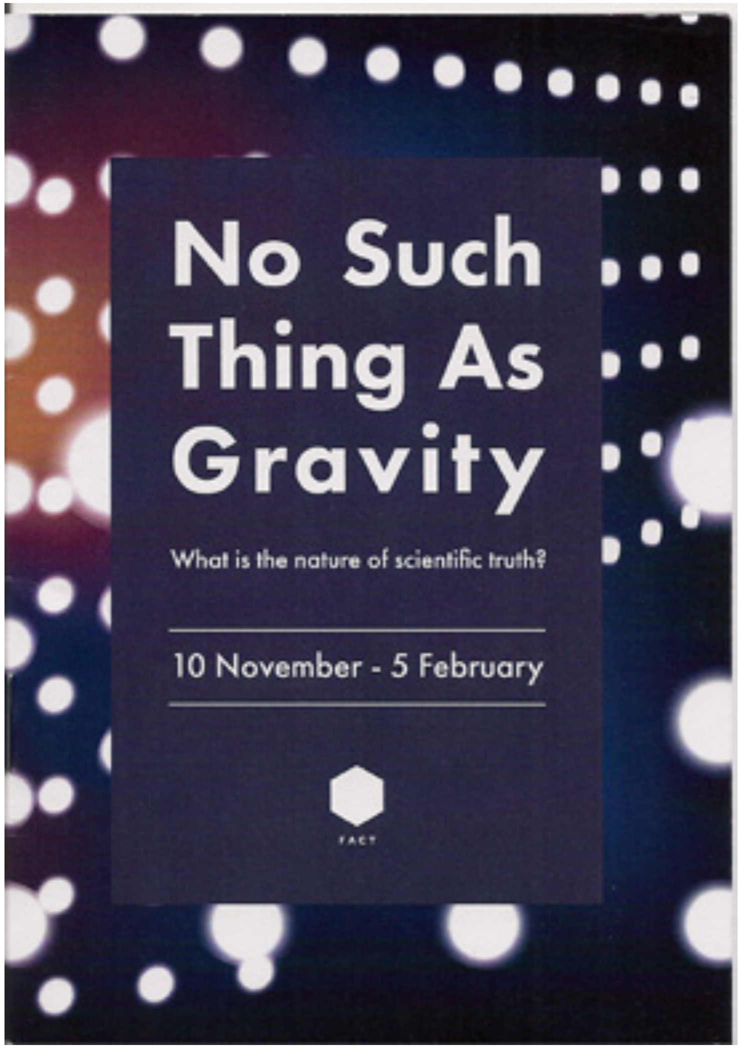


Evelina Domnitch and Ferdinand Schmidt-Kaler, head of the Cold Ions and Experimental Quantum Information Processing group at Mainz University.
Ferdinand Schmidt-Kaler helped Domnitch and Gelfand build the two prototypes that would lead to the artworks *Ion Hole* and *Quantum Lattice*.
Photo: Dmitry Gelfand

OCTOBER 2016

Dmitry Gelfand visited the quantum optics lab of Philippe Grangier, where he was shown among the world's most advanced spatial light modulators an instrument which holographically traps individual atoms within a grid.

The artwork *Ion Hole* is premiered at the personal exhibition of the artists «Le vide et la lumière» at Le Lieu Unique in Nantes, France which took place from Octobre 21st 2016 to January 8th 2017.



NOVEMBER 2016

In November, the artists travelled to the University of Nottingham, where they visited several quantum optics and fluid dynamics labs, and gave a talk about their FEAT collaboration for the Department of Physics and Astronomy. Proposals for future collaborations were discussed.

The second artwork *Quantum Lattice* that they have created thanks to the FEAT residency is premiered at the exhibition «No such thing as Gravity» at FACT Liverpool, UK, from November 10th to February 5th.

FEAT
A JOURNEY THROUGH ART SCIENCE PROJECTS

2/ SLICES OF REALITY: *ION TRAP & QUANTUM LATTICE*

Conversation between Evelina Domnitch, Dmitry Gelfand and Annick Bureaud (podcast)

https://creativedisturbance.org/podcast/slices-of-reality-ion-trap-quantum-lattice-meeting-with-evelina-domnitch-and-dmitry-gelfand-eng/

3/ EXPERIENCING THE TANGIBILITY OF A SINGLE ATOM

Conversation between Tommaso Calarco and Annick Bureaud (podcast)

