QUANTUM

THE BLACK CUBE ISSUE 01

and the

MOVING IMAGE

Dialogues at the Intersection of Artistic and Scientific Research

Quantum and the Moving Image

The Black Cube™
Editors in Chief **Giulia Yoko Galbarini, Carlo Rizzo**

The Black Cube explores how moving images are conceived, produced and experienced — through the lens of technology.

Each issue features a curated selection of extraordinary voices at the frontline of creative and technological progress, sharing insights into their process and the wider resonance of their practice.

No high-tech vs low-tech hierarchies. No fear. No hype. We unpack the thorniest debates about technology, creativity, and the space in between — and look with curiosity and a sense of wonder at what we can create with the tools at our disposal.

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Issue 01, Autumn 2025

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The collection of exclusive interviews in this publication, co-edited with Eva Fischer, mark the first issue of *The Black Cube*. Recorded between October and December 2025, in the last months of the International Year of Quantum, the conversations explore the intersection of scientific and moving-image research and the impact of the emergence of a new Quantum culture on time-based media.

All texts in this issue are transcripts of live, recorded conversations, initially produced as part of a live podcast studio hosted by *The Black Cube* during the opening weekend of the *Contemporary Immersive and Virtual Art (Civa)* Festival at *Belvedere 21*, Vienna, on 4 October 2025. The selection of contributors draws from the festival programme, which was co-curated by Eva Fischer and Ana Prendes. The choice of topics and areas of focus for the interviews is the result of a longstanding collaboration between *Fondazione CinemaO* (owner of The Black Cube) and Eva Fischer.

All interviews were hosted by Giulia Yoko Galbarini and Carlo Rizzo, editors in chief of *The Black Cube*. AI assistants have been used solely for generating transcripts and proofreading the final edits.

We wish to give a special thanks to all the contributors who have generously shared their time and insights. Much gratitude also to Lisa Janka and *NTRP Design* for recording the Podcast sessions, and the team at *Belvedere21* and especially Anna Ewa Dyrko and Daniel Wallner for hosting the opening programme of the festival and all the screenings. Also thanks to Marlene Kager for the print design of this publication. Many thanks to the *Federal Ministry of Housing, Arts, Culture, Media and Sport* (*BMWKMS*) *Austria* for supporting Issue 01 of *The Black Cube* and the collaboration with Eva Fischer that brought it to life, and to the *Austrian Cultural Forum Milan* for supporting the launch of the publication at *Fondazione CinemaO* in Milan.

Finally, we are grateful to Ana Prendes (*Arts at CERN*) and Claudia Reinprecht (tech diplomacy, *BMEIA*) for their advice and support.

This first issue of *The Black Cube* emerges from selected conversations that took place during the 2025 edition of Civa |indeterminate×apparatus| at Belvedere 21 in Vienna, focusing on the quantum realm. It is a deeply fascinating subject that resists easy comprehension and demands sustained engagement. Yet it is precisely this complexity that constitutes its allure. Curiosity becomes a driving force: a shared impulse that brings together a wide range of voices, from established experts to those at the beginning of their journeys, in order to think, question, and learn collectively. This spirit of exchange lies at the core of Civa and continues to energise this publication as well.

At the centre of this inquiry are the possibilities that quantum-based knowledge frameworks open for the moving image. At the same time, the critical questions arising from quantum theory and quantum technologies increasingly move beyond the confines of the laboratory, entering broader cultural, artistic, and political discourse. What emerges is not only a shift in scientific processes, but a reconfiguration of how reality itself can be perceived, represented, and narrated.

A vivid example of this exploration is the series of screenings curated by Ana Prendes and myself. The programme unfolded across multiple registers, ranging from abstract animation to documentary forms, speculative narratives, and AI-driven works. It reflected the diversity of approaches through which quantum concepts are translated into aesthetic and experiential formats. This trajectory continued in further events, such as the presentation of *Brute Force* by Felix Lenz, Ganaël Dumreicher, and their team – a work that is both visually compelling and critically incisive. Drawing on theoretical perspectives including those of Karen Barad or Rosi Braidotti, and situating its inquiry within sites such as Silicon Valley, the film foregrounds the infrastructures and power relations that underpin technological development, reminding us to look beyond the visible surface. Bringing these elements together means moving beyond an affirmative fascination with technological innovation towards maintaining a critical and reflective stance. The quantum paradigm itself challenges stable distinctions: between

Eva Fischer is a festival director, curator and lecturer in the field of post-digital art, artistic research and art & technology. Her practice focuses on creating platforms for interdisciplinary exchange, connecting artistic production with technological and societal developments through festivals, exhibitions and educational formats.

use the visual guide on the right side of the page for jumping faster between links

subject and object, observer and observed, human and non-human. In this context, indeterminacy is not simply a limit of knowledge, but a constitutive condition of reality. It opens a space in which multiple states, perspectives, and temporalities can coexist, shifting the logic from either/or to both/and. Such a perspective resonates strongly with artistic practices that engage with ambiguity, multiplicity, and transformation.

At the same time, this also entails a reconsideration of how knowledge is produced. "The observer, the observed, the apparatus, and the surrounding conditions" [23], cannot be understood as separate entities; rather, they are entangled and *intra-acting*, as Barad puts it. What can be seen, measured, and known is always shaped by specific material, cultural, and political configurations. To engage with quantum thinking, therefore, also means to reflect on the conditions and infrastructures through which knowledge emerges, and on the power dynamics that continue to shape these processes.

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page 23 [Ana Pendres]
"Worldviews"

The coming together of artistic and scientific research within this context proves particularly valuable. The distinct modes of knowledge production enter into a productive dialogue that often yields unexpected insights and new forms of understanding. It is within this intersection that *Civa* and consequently the first issue of *The Black Cube* find their specificity: as a space where different worldviews can encounter one another without collapsing into a single narrative.

I hope that this community of diverse and inspiring minds will continue to meet, exchange, and evolve. Connecting with people who share this dedication is what truly drove Ana Prendes, Carlo Rizzo, Giulia Yoko Galbarini and me in our collaborative processes. These exchanges and relations are well represented in the conversations in this book, intentionally arranged in a non-linear manner, allowing for unexpected links and pathways to emerge. Readers are invited to navigate these intersections, to follow their own trajectories, and to engage with the questions that arise along the way.

Read this issue like you would play hopscotch.

Because knowledge,
memory,
and
intuition
are never linear.

“y yo te siento temblar contra mí como una luna en el agua.”

Julio Cortazar, Rayuela, 1963

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PART 1

Ana Prendes is a curator and writer exploring how artistic practices critically engage with technoscientific culture. Her work connects art, science and research contexts through exhibitions, collaborations and institutional programmes. She focuses on knowledge production, interdisciplinary exchange and the cultural implications of emerging technologies.

W⁰rldviews

Ana Prendes

You co-curated the film programme for the 2025 Civa Festival. Is there a common thread connecting all these films, a dialogue that feels urgent?

When we were planning the festival and the film programme, we wanted to explore how a quantum worldview might manifest through moving image. As the physicists I work with at CERN remind us, the world has always been quantum — it's been around 100 years since we first began to understand its implications. Since the 1920s, when the fundamental principles of quantum mechanics were first introduced, artists have been trying to make sense of its counterintuitive concepts and radical new views of reality.

In the last five to ten years, with what they call the "quantum decade" — marked by the increasing public and private investment in quantum research and technologies — these ideas are entering culture through many different entry points: narratives, images, and of course moving images.

With the film programme, there are many threads we can open up. The first film that came to mind is by Jordan Belson, an American experimental filmmaker from San Francisco who developed early experiments combining abstract film with electronic music. Belson didn't address quantum physics directly, but his work connects beautifully with our discussion. His film Allures (1961) features an abstract visual language of circles and spirals bursting between dark and light backgrounds, evoking something between the atomic and the cosmological. It plays with perception and consciousness through the passage from micro to the macro. And Belson himself described the film as a journey from matter to spirit.

When we think of a quantum worldview, his unique visual language renders perception as a subjective encounter with reality. This connects to how, in quantum measurement, what we observe is never separable from the conditions of observation: the observer, the observed, the apparatus, and the surrounding conditions all participate in what becomes. I am very struck by his cinematic language, and Allures became the entry point that opens up many new threads in the programme. [81]

One thread that runs through many of the films you selected is indeterminacy, and a desire to look beneath the surface of how reality is made and constructed. It was enlightening to see how some films, like Allures, were playful, while others were intentionally disturbing. When artists explore topics like quantum, time, and matter, how do they contribute to the wider discourse that you witness at CERN and in the wider scientific community?

Quantum physics touches on fundamental notions of time, space, and our understanding of reality. Artists are exploring what it means to make and construct scientific knowledge, along with the infrastructures surrounding it. They are interested in the dynamics, and communities that develop this knowledge and drive toward understanding the fundamental nature of matter. The Laboratory began in the post-war period, during the 1950s. James Lee Byars, an American performance and conceptual artist, was the first artist to visit it, getting involved in the 1970s through a network of connections. At that time, CERN was in a period of significant expansion, building new accelerators. And then there are photographic archives of Lee Byars wearing an all-white suit, long hair, and a Panama Jack hat — a pretty unusual figure in that harsh space. He was deeply interested in understanding the people working there. One person he talked to was John Bell, a physicist known for his theorem that proved that reality is not local: no local hidden variable theory can reproduce all the predictions of quantum mechanics. This means that entangled particles can share correlated properties regardless of the distance between them. This has since become foundational to many quantum technologies, including quantum computing.

Spanning speculative fiction, documentary, non-narrative abstraction, and video essays, the artists included in the Civa programme all examine the sociotechnical imaginaries surrounding quantum phenomena. For example, Blanca Pujals, an architect and filmmaker from Spain, studies how massive underground intergovernmental laboratories influence knowledge construction. In her film Quantum Sensing Infrastructures. Deep Underground Architectures for Spectral Matter, she traces a journey from CERN's underground Large Hadron Collider experiments, scientific bases in Antarctica, and the Canfranc Underground laboratory, a neutrino experiment in the Pyrenees. Interconnected systems of material and technological

infrastructures, people, data, wires. They can seem abstract, hidden, or otherworldly, but science is rooted in the materiality and community that built this knowledge, in deep underground realms which extend territorial governance.