Quantum physicist Tommaso Calarco discusses his relation to contemporary art and shares his experience of collaborating with the artist duo Evelina Domnitch and Dmitry Gelfand

https://creativedisturbance.org/podcast/experiencing-the-tangibility-of-a-single-atom-meeting-with-tommaso-calarco/

3/ « TRAPPING THE OBJECTLESS »

Leonardo Article about the project

« Trapping the Objectless », Evelina Domnitch, Dmitry Gelfand, Tommaso Calarco, *Leonardo*, MIT Press

Through the epistemological lenses of quantum theory and phenomenological art, the authors describe their collaborative development of several artworks exploring electrodynamic levitation. Comprising diverse ion traps that enable naked-eye observation of charged matter interactions, these artworks question the murky boundaries of perceptibility and objectification.

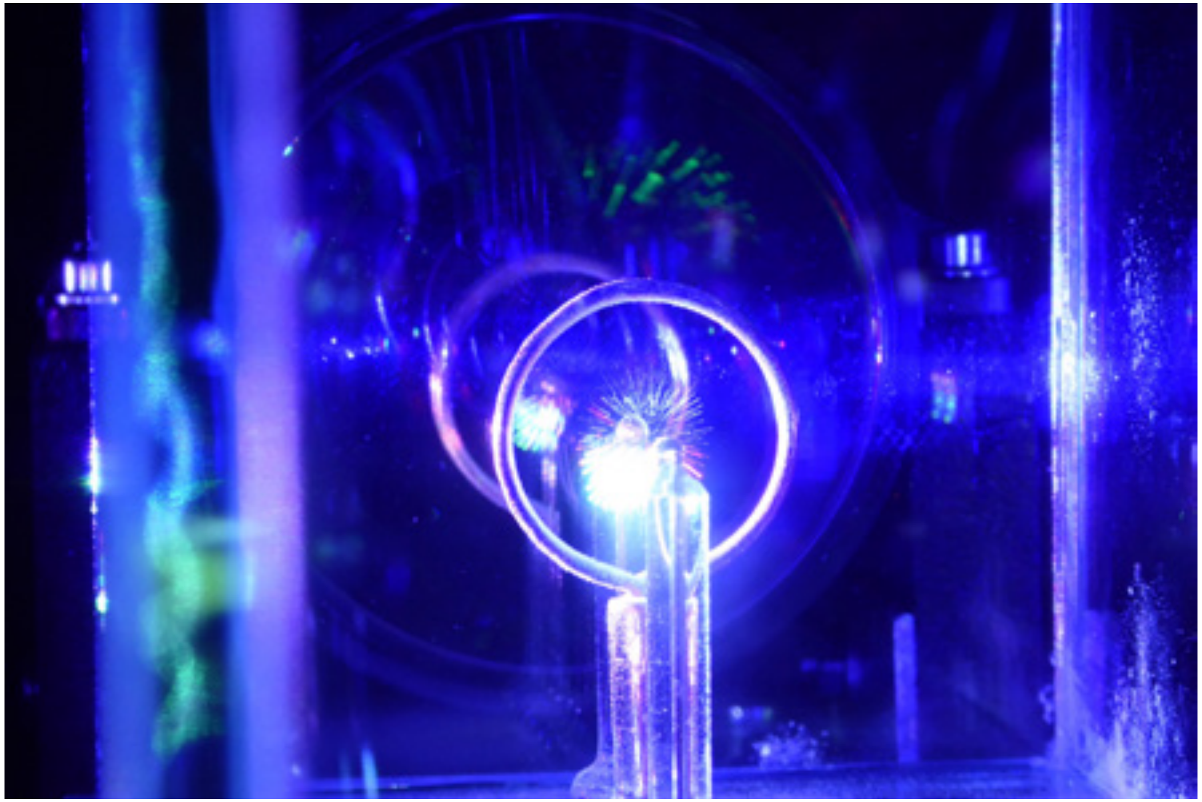
http://olats.org/feat/Domnitch-Gelfandeon_a_01465.pdf

ION HOLE,
EVELINA DOMNITCH & DMITRY GELFAND

ION HOLE, **MATTER BETWEEN WONDER AND SEDUCTION**

by Annick Bureaud

ION HOLE, MATTER BETWEEN WONDER AND SEDUCTION



Ion Hole, Evelina Domnitch & Dmitry Gelfand, 2016. Image Annick Bureaud

In a dark room, suspended in mid-air, as if floating in weightlessness, is a circle of pulsating, colourful light particles that look like the grande finale of a firework or the burst of a star from a distant galaxy (but isn't it the same?).