Similarly, we feature the film Building for Quantum by Colombian filmmaker Manuel Correa and Spanish architect Marina Otero: a beautiful experimental documentary that follows the construction of the building that will host the first IBM quantum computer in San Sebastián, northern Spain. The film juxtaposes scientists trying to explain quantum phenomena. One physicist, in particular, struggles to find a metaphor for how a quantum computer works, searching for the right words. This is telling from a curatorial perspective. We still lack the language to describe these concepts, and I wonder whether we will be able to capture their abstraction and counterintuitive nature. Perhaps that is precisely what makes them so generative for artists: abstraction resists resolution, and art can sit with that irresolution in ways that other forms of knowledge cannot. At the same time, the film highlights that quantum computing, a technology with the potential to revolutionise healthcare, finance, and many other fields, first requires a physical building to maintain the extreme conditions under which it operates. This means bricks and mortar, human labour. Many of these workers are immigrants, and the film brings this into view: the architectural, material, and human dimensions of a technology whose development usually remains hidden beneath the high-tech narrative.

Imaginary Time

Some films jump across formats, perspectives, and time. Jia Zhangke's *Caught by the Tides* used footage from his previous movies to create a collage covering 23 years of Chinese history. Past and present coexist, but their meaning changes. Coming from CERN, you witness research

that unfolds over decades. How do you think about time in your curatorial work?

Working in a physics laboratory changed my thinking about time and how I engage with it.

Artists like Black Quantum Futurism have a remarkable practice in which they tap into the time-symmetry in quantum physics — the fact that its fundamental equations do not privilege a direction of time — and find parallels with the understanding of time in Black Afrodiasporic traditions, which are similarly non-linear. In the Western world, and even in our own biology, we experience time as directional, and that arrow of time affects how we live our daily lives.

What I found so enriching about working at CERN is the exposure to other ways of thinking of time together. I remember being with Rasheedah Phillips, one of the members of the Black Quantum Futurism collective, three or four years ago, during their residency. We sat down with Dorota Grabowska, a theoretical physicist working with quantum field theory. She was explaining her work while writing an equation on the blackboard that included the concept of imaginary time, represented by a T with a superscript i. I recall Rasheedah asking her how she might bring her own thinking into that concept. For the physicist, it was simply an elegant naming of a mathematical tool; she wasn't quite able to articulate what it would entail for our experience of our physical reality. I found that moment beautiful because it revealed a contradictory position at the heart of her own practice: a physicist who works with abstract equations in which time has no fixed direction, yet, who like the rest of us, can only experience it moving one way. The arrow of time remains one of the fundamental open questions in physics.

Going back to your question, my practice has been enriched by how broad our understandings of time actually are, and how they tap into many different levels of reality. This, of course, connects to different understandings of time in moving images, in performance, and even when we work quickly to put together a festival and an exhibition. It is very refreshing and inspiring to think of how we could also escape the very linear arrow of time that we have to live in.

→ (149) [Ana Pendres]
"Quantum P°p" *in* PART 2

Ivona Brandić is a researcher in high performance computing focusing on cloud computing, edge intelligence and hybrid quantum-classical systems. Her work addresses sustainable and adaptive resource management, with an emphasis on green AI and computational approaches to environmental challenges.

Building Intuition

Ivona Brandic

How can we understand quantum computing, in the real world?

I was somehow relieved after watching Manuel Correa and Marina Otero's film *Building for Quantum*. There were experts, physicists, trying to explain quantum computing, and they really needed time to find the words to explain it. Just to understand that such a complex topic is so difficult to communicate, even for experts in the field who have not focused on anything else. To find the right level of abstraction, the right way to explain it — it shows the whole complexity of this topic. 47

When Marina said that the reaction of the scientists from the Basque Center, when she showed them the film, was just: puzzlement — I also understood the impact. The film left many questions open. And for me, quantum computing is also opening a lot of questions.

One of the most important ones is how to communicate about a topic that is so counterintuitive. Every scientist tries to find examples: I myself use molecules. And I need to say that I have never found two scientists who used the same example to explain it – depending on where we come from as scientists, we each try to find our own intuition to explain concepts. This shows the complexity, but also the power of quantum computing. Because it is so different to what we are used to, it is so disruptive. It has the power to change how we deal with computation and also how our society works.

Our modes of knowledge-making have been shaped by scientific determinism, the classical Enlightenment sciences, and their continuities over the past 300 years. These frameworks have played a significant role in forming our capacity for intuition. I'm wondering whether you think that

the more quantum computing enters into reality, the more normalised it becomes to think in terms of superposition, indeterminacy, and entanglement — does this have the potential to change the very structure of our intuition?

I think it has the potential. The more this technology reaches a broad audience, the more people pick it up. We have the Science Night in Vienna now, where scientists are creating a kind of exhibition for a broad audience, trying to explain their topics.

We also have a team in my university, a department called EduLab, that helps us build demonstrations for a wider audience. You have to find the right way, and you have to find an entertaining way. We work with haptic approaches, develop games, and use different ideas to make STEM topics approachable and interesting.

You have to engage kids from a young age, to spark questions so that they develop an interest in topics that are ultimately interesting. But you can scare them off as well. I also see the role of education, and of art, in sparking this interest in doing something with their mind, so they are inspired instead of scared away.

And this is also the level or mechanism where we can evolve our intuition. I don't think it's something static. Our intuition today is different from the intuition of the Middle Ages, when people believed in witches. Now we can explain many things happening around us through the laws of nature. And this also influences our intuition. 43

When I'm making decisions — it's always intuition. How do you choose your partner? Sure, there are some criteria, but still it's your gut feeling, things that I at least cannot explain as a scientist. And I think you need this if you want to perceive science in a way that, for example, makes STEM topics attractive — how to attract people and not scare them off, especially if they are in disadvantaged environments.

If they don't have parents who can show them things in an entertaining, fun way, how can you attract people who have never been exposed to STEM topics in their life? Maybe it's the same problem in the arts — how to engage people who are not exposed to the arts. Both could change someone's life. 55

→ (141) [Ivona Brandic] "New Paradigms" PART 2

Emerging Ecosystems

If we look at filmmaking and audiovisual narrative structures as a form of 'world-building', what possibilities does quantum open for new forms of world-building? How can we think of reality in a new way, thanks to advancements in quantum computing?

> What makes me wonder is the dynamic of technological developments that we have today. If I look back to where we were 20 or 30 years ago, when the internet was just starting — who would have thought we would be where we are today? I'm somewhat amazed by this technological pace. Generative AI, for example — who knows where we will be in five or ten years.
>
> What makes me scared is if those technologies start to get abused without us noticing. Sometimes that might happen in a very obvious way. But if we start to somehow lose control, so that society enters a state of instability as well — that is what worries me.
>
> I try to find my place in this society where I can make a contribution. I'm very persistent with this. I try to reach schools, to make noise so that people understand it's time to do something with school education. We should not leave any of the kids behind. Every potential we have – we have to use it in the right way. 58

We often hear the term 'Quantum Culture'. At times intended as a framework for new intuitions, new ideas, or new perspectives, driving new forms of storytelling and world-building. Is there such a thing as a quantum culture? Is there a new worldview emerging?

If you think in terms of a community, yes, there is one that is developing. Especially in Vienna — I have to say, I believe that there is no other place in Europe that is more driven by quantum. There are a lot of strong groups, and it has a long history. We have two Nobel Prize winners since 2022 who received international recognition related to this area — Ferenc Krausz and Anton Zeilinger. Vienna sometimes feels a little bit like a bubble. But within this bubble we certainly have a diverse culture and community. And we have the first interdisciplinary masters in quantum information science and technology, cutting across physics, electrical engineering, and computer science.

Is there a challenge to scientific determinism coming from within the scientific world itself? Quantum theories are being picked up and reevaluated by advocates of alternative cosmologies that preceded classical traditions in science. It has a little bit of the feeling of something new, but also of a rediscovery, originating within the scientific world, but acquiring an interesting, strong level of legitimacy outside of it.

Quantum is sold as something super difficult, and I always have the impression that whenever you talk about STEM, people think, oh, I'm going to get a headache. We have to change that perspective, and also the way we teach. It needs to be more entertaining and more participatory.

I remember that my dad, when I was about 12, enrolled me in my first programming course, which was awful. I was like in *The Big Bang Theory*, sitting with five or six other males who did nothing else in their lives but coding. From a didactical point of view, it was a total disaster. But my dad — being a mechanical engineer in 1989 — knew at that point that this was going to change the world. He told me: you have to do that course! I didn't want to. I think I traded off some piano lessons, and I hated it. I didn't understand anything.

But then, later, I came to Austria during the Bosnian War, and I understood that I was not going to succeed on the classical school track. And then decided: let's go to a school where I learn programming. I'm going to figure it out. It's difficult, but it's better than learning German.

This sparked something in me — wanting to understand how it works. Looking back, I'm so glad I did what I did.

Natalie Paneng is a new media artist working between digital environments and performance. Her practice combines self-taught digital techniques with theatrical approaches to create immersive narratives. She explores identity, embodiment and speculative subjectivities through performative and virtual spaces.

Iridescence

Natalie Paneng

How did your meditation go?

It was good, thank you for asking. It brought me into my body, into my emotions, into my reality.

Let's talk about reality. You prompted us to think of your art as a portal to other possible realities.

My work is really trying to instil this philosophy, which I call Iridescent Philosophy. I'm trying to create this way of thinking that brings in multiple perspectives — like the surface of a soap bubble, where colours shift depending on how you look at it. We are called to look at things from plural perspectives. These can reflect, and we can take what we see as truth, or they can be distorted. For me, the perspective of iridescence is this shift — this shifting colour, this shifting possibility.

And *intra-action*, as Karen Barad tells us, is really the most productive way to think about how entities constitute one another through their relations. This continuous relational work, a collaboration of elements, brings the shifting perspective. Also stillness gives a perspective.

I'm inviting people to look through a kaleidoscope of possibilities, of diverse colours. I'm trying to have this softness and this playfulness and openness to be present with us as we do very technical, hard things or ask hard questions. And to let it become a kind of healing balm for our brains, our hearts, and our ways of seeing.

So as we look, things shift — and in turn, we shift: in our minds, in our hearts, and in how we look again when we return to the world. How do we see a reality we believed we had already seen, already deter-

mined, already understood? Those little moments of change — and then: oh, I thought I understood this in one way, but now I understand it like that, and also like this, through a connection that seems arbitrary, but isn't at all. It's this strange loop.

Could we call this *quantum thinking*? In fact, your approach contains elements that predate the now popularised notion of quantum thinking. This idea of multiple realities and multiple possibilities — what are the roots of *iridescent* thinking?

I'm going to answer your question with a stream of consciousness — messy and soft. When I started researching this I was listening to people speak about quantum and defining terms, and I always wondered: What would my granny call this? What would her mother have called it? What would my grandfather see in it?

When my family lineage many years ago encountered a moment that was hard to articulate, what was the language? That was one of the prompts that made me ask: what is the language that precedes the current articulation? That was a big part for me, because I was always aware that just because we've defined something and given it a term, it doesn't mean that's the only thing it is.

And then it obviously broadens out too much — which is possibly not quantum, which is why we have to contain things in terms. But there's still something special in giving respect to what was before that containment. Western containment, Western language — all these formats have helped in many ways, locking in and progressing. But I find it very important that all the knowledge I get always takes me back, somehow, to a place where I'm like: there's so much knowledge, and now I want to feel it or understand it in another way that is not words.

The first time I started my residency last year with Studio Quantum, I made a video prompting the question: what would happen if there was an African deity who has always been engaging in the realm of quantum? Would she be churning out mathematical equations? Or would she be creating sounds? That also leads me to Pauline Oliveros, who wrote the book *Quantum Listening* (2022) and created meditations around it — saying "Quantum listening is listening to listening…".

And I realised that there are ways and realms in which quantum thinking, quantum formats, metaphors, and applications could be approached in an embodied way. And for me it's very important that there is a huge level of embodiment with something like this, because I don't think there should be too much of a separation between us, our reality, our universe, and its mechanisms.

So it's still something I'm investigating. I don't have an answer. I'm constantly asking: if it isn't quantum, what is it? If it's not observed in this way, what is another way? How was this brought back to a general understanding? I know that a lot of these things have always moved into

the realm of the esoteric or the realm of magic. And then I think about indigenous technology systems. It always leads me into this inquisitive rabbit hole where I just ask more questions.

At some point we were all particles, and then at one point we all developed eyes. That collective coming together, and the understanding that we move from one thing to the next — and the in-between of why we move to the next thing — is something I'm really interested in. That feels visceral and not necessarily logical. It moves me.

So I'm interested in that visceral connection, that visceral articulation, that ability to try to contain it in words and form. But then also, when it's not contained, what is it? It's not just in the lab — where else is it moving? Can it move in me? No? Maybe? Yes? Could it move into something else? No. Maybe. Yes.

You know what they say about pigeons – like the way they navigate through the Earth's magnetic field, where some suggest something like a quantum system might be at work. What are we signalling?

This inquisitiveness, for me, just makes life a soft game that I can participate in with autonomy. And also gratitude that there are explanations and formats and people researching and developing that knowledge. But also living that development. I'm trying to live it. I'm trying to share it and soften it again — the perspectives don't have to be clear, but they just have to give a little shadow, an inkling of something more. And I'm trying to make more of those little inkling marks. 115

What possibilities are we opening for image-making?

Imagery and imaging are super important for this kind of grasping. With the *Iridescent Philosophy Quantifying System* — which is just a playful title — I really wanted to make a device where I could see the patterns of interference from an everyday perspective.

Usually, when you see iridescence very clearly, you need the light and the angles, but you don't actually understand the granular perspective shift. And so when I started using digital generation to make images, I was really grateful that the pixel could allow me to isolate and show, step by step, something like how an oil spill works.

How the oil and water move is very seamless — but if I zoom in and try to pixelate that, I can see the spectrum of colours and realise: it's a dot of yellow, it's a dot of green, and that makes the whole scope.

That's how I got really interested in making these little devices that zoom into the shifting of the colours and allow you to visualise what is working together to make that iridescent flow — because iridescence is actually quite seamless, shifting and moving all the time.

But even when you look at a bird feather, it's so seamless, and yet actually it's tiny little elements. A shell, a pearl — actually small structures working together. When you zoom in, you're able to see a lot more clearly. And then you zoom out and you're able to appreciate the beauty of it.

So this imaging has been a way for me to deepen that articulation and also set those articulations out in the world, more in the way nature does — and feeding that back into the digital system, speaking on nature and how these two things work together.

Cr°ws and Bismuth Crystals

Was there a moment where you felt stepping into another perspective, a bit like with iridescence? Other colours, other kaleidoscopes. It could be a sensory, visceral or embodied moment.

So many moments. Let me share a few random ones.

One moment that shifted my perspective was around crows. In South Africa, I don't think we have many crows — maybe another species variation. But when I first started learning quantum concepts, my brain was on fire — sore, dense — and I felt jammed within these hard lines. I would have these walks, moments that were just very functional — just me walking.

And one time I saw a crow and I was like, oh, it's black. And then about two days later I picked up a feather and there was so much iridescence on it. In the next few days I started thinking: What can my

eyes actually perceive? Is this crow black? Is it really, truly jet black? Or is it an insanely psychedelic, stunning bird that I just don't have access to experience at this moment?

And this — step by step — took me deeper into understanding what I was trying to investigate: my metaphor of iridescence in quantum physics. Another easy example I use is bubbles. I love bubbles — they are clear, and then light hits them, and as you shift your perspective and move, the colour changes again, and then it pops. It can hold that state, and then it can't — and you're not really sure when. It's not a perfect metaphor, but it was one that wasn't forcing a concept through, and instead was opening more doors for me. And it was also practical — I had genuinely thought these birds were black for the longest time, and then I was able to slowly apply a new perspective and build from it.

And another one — a funny, cute example. When I was starting to research iridescence as a metaphor for how we engage with quantum physics and systems, I started from a place that was not really appreciated by many of the physicists I was in dialogue with. I was always asking: but is it magic? Like, just say it — it just feels magical. For maybe a week, I was really hell-bent on making that connection. And the physicists made me very aware of the dangers of trying to connect the quantum world with the esoteric world. 43

And then one day, feeling really tired again, I walked into an esoteric shop to try to find a bismuth crystal, which was itself a great metaphor for me. It's a very structural object mathematically, it keeps building itself in a particular way, but it is also iridescent. And while I was there I found the book *Meeting the Universe Halfway* (2007), and I just found it funny, because I was like, this is such an esoteric-sounding title, and yet it's Karen Barad speaking about quantum physics.

These cute moments in life, where everyday things bring you back to theory, back to concept, back to that sense of ownership over the ways that our universe exists and works…These small examples feel like planned serendipity. They reflect back into the technical ways I started applying in creating the work, and into the technical questions where I started having aha!-moments and entering a better back-and-forth dialogue with physicists: I understand it this way through my everyday experience, and I want to reconnect it to that.

So those examples were really instrumental to the investigation. But sometimes you think you've stepped out of it — you're tired, just walking — and then life is like: hi, here's another one. And you start to notice.

Tanja Traxler is a science journalist and researcher working on physics, philosophy of science and feminist science studies. Her work connects scientific knowledge with societal and cultural contexts, focusing on interdisciplinary dialogue between science, media and the arts.

Martin Reinhart is a filmmaker, media historian and inventor working with experimental film and data systems. His practice explores technological histories, perception and knowledge production, developing tools to analyse large data sets and reflect on media infrastructures.

→ (155) [Tanja Traxler + Martin Reinhart] "Quantum Ghosts" PART 2

Cultural Res°nance

Tanja Traxler **Martin Reinhart**

In the same way as classical theory generated instruments and ideas like single-point perspective, which then generated a new practice of image making, this quantum revolution, so to speak, is also generating new perspectives — mediated by different cultures. There is strong awareness of the impact of these new ideas. Are we witnessing the emergence of a new culture?

Maybe I take one step back to explain why the cultural impact is so prevalent in quantum physics. The theory of quantum physics, mathematically, is solved — the job is done. There is nothing else to do, except for developing further and finding a way to bring it together with Einstein's general relativity and things like that. But quantum mechanics as such are mathematically complete.

However, conceptually, there are so many unresolved questions. The language of physics is mostly mathematical. But when we come to conceptions like space, time, causality — you name it — our everyday conceptions naturally enter through language. And because there are so many unresolved conceptual issues in quantum physics, reflection on language, cultural impact, and so on really comes to the foreground. This is quite different from earlier theories of physics.

Quantum physics, when it was received in the 1910s, 20s and 30s, had a philosophical dimension to it. These people did not only see it in a technical way, but also in a philosophical way —

in terms of what we can perceive and how our universe is organised. And then, with the utilization of this knowledge that literally exploded in Hiroshima and Nagasaki with the atomic bomb, this whole discourse came to an end. It's very surprising that until the 1960s, quantum physics was not taught anymore. There was no resonance in thinking. I think it was just too hard to handle. It was not easy to explain. And it still isn't.

There's this book — *How the Hippies Saved Physics*, by David Kaiser (2011) — and it's an excellent read. It's about how a young generation of students in the Bay Area started to be interested in quantum physics again. In their altered minds (let's put it that way) everything suddenly made sense. They started to join the theories coming out of quantum physics with a certain esoteric movement that was taking place. Out of this very small circle of scholars, the book *The Tao of Physics* by Fritjof Capra (1975) came out, which was an instant hit. If you put on your scientific hat, you might say that's all nonsense. But what it did was bring quantum physics back onto the stage. From that point on, it was taught again and became the serious scientific field it is today.

What this story shows is that it's not always the science itself that makes things compelling. You need a mediating force — like philosophy, art, or similar practices — to hold these ideas and make them, perhaps, more accessible. 149

How is this cultural shift being translated into images, in your view? There is an established perception that the work of artists in the context of science is limited to a mediating role — that image-making becomes a means to explain, or to make things accessible. At the same time, there is a productive exchange that happens at the research level — beneath the surface of public sharing, beneath the surface of pedagogy. That exchange could happen already in the lab, or in the discovery phase. It goes beyond making concepts accessible — it works as non-hierarchical, interdisciplinary thinking. If we were to enter into your labs and your research groups, what would we witness in terms of the exchange between the physicists, the engineers, and the image makers?

Since it is so hard to make sense of quantum physics in language, producing analogies, metaphors, and images has always accompanied the process of digesting this new theory of physics. There are very different ways to approach this, and one is certainly through an exchange with the arts. As you mentioned, there are plenty of examples where scientists teamed up with artists, and in the end this led not only to artistic work, but also to scientific discoveries. It doesn't matter where the good ideas come from — you very often just need totally out-of-the-box inspiration. The further away from the scientific canon, the better.