The projection is coming from a nearby box which hosts an even more fabulous and mesmerizing dispositif: a device, that we learn later is a Paul trap, looking like a jewel designed for an unknown alien creature, is maintaining in its ring tiny particules that are sparkling and vibrating like rare precious stonepowder in an explosion of joy and vitality

In between magic, fairy tale, cosmic dimension and fundamental physics, it is seing the infinitely small, the universe contained in nothingness.

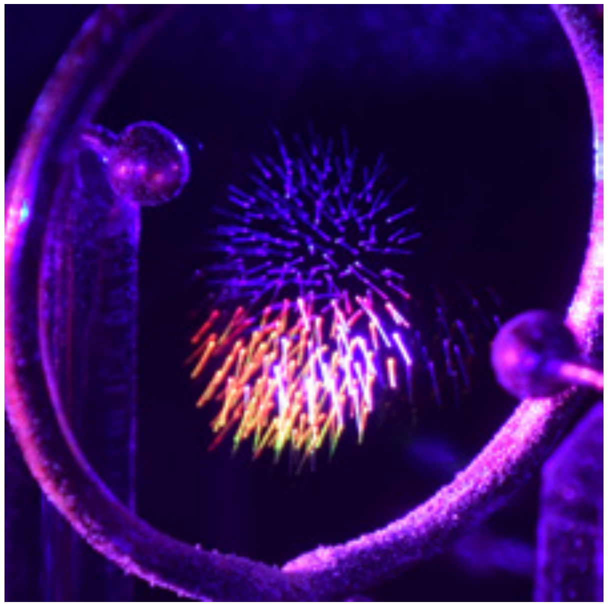
Ion Hole is a highly seductive light installation which is not based on understanding but on wonder. In this respect, it relates to an art-science approach and philosophy defined and promoted by The Exploratorium in San Francisco: attracting people to science through direct experiment and wonder. The hence triggered curiosity will lead then to research, to a quest for understanding; the artworks being «experiments among experiments».

How to make quantum physics «approachable» when the minute you pronounce the term the flag «too-difficult-for-me» raises? How to make «concrete» something which is considered intensely «abstract»?
With *Ion Hole*, the answer of Evelina Domnitch and Dmitry Gelfand is by building upon the paradox. When quantum physics deals with matter but at an (almost) unperceptible level, the artwork shows totally observable phenomena but in a work that is (almost) objectless. Ion Hole, like many of the other artworks created by the duo, plays with this dialectic between tangibility and objectless, between cognition and emotion.

Nowadays, art being «scientific illustration» is dismissed. Although we praise it when it comes from the past, it has almost become an insult for contemporary creation in favour of a «critical approach» to science. Beyond the fact that this puts aside the whole blossoming field of visualisation and sonification and consider «science» as an undistinct global whole, I argue that this is a misunderstanding of what «illustration» really means. «Illustration» does not equal slick «image» or «drawing» or «charts». It is the action to put in relation something with something in a sensitive order that is then presented as a realisation in another form, it is the realisation in the sensitive order of something*. In other words, it is bringing something to the perception, to the senses. And this is exactly what Ion Hole does.

Ion Hole is an artwork as scientific illustration at its best. It is a scientific experiment that has ceased to be one by the very act of having been brought out of the lab. By having no other goal but proposing itself to a direct observation/perception as opposed to (digital) measures and processes *Ion Hole* is a scientific experiment that has become an art experience.

Annick Bureaud, October 2017



Ion Hole, Evelina Domnitch & Dmitry Gelfand, 2016.
Image Lucas Evers


Image Anastasia Domnitch

THE ARTISTS

Evelina Domnitch and Dmitry Gelfand create sensory immersion environments that merge physics, chemistry and computer science with uncanny philosophical practices.

Resource : www.portablepalace.com

CREDITS

«Ion Hole» has been created by Evelina Domnitch and Dmitry Gelfand
in collaboration with Ferdinand Schmidt-Kaler and Tommaso Calarco ;
Cold Ions and Experimental Quantum Information Group, Johannes Gutenburg University, Mainz,
and Institute for Complex Quantum Systems, University of Ulm
https://www.quantenbit.physik.uni-mainz.de/
https://www.uni-ulm.de/nawi/institut-fuer-komplexe-quantensysteme/mitarbeiter/prof-dr-tommaso-calarco/
RySQ: http://cordis.europa.eu/project/rcn/193719_en.html

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