Think about how science-fiction sets new limits for our thinking. We had a very interesting conversation with a student who wants to do a PhD on quantum weaving or quantum fabric. She said something very interesting that stuck with me: once you break a record — say in the thousand-meter run, a record that was not conceived as being possible to break — suddenly other people also break that record. It's as if you point to the future and say: this is the ultimate goal. And once you put a pointer there, you create a new reality.

I think filmmaking has always done that. I researched the history of Kubrick's *2001: A Space Odyssey* (1968), which is interesting because it is rooted in Fritz Lang's Woman in the Moon (1929) — even some of the same people working on the Fritz Lang movie were working on Kubrick's film. *Woman in the Moon* was in turn rooted in the first book about space travel, *The Problem of Space Travel: The Rocket Motor* (1928), by Herman Potočnik Noordung. It's very interesting how this first book about space travel was illustrated in the Lang movie, and how these images, once created and perceived, were taken as reference.

Why I point to this story is because of a comment by a NASA official after 2001 was released. He said, "Filmmakers have been stealing from our model movies — and now the situation is the other way around. We have to take from those films, because they show us where the journey is going." And the first space shuttle was called the Starship Enterprise, because the idea was already out there, the community was so large, and expectations for space travel were so high.

Sometimes science brings out something totally unexpected, and it takes time for it to be digested — and then imagination shoots ahead and asks: if this is like that, what might come out of it? We had a very interesting workshop where we brought together artists and physicists, and there was one session with a quantum physicist who works as a consultant for Marvel films: Spiros Michalakis. He was the quantum specialist on *Ant-Man and the Wasp: Quantumania* (2023). It was very interesting to talk to him, because he said that from a physicist's point of view, going into the quantum realm — becoming smaller than your own atoms — how would that even work? They had very long discussions with the set designers and special effects teams. They said: we know it's impossible to do — but how would it look? And he said, we had these conversations, they took notes, and then they showed me what they had done. For me, it was like — wow. I expected a lot, but not that. And in that moment, he captured how it works — that the exchange goes both ways, and that he, too, was inspired by their work.

I very much like those movies because they play with the simple idea that something is big and you can make it smaller, and smaller still, and then you arrive at the limits of physics. It has maybe an educational value, a value in the way it communicates science. And if Marvel is dealing with these ideas, you already have the cultural impact we've been talking about.

Witchcraft

With *Hiroshima mon amour* (1959), Resnais was initially commissioned to make a documentary, but chose instead to work through fiction — combining archival material with fictional elements to reconstruct what was almost invisible. As Karen Barad mentioned, some of the victims refuse to remain in the past, returning, in a sense, as ghosts.
There's a concern that the artist is only playing with fiction, but it's not so simple. From pre-cinema and phantasmagoria to modern filmmaking, this has always been a question. In your article for the Civa exhibition catalogue, Tanja, and in the panel discussion with Martin and Julia Grillmayr, you introduced the idea of *Quantum Witchcraft*. Where does that come from? Are you also borrowing ideas from feminist literature? There seems to be a reference to Silvia Federici.

Yeah, definitely. There are figures missing. The idea to call it quantum witchcraft, especially as a reference to a specific epistemology, is also to bring out considerations from queer and feminist theories.

The Fox sisters were the first witches in this context, in a sense — they brought to life what later was called spiritism. And it's very interesting at which moment this happened. If I ask my students about spiritism, they always tell me it's something from the Middle Ages. And I say, no — this is 1850. Modernity always had this other half.

If you look at Western civilization, it's totally clear where it comes from. Until the 18th century, believing in God had always been the counterweight to scientific research and scientific findings. It was very clear that God enabled humans with a brain and with logical thinking so that they could better understand the beauty

and greatness of his works. Being enlightened and being religious was not a contradiction — that's the story we tell ourselves today. But if you separate these threads — and I'm not a religious person — we can see that something was lost in that equation, and it had to be filled somehow.

It's this figure of the male rational scientist that abandons every idea that cannot be measured or proved. This led into a one-way street. Philip Haslinger once gave a very interesting talk that left me speechless. He said that when he began studying physics, things still seemed more or less coherent. But with the latest measurements, we now know that only about 3% of matter is understood, while 97% remains unknown. He asked — how can I, as a physicist, base any theory on anything if I only see 3% of what exists?

When watching a film with these presences — creatures, ghosts — you get the sense that you understand more by listening than by watching. When I first read about quantum computers trying to eliminate all the *noise*, I thought: what exactly is this noise?

Something I keep returning to is our observational tools, the whole apparatus. There is something out there — it could be part of dark matter. We don't know. It could be all across the universe, but we don't see it. So there is something very present, as empty as it seems.

Maybe as an analogy — what physicists do to deal with exactly that problem is to measure gravitational waves. Most of what we know about the universe comes from electromagnetic waves of different frequencies — visible light, but even more so other parts of the spectrum — and to a lesser extent from cosmic particles that we can collect here on or around Earth.

Only in the last — not yet ten years, about eight years or so now — have we gained a third resource for learning about the universe, and that is gravitational waves. If one speaks metaphorically, electromagnetic waves can be associated with seeing. Cosmic particles have sometimes been referred to as tasting. And gravitational waves are like "hearing the universe."

Most of the gravitational waves detected so far originate from merging black holes. These are entities we can only access indirectly through electromagnetic waves — we cannot see them, because they are black. Yet the gravitational wave signals they produce are remarkably rich, teaching us far more about them than electromagnetic observations ever could. I have high hopes for gravitational-wave astronomy to deepen our understanding of the universe's apparent emptiness — which is, undoubtedly, far more full than we currently imagine.

Manuel Correa is an artist and filmmaker working on memory and post-conflict reconstruction. His practice uses documentary methodologies to engage with fragile social relations, creating collaborative spaces between communities, researchers and activists to reflect on trauma and collective processes.

Marina Otero Verzier is an architect and researcher working on the intersection of digital infrastructures, data storage and climate. Her practice investigates the environmental and political implications of technological systems, addressing extraction, energy and the material conditions of computation.

Building Advantage

Manuel Correa **Marina Otero Verzier**

There is an intention to document something and to trace a memory, to go deeper into the materiality of these new quantum machines.

I think one of the main reasons why we chose this kind of observational style — what we might call an anthropological or ethnographic approach to filming the construction process — is that building new worlds requires an understanding of the world we are currently in.

When we try to come up with ideas about what this technology should look like, how it interacts with the world, how it changes the world, we need to understand first that it is constructed from material. It is constructed by workers who come from different parts of the world. Different types of materials are arranged, mixed, assembled, and put in place. And in the middle of this is the quantum computer.

One of the most telling moments for us was realizing that the building itself had not been properly designed for the quantum computer — it had been added almost as an afterthought. This gives a sense of how large-scale scientific projects, in attempting to redefine the frontiers of human knowledge, often require material conditions that force other spaces to adapt to them.

I really think that, given the current state of the world, we need to look more deeply into it, instead of flying away and escaping into entirely detached worlds. We need to engage with this world, here and now.

We're building for something that arguably we still don't know what it's going to look like. From an architectural perspective, is this still an open question?

We know that many worlds operate simultaneously within this one: different temporalities, different realities — digital and analogue — alongside technologies that date back centuries and are still present in our society. We therefore reject the idea that everything will become homogeneous around a single technology.

When we think about the arrival of quantum computers, we imagine that this technology might reshape our understanding of the world, allowing us to see it differently. Yet many other worlds will continue to coexist with it. Architecture, as basic or flawed as it may be, will remain, even as quantum machines invite us to rethink space and time.

So for us, it was very important to document this historical moment. You don't often have the possibility to document the arrival of a quantum computer and to have access to that process. It was interesting as a historical document, showing how we were envisioning the arrival of these technologies: what was needed, what kinds of mobilisations — of matter, of resources, of people, of capital — were required to make it happen, and what our expectations were at that moment of how this might change the world.

So it is contemporary now, but perhaps in a few years it will become a historical document of the arrival of these technologies. At the same time, it serves as a reminder that — even if we know that the world of particles is far more complex — in the end we still work with textures, with gravity, with brick and mortar, even though we know that all of these are, ultimately, relations between electrons and forms of electric currents between particles.

You may not be able to access the quantum computer when it's built. This act of documenting is necessary, but not necessarily a neutral act. It is sometimes looked at with suspicion by those who are being documented.

The negotiation to get inside the building was really Marina's very strong effort and her community-building. She's been working with the

scientists for a long time, so she gained access through them, and they allowed us to film. This was a very complicated part of the project — almost half of the project's time was spent on that.

I think images are powerful. Images hold the possibility of interpretation, the possibility of creating different ways to imagine worlds and to see events as they unfold — as in the case of forensic architecture, the research agency I am part of, or my own personal practice.

What interested me most about quantum was that there are so few images of it — partly because it is so difficult to imagine and represent. When you talk to scientists, they will often tell you that their understanding comes like a passing light — something that appears, and then fades again as it slips away. Often, when you listen to talks or read about it, you encounter metaphors. And I really think that metaphors are images that emerge when language breaks — when there are no words to explain something, you turn to metaphor to fill the void that is created. So I'm very interested in how to create images in spaces where language fails, or where images do not yet exist.

Of course, what you replace that with is the materiality of the computer — the building itself, all the shining cables. But in a sense, that is just the tip of the iceberg, or actually just the cooler of the computer. When you see this shining tower that we associate with a quantum computer, it is really just a fridge. The computer itself is a tiny chip hidden away. So there is a tension between the surface and the depth of the machine.

I've been working with scientists from Ikerbasque (the Basque Foundation for Science) and the Donostia International Physics Center (DIPC), but this was something different. It involved IBM as a major corporation, with its own protocols for how to disclose the technology, how to film, and how to communicate. The Basque Country is investing a huge amount of money in this project — more than the entire Spanish state — so it is extremely important.

The Quantum Basque Center in Donostia was generous enough to allow us to do what we wanted within certain constraints — specific days for filming while construction was ongoing, and access to scientists. But there was, of course, some apprehension about how we would portray this endeavour. I think they were certainly surprised, perhaps even a little disappointed, because it was not a polished documentary about quantum computing, but rather a very down-to-earth representation of what it takes to build that infrastructure. And for us, that was very important.

Because art, and artists, and researchers like us have, in certain ways — I would argue — been complicit in enabling certain technologies, such as military technologies, drones, and others, to permeate the public sphere and even become normalised in our lives. These are technologies that come into being and that many artists like us are eager to embrace and build speculative worlds around — drones delivering packages to the top floors of high-rises, and many other scenarios, speculating around them. And I think that's fantastic; it's part of what we do. But at the same time, the images we create can contribute to normalizing technologies that are also surveillance technologies, military technologies, technologies of death — as we are seeing around the world.

And quantum is similar to those — much like AI. Quantum technologies open up the possibility of thinking about the world differently, in more complex ways, perhaps moving beyond binaries into something fundamentally quantum, which is very compelling for the artistic world. I think there has been a boom in people thinking through quantum, and I find that fascinating. And at the same time, our concern is that we mystify the technology to the point where we aestheticise it, and its real consequences are forgotten.

So for Manuel and for me, it was very important to show the apparatus required for this technology to come into being — the mobilization of matter, the migrant workers, the investment of the state, the security surrounding it, and the expectations attached to it. In the end, you don't see the technology itself, you don't see the machine, but you see all of these things.

→ ⑫③ [Marina Otero Verzier + Manuel Correa]
"In Praise of Fᵒrgetting" PART 2

Extra°rdinary Maintenance

Filmmaking is about community building to access spaces, or to access and maybe hack or activate archives. This impacts the materiality of the film object, how it was taken care of by the community, or not. The idea of decay is very interesting for memory, for film, for architecture — the inevitability of decay. Perhaps with this kind of observational filmmaking fiction and documentary merge.

In architecture, images are very often instrumental, because they represent something that is meant to become something else. If you think of a building — in a more conservative understanding of architecture and convention — the drawing itself holds a great deal of power. But we don't always reflect on the means of production behind that drawing, or the images that accompany architecture.

And increasingly, these have depended on very specific technologies, to the point that in recent years we have seen rendering take over architectural production and representation — and now AI as well. Most of our students at the university can simply give a prompt and receive an image. That is quite unprecedented.

To me, it is very important to keep reflecting on what it takes to produce an image, and — instead of becoming merely end users of tools we do not control — to consider how we can intervene in those systems and retain agency over them. Because these tools and

technologies define the limits of our imagination. You can see this clearly: when most architects were using AutoCAD, it shaped the outcomes visible in our cities. When people began using Rhino, SketchUp, or Blender, you could see that as well. And now, with AI, we are witnessing it again.

Working with Manuel was the first time I really came closer to understanding what it takes to make an image. You need a camera, of course. You need someone handling sound. It's actually quite heavy — you have to carry all this equipment with you. I go to a place, I see something, and then I see Manuel with the camera focusing on something completely different. We are in the same space, but he finds a frame, an image that is entirely different from what I see. Then, of course, there is post-production — editing, and the need for large amounts of storage to hold both the process and the final film.

For me, that was a moment of — okay. I was used to seeing only the final image, and now I was confronted with everything behind it. Because I'm not a filmmaker myself. I work with Manuel on this project, but I'm very much a trainee when it comes to filming.

To me, it is very fascinating to see how an image is produced, and I am trying to bring that back into architecture. In my courses right now, part of what we do is to work very explicitly with the infrastructure and not take it for granted. How is this image produced? On which server will it live? For how long? What is the appropriate resolution? What does it mean for an image to be very high resolution, and how much energy does that require? Why not use low-resolution imagery — perhaps it has both an aesthetic and a political dimension. Will it be stored in the cloud or on your own servers? Sometimes we even develop our own servers.

And I find this very refreshing — to have the possibility of some agency in the production of images, rather than simply following what the market offers and accepting it as users.

When it comes to community-building, we really wanted to bring all the scientists working on the quantum computer onto bumper cars. But that wasn't possible, because the fair we had imagined would be there

simply wasn't. This is the point — it's not that we are working with fiction, but that we construct situations that would not otherwise take place.

Please do not give up the idea of putting quantum physicists on bumper cars.

About what you said on decay: I think what it comes down to is the importance of maintenance. Who thinks that something is relevant enough to take care of it? Architecture might be destroyed, but as long as there is someone who cares about a building, a house, a property — that thing will be maintained. The same with files, the same with tapes, the same with old photographs, or clothes, or objects, or art. 63

The problem with data is that it's very much in the hands of very few companies. We don't have that much agency in deciding how it is kept, because it's very obscure — where it is kept, what the conditions are. And there may be moments in which we cannot decide how to maintain it. We don't have agency in maintaining that data that we rely on and that we are accumulating, thinking that it represents our life. Most of the time it's in a cloud that belongs to someone else.

So the question of decay is inevitable — but the question of maintenance is key. We always need someone who cares about whatever we think is relevant for the future, for future generations.

Katia Moskvitch is a science and technology journalist focusing on physics, astronomy and scientific innovation. Her work translates complex scientific topics into accessible narratives across international media, engaging with the cultural and societal dimensions of scientific research.

A New Quantum Sch°°l

Katia Moskvitch

You want to build a new quantum school so that we can be ready for the implications of what these new machines will have in our lives, in the way we work, educate ourselves and others, develop ideas, and test things. The question of educating ourselves for the arrival of quantum computing means more than just understanding it. And this is a space where you do a lot of work and something you care about.

I care deeply about making technology and science accessible to a wide audience; I've spent over 15 years working in science communication as a journalist and in communications departments. Over time, I've become particularly interested in quantum computing because of its potential to impact our daily lives.

In the future, most people won't need to understand the complexity of quantum mechanics to use quantum computing — they'll be able to use it like we use AI today, without knowing all the details. However, for some, it will be fascinating to learn about qubits and how quantum computers work, and why they mimic nature. I think it's crucial to teach people how to use this technology.

We're looking at a timeframe of a few years — it could be around five years, perhaps a bit sooner or later. The key point is that it's not decades away. When the technology is ready, we'll face a shortage of people who can actually use it. I've noticed that when I talk to people outside of my usual quantum circles, they often don't understand what quantum computing can do or how it can benefit them.

And yet, if you think about it, it's just a different way of computing. It's a technology that will make it easier to complete specific tasks:

optimization, logistics, finding new materials, new drugs, financial optimization, risk assessment, and so on. It won't replace traditional computing, but it will complement it.

If you look around, there are many small and medium-sized companies with IT departments already doing remarkable work in software. This would be an ideal group to upskill for working with quantum computers in the near future. But this isn't happening — or at least not quickly enough. There are university courses for young people studying computer science or pursuing a master's in engineering, and more institutions are beginning to offer them. However, when it comes to upskilling the existing workforce of software developers, there are still very few opportunities.

Companies and universities are starting to realise this, and I'm sure courses will begin to appear. But they need to appear sooner rather than later, so that we are prepared for the moment of quantum advantage — when quantum computers begin to outperform classical ones in specific tasks.

Our current binary computing and quantum computing will, at some point, coexist. At the same time, from a hardware perspective, this represents a complete paradigm shift. It's interesting to consider what is needed to understand this shift, as it is not simply about learning new software.

Maybe in ten years, quantum technology will be part of traditional computing systems, making it less intimidating. But even if that happens, there will still be big changes happening behind the scenes. You've said before that we need to approach this change from many different angles. Looking at things from an interdisciplinary perspective can help by going beyond the usual ways of teaching and training. Does that matter for understanding the paradigm shift?

It depends on who we want to educate, and whether we are thinking in the short or the long term when it comes to quantum.

In the short term, we need to focus on educating decision-makers, especially in industry. Large companies — such as banks, big pharma, and automotive or transport firms — have already been exploring quantum for some time and often have dedicated teams working with quantum computers. However, smaller companies are far less involved, and their leadership — their CEOs — are often not even aware of the potential benefits of quantum.

When it comes to education, it is crucial to reach those in charge, so they can make informed decisions about upskilling their existing IT staff. This does not require diving into quantum programming right away. Rather, it means introducing them to the potential of the technology, sparking their curiosity about the underlying physics, and explaining how it could be relevant to their business.

Then there's a parallel area of education for software developers who already have a programming background. What they will need is a deeper understanding of quantum mechanics, because AI is likely to take over many of the more routine programming tasks. What we will really need are people who can design quantum algorithms — and that is something AI cannot easily replace. For those people, it is crucial to become familiar with quantum mechanics, because we need to understand which problems from the physical world can be translated into problems that quantum computers can solve. Not every problem is suited to quantum computing — it requires identifying the right ones, and then developing new quantum algorithms to address them. Right now, there are only a few dozen of these algorithms, and there aren't enough algorithm designers to create more. 141

So that's one reason why upskilling the existing workforce matters. When it comes to education, there are different areas to focus on: we have mentioned the CEOs of big and smaller companies as well as existing professionals, especially software developers. The third area is young people. Currently, few schools teach quantum computing, even at the secondary level. I have heard that the UK is beginning to introduce quantum mechanics into its curriculum, which is a positive step. However, this is not the case everywhere. I live in Switzerland, and my 17-year-old attends a school focused on mathematics and physics, yet they do not cover quantum mechanics — let alone quantum computing. Thanks to me, he has at least heard of it, but his friends have not, even though they are studying mathematics and physics. This is a problem.

There should be an introduction to quantum computing at least at a basic level, and it should happen earlier. In five or ten years, these kids will be using the technology, and it's their future. We're already behind in incorporating quantum computing into high school curricula.

Imagine a World...

Storytelling can contribute to changing perspectives. What did you think of The Year of Quantum?

The UN naming 2025 as the Year of Quantum is a big deal, and it has already changed how people think about it. We need to keep the momentum going and make sure these events aren't just a one-time thing. People planning future events should ensure they are not only sparking curiosity, but also creating pathways for deeper learning. Curiosity is important, but it is not enough. We need to channel that curiosity into something meaningful — whether that means introducing quantum concepts in high school or training employees within companies.

It all comes down to raising awareness. When I worked at the BBC, hardly anyone knew about gravitational waves — now they are widely discussed, largely because they have been in the news. If we can bring quantum technology into the news, people will start to pay attention.

I think journalists are doing a pretty good job, but the problem is that quantum stories are still quite niche. Bringing an education minister onto a popular BBC breakfast show would be a powerful way to get the message out.

When we talk about computing and what it could do — the risks, the dangers — a lot of our imagination has been encapsulated in stories that made it into books or films. We take your point about getting the message out from experts, but we're also wondering more broadly about how we unlock the imagination of people. Starting from kids.

Kids aren't that difficult. They're naturally curious and wonder about things like where we come from and how the universe began. That's why

I started my podcast, *The Quantum Kid*. My son is nine years old, and he doesn't claim to be an expert in quantum physics, but like his classmates, he is full of questions because he is curious. When you explain something like quantum superposition to him, he doesn't simply accept it, as many adults might. Instead, he wants to understand why it happens and how it works. He wants to see the machines and try them out.

Of course, children cannot yet grasp the complex equations behind quantum mechanics. But they can learn that this technology exists, and that may encourage them to pursue STEM subjects later on. Another way to spark curiosity is to tap into people's natural interest in space and black holes. Most people are fascinated by black holes, which is why books like A Brief History of Time by Stephen Hawking (1988) are so popular. Even if people do not finish the book, they are often drawn to the topics it explores.

It's not a big stretch to connect astronomy, space exploration, and black holes to quantum computing. Quantum mechanics has been around for a long time, and it has led to many breakthroughs. We have also made progress with general relativity, which helps us understand how planets move. However, we still haven't found a way to reconcile these two theories and create a "Theory of Everything". This is something that many people have heard of, thanks to books and movies like *The Theory of Everything* about Stephen Hawking's life directed by James Marsh in 2014.

It would be great to harness people's curiosity about quantum gravity and channel it into quantum computing. Quantum computers could be key to simulating what happens when quantum mechanics and general relativity intersect — for example, inside a black hole. Currently, neither theory — quantum mechanics nor general relativity — can fully explain what happens in these situations, but quantum computers might help us explore this further.

If I could create a movie or TV show that explores these ideas, that would be ideal. The movie *Interstellar* (2014) does a good job of tackling some of these concepts, and people love it. While it doesn't directly relate to quantum computing, it could be a starting point for exploring these ideas further.

We can build on this surge of interest, maybe through policy, to rethink how we approach education. We're curious about who's learning and where: which countries are seeing the most excitement and radical change in education, and what can we learn from them?

Many countries are trying to do more in terms of quantum and education. In the UK, for instance, there's a company called *Quantinuum* that worked with the University of Oxford on a study a few years ago. They experimented with teaching quantum mechanics to high school students in a different way — using visual methods — using visual meth-

ods. Then these 15- and 16-year-olds took the same postgraduate exam as Oxford University students, and they actually performed better. I don't remember the exact numbers, but it's a very interesting study. Of course, the students might not have delved as deeply into the subject, but they gained a solid basic understanding of quantum mechanics. This shows that it is possible to teach younger students about quantum mechanics using alternative methods.

When it comes to which countries are doing more, Canada is making significant investments in quantum education. The United States is also making a considerable effort, and the United Kingdom is trying to step up as well. In Switzerland, I believe we could be doing more than we currently are. There are many ongoing conversations about this, which is important. I think things will start to happen as the technology gets closer to being ready for use.

→ ⑭⑤ [Katia Moskvitch]
"Quantum Advantage" PART 2

Chino Moya is an artist working across film, photography and writing. His practice explores failed models of society, the self-inflicted nature of human problems and the illusion of progress. Through dystopian narratives and constructed environments, he reflects on detachment, dehumanisation and the psychological conditions of contemporary life.

Gr°wth and Decay

Chino Moya

In your film we see a dance between utopia and dystopia. A buildup to something good that degenerates very quickly, and then another buildup, and then things degenerate again. It's interesting that the fourth chapter was added later — I'm imagining you might be thinking of a fifth. I like the possibilities of this not ending. Could you tell us a little bit more about this wave, this dance between utopian and dystopian visions?

One of the defining features of our current historical moment is this pervasive indeterminacy — how difficult it is to pinpoint anything, as nothing seems tangible anymore. We live in this highly indeterminate reality, and it is becoming even more so every day.

At a very basic level, there is an endless cycle of life and death, of growth and decay. But I also think it connects closely to this idea of grand human projects — something that has recurred throughout human civilization. This idea of having a grand vision that will turn the world into an amazing place, and then, when these ideas are put into practice, everything collapses. But there is always a moment of growth first. North Korea had a much higher GDP than South Korea for a period after the Korean War. And we see this in many communist projects — in the Soviet Union, in China, in North Korea — where the first twenty years are often very successful under centralised economies, before reaching a state of entropy.

I'm from Spain, and I grew up in this kind of historical limbo. I was born about a month and a half after the dictatorship ended, just before democracy. So I was born in the aftermath of one failed utopian project, and then raised during the neoliberal project of liberal democracy and late capitalism — and I have seen that begin to falter as well. I've always been fascinated by these models of society and how they

ultimately explode and collapse. There are also these theories that after the Big Bang will come a Big Crunch — a kind of condensation — and then another Big Bang. So there is this sense of a cycle in everything.

Is there also a critique of the technological infrastructures that sustain this? A growing number of artists are using AI in speculative and subversive ways for filmmaking — I'm thinking of Radu Jude and his latest *Dracula* film. But also we see an increase in artists using analouge filmmaking at the same time. And there seems to be a common intent to subvert an established practice, a desire to make standard digital filmmaking obsolete.

We play with this ambivalence — a bit like you being born in this limbo between dictatorship and democracy, or moving from technophobe to techno-enthusiast. And I also felt an ambivalence in your film between imagining new futures and diagnosing the present.

To be honest, I used to be more of a technophobe. I mean, I make moving images, and technology is the only way I have ever been able to express myself. But I was more critical of technology, and I have to confess that, as AI has become more integrated into our lives — and as I've started using it more and more — I now find myself in two minds. Technology always has this kind of neutral ethical stance, and I think it depends on who uses it or who controls it.

In the film — the first chapter deals with this financial-tech apparatus, then moves into the virtualization of reality and society. The third chapter is about AI attempting to create an ideal human society, with echoes of problems we have seen in the past. The fourth is an explosion into an unknown world — a new form of AI. So yes, I am very ambivalent about whether technology is good or bad. I used to be far more critical.

→ (151) [Chino Moya] "Generative Reality" PART 2

S()fia Braga is a transmedia artist working with computational systems, machine learning and moving image. Her practice develops speculative narratives that explore agency, human–non-human relations and the cultural implications of algorithmic systems, addressing questions of labour, power and platform infrastructures.

The Failure of Machines

S()fia Braga

Third Impact (2025) is a movie generated in collaboration with AI systems. Its central theme is a quantum computer whose goal is to prevent the extinction of organic life on Earth. But because of an unknown event, the computer fails. And we go through this emotional journey, seen from the machine's perspective.

This is my second AI-generated film. And it's interesting how I came to the topic of quantum computing. At the beginning, I was imagining an algorithm — something more related to AI in general. But then I was talking with my father in 2023, and he said, "Sofia, AI is so done — quantum computing is the new thing." I said, "Oh, I hadn't thought about it before." So I started researching the topic further, and I realised that it actually resonated more strongly with the overall theme of the film.

Also, I'm not someone who generally believes in the singularity, and I thought that perhaps a quantum computer — with its computing power and capacity — makes more sense as something that could actually address the problem of the extinction of organic life. And that's how everything started.

The relationship between quantum and AI appears as almost one fad after another — the age of AI will be replaced by the age of quantum. But in reality I think there is some commonality which you explore, which is the potentially destructive power of both technologies. Not necessarily in a physical sense, even though your landscape is a very dystopian, abandoned lab. But it's also talking to a moment that feels post-apocalyptic

in some way — as if these technologies didn't destroy us, but neither did they save us.

One of the main struggles I had working with this idea of quantum computers was: how can a machine that requires so much energy — and we know you need to maintain a very specific temperature in the room in order to let a quantum computer run, so ecologically it's not sustainable — how can this work? And then I thought, maybe because of this force — this computational power it has — we may have to accept certain inefficiencies, invest more energy into it, and still consider it as a possible solution. So we give up something in order to gain something else.

But then, in the end — how can a machine truly prevent the extinction of organic life? There are so many problems that cannot be solved through mere calculation. The main point was also this fundamental impossibility of saving life through a machine alone. We, as a community, as people, as a living biological form, somehow have to be part of this.

So this journey of failure — a machine finding itself alone in the world with this goal, and then trying to recreate some form of life — felt very compelling to me. And at the very end of the film, we see a human eye. For me, that was a final glimpse of a living form. That is also why I refer to transhumanism: humans trying to find solutions for a time when organic life may no longer exist on Earth. How can a machine, with nothing biological, continue to pursue this goal? I began to feel that this new form of life would have to be a hybrid — a mix of machine and something biological. Not human, but somehow still biological.

And this goes somewhat against the previous film I worked on, *The Artificial Conjuring Circle*, where I proposed that we might simply be a bridge toward another form of life — one that is not biological but purely synthetic. But in this new film, I suggest something different: perhaps it has to exist somewhere in between.

→ ⑮③ [S()fia Braga] "Open Stuff" PART 2

A.Eye.

You are generating these images without an optical tool, without a camera — without something that is an extension of your gaze — but with a computer that is already processing something, processing images through text and preset coded parameters. Where does the gaze emerge in an AI film? How does filmmaking change when optical technology is no longer the primary cinematographic medium?

I mean, I have a very technical answer, perhaps a bit boring — it depends on the tool you are using. Throughout the film, you somehow feel as though you are the main character — it's a point of view, a kind of POV, where you inhabit the perspective of this machine, which is something I'm used to doing and that I enjoy. And of course, that can be achieved through prompting. There is no lens, but through prompting you can still specify certain visual effects — a fisheye, for example, and so on. It can also be done when you create your own workflows using different nodes and parameters. For me the main point was to have this first-person perspective and create a sense of disorientation. The camera moves very quickly through spaces — going down and up, turning, panning. I wanted to create the feeling of not quite knowing how to inhabit the body the machine finds itself in.

And then, at the end, when we see the eyes, I think that is one of the stillest moments in the film. The camera is no longer really moving — it is just this eye moving very quickly, which reflects what was happening before, when the camera itself functioned as that rapidly moving eye. And then we see these eyes looking around, searching for answers, trying to understand what is happening.

Are there hallucinations, dreams or nightmares that occurred during the process of working on this film?

There are many dreams, but also many nightmares. First of all — when you direct a film with a camera and a classical setup, you have a very clear idea of what you want. It is never going to be exactly as you imagine it, but it feels easier to me than working with AI.

When it comes to AI I like to say *collaborate*, because it really is a kind of exchange — even though I do not want to attribute any agency to the machine; let me underline that. I still think of it as an exchange.

Often, when you start working on an AI film, there are many parameters to consider. It is not just about prompting — unless you are using proprietary tools, which do not leave much room for creativity. In that case, it really becomes just about prompting, which is still an art in itself and not easy. But I find it quite difficult to achieve the aesthetic and the results you are aiming for.

For this second film, I spent months experimenting with different prompts and parameters to reach a specific aesthetic. I don't know if you are familiar with the *backrooms* lore — this online phenomenon around liminal spaces. It was very difficult, because the datasets kept producing very stock-image-like results. You really have to work at it to achieve something that could work for your film.

So there were a lot of nightmares — really strange imaginaries, but mostly not creepy or uncanny. Mostly just very boring. And that was my worst nightmare: endless stock-image landscapes that you don't want to see — not even in your worst dream, and not even in the worst AI-generated advertisements we now encounter everywhere. That was the nightmare.

But then it became a dream. Things began to change. And in the end, I reached what I was looking for, because I finally understood what needed to be in the image.

Patrick Emonts is a researcher in quantum physics working at the intersection of quantum information and many-body systems. His work focuses on numerical methods and tensor networks, exploring computational approaches to complex quantum systems.

Quantum Pr°mise

Patrick Emonts

The field of quantum, much like artificial intelligence and, before that, global warming, is beginning to take on the promise of a paradigm shift — a new way of understanding nature in an increasingly complex world. What makes it particularly powerful is that the scientists and researchers working in quantum theory, quantum physics, and computing come from a position of authority rooted in the Western notion of scientific progress. And yet they are proposing something that radically transforms our understanding of nature, changing the way we make sense of it. Is there a new *Quantum Culture* emerging?

It's a fascinating way of looking at it. I've actually never seen it that way, but in a sense it's a bit like traditional shamans, right? You have the knowledgeable healer in your tribe who tells you how things work, without you necessarily understanding the underlying mechanisms. I've never seen myself as the shaman, but if you describe it like that, it does feel a bit like it.

The reason I never thought about it that way is that, in the world I usually operate in, everyone has that knowledge. Within the bubble of quantum information theorists — or physicists more generally — what we know is nothing special; everyone shares it. And then, when you start communicating with people outside that bubble, you realise that what seems obvious within your field is not at all obvious outside it – you realise that people are interested, but there is a kind of language barrier. The words we use either have a completely different meaning, no meaning at all, or carry specific philosophical or political connotations.

Which is sometimes extremely interesting — suddenly you say a word, and people associate it with a particular line of thought from a philosopher, and you realise you were completely unaware of that entire philosophical tradition.

Coming back to this point about the culture of quantum — for us, it sometimes feels a bit like a hype. The things we do as researchers have not changed that much; we are still asking similar questions to those we were asking before. But suddenly, what we say — and whether we are asking the right questions — seems much more important. And that is a double-edged sword for us.

On the one hand, it is amazing: attention can lead to funding, and that allows you to conduct your research under better, more comfortable conditions, which is very valuable. But on the other hand, as soon as money is involved, expectations come with it. There have been cases where funding has pushed scientific ethics into the background, leading to publications that later had to be retracted. You also see this in companies that invest millions into technologies they promise to develop, but ultimately might not be able to deliver.

So this is something we, as a community, are concerned about from within. If we overpromise now and cannot deliver — and this does not even have to be on an individual level — if companies fail to meet expectations, the consequences will be felt across the entire field.

This is where I think the question of communicating the importance of your field and the culture of quantum in other fields of knowledge, are beginning to intersect. Because with that double-edged sword you're talking about, there is an opportunity for people in your field — not so much to acquire the status of shamans, but more to acquire agency over the images and the stories you produce. The moment your narrative gets appropriated by those who are not studying in your field, those who are not privy to the knowledge you all share, then there is a lot of possibility for misconceptions and for concepts being used in ways that are purely metaphorical.

The best artists who choose to engage with science are those who are accurate in the science they work with — or at least make a genuine effort to achieve accuracy. So that beauty is found in knowledge rather than in speculation only. It's both possible, but...

The word *entanglement*, for example — anyone is free to use it. There is just a small caveat. Usually, if you use a particular word in a certain context, there should be a reason for choosing that word.

The game I often play with artists is this: if they use *entangled*, I ask them whether they could, in their minds, substitute the word with *intertwined*. If that works, then they don't really mean entanglement, because *intertwining* is just a normal English word. Entanglement, on the other hand, refers to a very specific scientific concept. So if you don't actually need the term *entanglement*, then the more interesting question is: why did you choose to use it?

A completely valid reason for using "entanglement," for example, is that it is a term currently widely used in the community and that it generates interest. That is perfectly fine. But then one should not try to make it more scientific than it actually is. I am completely fine with using a word to attract attention — we all do it — but we should be careful about the causal connections we draw from it afterwards.

If the term is used for a scientific reason, then perhaps the analogy can be developed further. But if it is used simply because it is en vogue, then it becomes much harder to build something meaningful from it.

Cultures of Image Making

Before establishing collaborations with artists, what mechanisms did you have to generate images and stories about your research?

One way that comes to mind is through more traditional visual representations. For example, when you think about a Hilbert space, you are thinking about a vector space in which you can combine vectors and still obtain a vector that remains within that space. You cannot leave the Hilbert space by adding elements, which means it is convex. If we were to draw it, it is often represented as a kind of convex bubble — simply to ensure that we are not misrepresenting it.

On the other hand, there is this tendency to personify concepts. You might hear a theorist say that a state "lives" in Hilbert space. By representing concepts as more agential, it becomes easier to talk about them. Of course, that thing is not alive and does not know what it means to "live" somewhere, but it allows us to speak in more accessible

terms. Otherwise, we would constantly be dealing with dense mathematical notation.

The most famous equation in quantum physics is probably Schrödinger's equation. It describes how the state of a quantum system evolves over time. What we are talking about can also appear, to a non-physicist, as part of a broader aesthetic of equations — entering people's imagination in that way.

We've been talking about equations having their own aesthetics, and they have been used as an aesthetic element in different fields, certainly in cinema as well. The choreographical element, the performative act of calculating, the performative act of debating — I think that also generates a specific kind of aesthetics.

From the world of film, cinema, and art, many different images arrive at us audiences about your world. Some in documentary format, some more speculative, rooted in abstract imagery and the intersection of multiple times. What images are you seeing coming from the outside, towards you, that you see yourself in somewhat?

There are kind of two viewpoints conflicting in my head here. The one is — it's way easier to think in images. You want to have something graphical. If I do a talk, there will be images that explain what I do.

There is a long tradition of introducing graphical calculi. Richard Feynman's diagrams are famous for how they represent perturbation theory. Before that, the approach was very integral-heavy and cumbersome to compute with, and then Feynman introduced this elegant graphical way of expressing the same ideas. The same applies to tensor networks — a field in which I work. Tensor networks are a way of graphically representing quantum states using boxes and lines.

Jokingly, I sometimes say that the main thing I learned during my PhD was how to draw squares and circles on a board very quickly, because that is essentially what we do. Instead of calculating with states and operators, we draw boxes. It is much quicker, and it gives you a very intuitive sense of what they mean and how to use them. At the same time, you are aware of their limitations — outside of these fields, these diagrams do not really make sense.

On the other hand, artistic representations are very interesting because they offer a different perspective from which to approach quantum mechanics or quantum technology. The question that usually comes to my mind is: how far can we push this?

If, for example, you work with interference fringes — I am thinking here of the idea of iridescence in the work of Natalie Paneng — you encounter very striking effects that are also visually compelling. Iridescence — those shifting, colourful patterns — can arise from polarization effects, or from interference between thin layers. But how far

can this be pushed into the quantum realm? How much do we actually learn about quantum phenomena from this? And where are the limits of the analogy? 33

Which images do we choose? For example, in quantum mechanics you have discrete energy levels. If you heat a pot of water, you might look at a mercury thermometer, and it would pass through every temperature between, say, 20 degrees at room temperature and 100 degrees at boiling point. In quantum physics, however, systems can have only discrete energy levels. So how do you visualise that?

One of the best images we came up with was a frog on a ladder: the frog jumps from one rung to the next, and the rungs are not evenly spaced — it is a *bad* ladder. In physical terms, that would mean that the energy levels in an atom are not equally spaced. Then you can ask: how far can we push this image? The answer is — not very far, because at some point it breaks down. But you have one image for one situation. And I think this is a very interesting discussion to have with artists — but also a very limited one from their perspective.

Some of these notions that you are referring to, such as non-linearity, discrete positioning, and co-existence in multiple states, are being extracted and abstracted into narrative principles that transcend the representative or explanatory power of the images themselves. Whether they are narrative principles about how I understand my own world as being non-linear, or how I am driven by forces whose origin we don't know. For artists working with time-based media, the possibility of the non-linearity of time has major implications.

And that, in a sense, is where the cultural industries begin to develop a sensitivity to — and engagement with — the fundamental questions of quantum theory.

There is a particular notion of time associated with quantum theory. While energies and certain observables are discrete, time usually is not — at least in most of the theories I work with, time is generally treated as a continuous parameter. So I was a bit surprised when ideas of circularity, or of past, present, and future being the same — or somehow interconnected — were suddenly brought to the forefront of the discussion. For me, time is typically a parameter within the quantum theory I use.

We all read Carlo Rovelli — these ideas derive from quantum theory, and in this case from the field of quantum gravity. They have been popularised and, in the process, appropriated and turned into all kinds of different things.

I don't know if you have read Rovelli's book *The Order of Time* (2017), but it effectively takes you on a journey: first, it explains why time does not exist in the way we usually think of it, and then it shows why it still matters to use it. It almost feels as though many people only

want to read the first half of that book, because it is more convenient. I think there is nothing more controversial today than presenting a linear narrative — at least within the cultural space we currently inhabit.

Part of the appeal is that this has, until now, largely been a philosophical question. Artists have always found a home in the philosophical realm, but often found themselves at odds with the scientific one — if I may generalize — partly because of questions of authority. And now, suddenly, there is this new authority in science that seems to open up entirely new possibilities. So it becomes extremely tempting, I imagine.

I'm very careful about how I phrase this now. Of course, there are speculations or theories that suggest things you would not usually expect. The question is how widely applicable they actually are. For example, if you look at quantum gravity, there are theories still being developed, and I don't think there is a consensus on the correct description of gravity — one that is fully compatible with quantum mechanics at all levels, including relativity. In that domain, you encounter a wide range of theories and possibilities.

That is also what makes this such an interesting boundary to inhabit as a scientist — this need to remain rigorous, to be clear about what is scientifically *true*, and where imagination or speculation begin. Some of the things that looked like science fiction fifty years ago are now completely ordinary. We carry small screens in our pockets that can show you cute pictures of cats if you want it to. It brings to mind the idea that any sufficiently advanced technology is indistinguishable from magic to the uninitiated.

Leon Lapa Pereira is an artistic researcher, performer and educator working across art, performance and ecological mindfulness. His practice focuses on resonance, collectivity and the perception of the invisible, creating participatory formats that foster shared experience and embodied knowledge.

New Machines

Leon Lapa Pereira

Instrument Inventors Initiative (III) is an interdisciplinary collective and instrument inventors' community. Why do we need new instruments?

The discovery of quantum mechanics fundamentally challenged classical physics, in which we assumed separable entities, a clearly defined measurement apparatus, and the ability to observe what was happening in a straightforward way. The idea of a linear progression in physics — researchers building directly on each other's equations — was suddenly called into question. It became clear that previously established results were not wrong, but incomplete.

What we discovered is that whenever we measure, we influence. Whenever we observe, we intervene. Whenever we touch, we interact. And therefore, the material reality, the field itself, appears differently depending on how we engage with it.

There is a very big philosophical question here: however we look at something, the answer is already inherently present within the question itself. Whenever we build something to look at something, what we will discover is already in the building of the machine.

And I think this was also a kind of renaissance for the arts — the realization that we, too, participate in shaping epistemological and ontological realities, and that we come to understand knowledge and practice in different ways. This is also where the power of quantum emerges, possibly affirming a more humanist perspective. It does not completely contradict classical physics — rather, it suggests that there is more, another layer of reality.

Whenever we measure using the tools and methods we have traditionally relied on, we obtain classical results. But we can also measure differently, look at things differently, and arrive at different outcomes.

I think most of the machines — or I would rather call them instruments — that artists build are research tools as well. They are not used as instruments in the sense that you simply acquire one and then learn how to play it. My teacher always said: you need one third of the time to develop the instrument, and two thirds to actually learn how to play it. So if you spend three years building an instrument, you need six more to learn how to use it.

This is a kind of basic rule within the art–science community in The Hague: if you build, say, a light synthesizer, and then want to learn how to perform it, you should expect to spend twice as much time learning as building. I think this is a helpful way to understand how we develop instruments to explore something new — sound in a different way, space in a different way, light in a different way, words in a different way — whatever materialities we choose to investigate. [127]

Emergent, Invisible

There are instruments like hunting cameras that would make you hear or see things that were never intended to be visible. What is your relationship with the invisible?

I like the invisible.

The invisible here is both a metaphor and an example of the unperceived — something that cannot be seen, heard, or felt. I think you can build something that makes people aware of it. And that, to me, is one of the qualities of art and artistic research: to understand what is actually changing, and how to map that.

A thousand people might walk through an exhibition — but how can you obtain both quantitative and qualitative insights into how what they experience might affect them? It is not a simple cause-and-effect relationship. It is not a kind of causality where someone walks into an installation and thinks, "oh my God, everything has changed." Instead,

you walk into the installation, find it interesting, feel something shift — and then you walk out again.

And perhaps two, three, four, or five days or weeks later, it returns. And maybe then you begin to ask: how did that installation change my life? Mapping these things is interesting to me. They are all unseen — things we cannot perceive immediately — yet they gradually make their way into our perception and begin to change it. And perhaps they also, in a subtle way, expand our imagination. I think that is beautiful, if it happens. 36 99

Never ask someone what they think of the movie as soon as they get out of the cinema.

That's right — you have to exit the world in which you were in.

→ 134 [Leon Lapa Pereira] "Tuned In" PART 2

Dieter Vandoren is an artist, performer and creative technologist working with spatial audiovisual instruments and immersive environments. His practice draws from music, experimental architecture and digital technologies, focusing on embodiment, interaction and primary sensory experience through performative systems.

Matteo Marangoni works across music, performance and technology, developing instruments and environments that engage the body and senses. His practice draws on bioacoustics and ecological think-ing, exploring sound as a medium for interaction between humans, machines and other life forms.

K°m°rebi: Sensing the Envir°nment

Dieter Vandoren **Matteo Marangoni**

Komorebi is a performative installation based on embodied swarm intelligence, in which a hundred artificial creatures make music together, responding to one another and to their environment. The result is a spatial audiovisual experience, where the visual dimension is provided by the environment, and the sonic dimension emerges from the swarm's interactions within the space.

The sensitivity of the work to changes in the environment means that visitors experiencing the radically immersive soundscape it produces become more sensitive to and aware of the minute changes in the natural environment — variations we would not normally perceive with our human senses. By sonifying these through the far more sensitive sensors embedded in the work, we become more aware of — and more connected to — this environment.

Komorebi doesn't seem to have the expected confines of traditional installation work. It is, to reflect on the title of the Civa Festival, somewhat an *indeterminate apparatus*. As a performance, it creates an experience through the response of human and non-human actors, and makes

the environment itself functional to the creation of the experience. It blurs the boundary between the projection and the projected, the emission and the emitted. How do you expand this space of experience?

The work we do is interdisciplinary, and I always like to approach it from different perspectives. For example, we can think of it in relation to cinema. In experimental film, it is almost a cliché to film the shadows of trees, or to work with lens flare. These are also important elements in this work. But instead of capturing them on celluloid, we leave them where they are — and you have to go and look at the shadows of the leaves yourself.

Computers are very bad at creating randomness, but the world is full of it. So why try to force a computer to be random, when, in the same way, we can find shadows in a park without having to put them into a film? We can find randomness in the world without having to simulate it in an algorithm.

With your work you create systems that respond to our presence in the performance space. Like with the observation of quantum phenomena, by being present, we influence the way that experience unfolds for others who are also present.

It's a metaphor, an analogy, but it's a stretch.

It is true that this is the kind of work that needs to be experienced in situ in order to be fully understood. By entering the environment of the installation, the visitor becomes, to some extent, an integral part of it — just as we are part of any environment we inhabit. The work functions as an additional layer within the natural environment in which it is presented, and is designed to complement it, rather than replace it or demand full attention, as other installations might.

The work is created entirely with the intention of complementing the natural environment through the sonic layers it produces, which directly respond to changes occurring in nature. And indeed, the visitor can also interfere with these phenomena, influencing the inputs registered by the sensors and, consequently, the resulting sound.

Maybe even more than that — I think the agency of the visitor lies in moving through the space, where every perspective is different. The visitor can choose to sit down and listen to the music in a more traditional, concert-like way, primarily observing how the sound changes over time. But they can also choose to move through the space, and then they will notice more how the sound changes spatially.

The starting point — if we reduce the project to a single question — was this: when we walk through a forest, light is distributed in a complex and beautiful way. Would it be possible to sonify this, or to create music that evokes that spatial experience of light on the level of sound? You can experience it as a concert, or as a walk in the park — or both at the same time.

Something that continues to amaze me is — I already used the term before — the radical immersivity of the sound. We have 100 sound sources, each producing its own highly localised output. Moving through this sound field, which emerges from these sources combined with the surrounding natural sounds, creates an extraordinarily complex auditory experience that shifts with every millimeter or centimeter of movement.

The experience changes with you, because of the intricate interactions between the sound sources. For me, this becomes an almost material, physical sensation — of moving through a field of sound shaped by these complex interactions. It is one of the aspects of the work I am most drawn to, and I hope that others also notice it as they navigate the space.

You are part of the Instrument Inventors Initiative (III) in the Hague. Can you tell us more about the instruments, the sensors you hacked for this installation?

We are two of the founding members of III.

The sensors in this work consist of two types of light sensors and a microphone. The actuators are a speaker and an LED light source in each of the *creatures*, as we call them. The project originated in breadboard experimentation, gradually refining the components and programming needed to achieve the intended behaviour.

These technical elements primarily serve to support the concept of a swarm of interactive and responsive creatures — with the algorithmic programming being the central component. When it comes to the sensors, the process involved extensive testing and selection, evaluating available components to determine whether their sensitivity and dynamic range were sufficient for our purposes.

For the light sensors, we wanted the work to function both at night and in full daylight. This requires handling an extremely wide dynamic range, and very few sensors are capable of doing this effectively. So we had to develop strategies to ensure the system performs reliably across these conditions — from bright sunlight to dusk.

The same applies to the microphones. Because the work is distributed across a relatively large natural environment, we wanted the creatures to maintain sonic communication with one another. This means their *ears* must be sensitive enough to detect sounds from several meters

away. Achieving this required a significant amount of engineering work — and we also received support from collaborators with more technical expertise. But this is only the hardware side. An entirely separate chapter of the project involves the development of the software.

Artificial Life

There is an interplay between non-human, technological intelligence — the sensors, in that sense —, and then human intelligence, which is the programming and construction of the material. How do you bring different forms of intelligence together to generate this experience?

At the moment there's certainly a lot of attention — for reasons we know — on artificial intelligence. But of course artificial intelligence research has been going on for quite a while. One of the branches that is less popular at the moment is artificial life, which is another branch, different from, say, machine learning. It connects more to the themes of ecology — thinking about swarm intelligences, groups of organisms, how they work together. How does intelligence emerge from life, and how does life emerge from non-life? These are fascinating questions. And therefore also, how does music emerge from this kind of complex system?

Dieter was talking earlier about the complexity in physics. As you are walking around the sound field, these different tones are mixing and interfering and adding and subtracting on the level of physical waves in space, which we pick up with our senses. But then

there is also the complexity based on the algorithm, on the swarm intelligence. Each one of these creatures is autonomous. Each agent is, in every instance, making decisions based on what it senses.

When we were talking about embodied artificial life — many of the algorithms we interact with on a daily basis are based on vast server infrastructures located elsewhere, with little direct relation to physical reality beyond the text interfaces through which we engage with them. What we are exploring is a fundamentally different idea of artificial intelligence. Rather than disembodied and massive, it is small, localised, and responsive to the same environment we inhabit.

These creatures possess a form of physical awareness that large-scale AI models do not have, with each node responding dynamically to its surroundings. In such a complex system — returning to the idea of indeterminacy — it becomes impossible to fully know its state. Mathematically, the system is too complex; it enters what is known as a combinatorial explosion. You cannot determine its exact state at any given moment.

We made a fundamental design choice for the work *Komorebi*: the creatures — the swarm — must communicate through means that are also perceptible to humans, namely light and sound. In many cases, this kind of emergent swarm behaviour relies on abstracted digital networks such as Wi-Fi or Bluetooth. Here, however, all communication takes place through light and sound — channels we can perceive, but also actively interfere with as humans.

There are physical limitations in space, so the system is not perfect — it is inherently imperfect. The sound from one creature will not necessarily reach most of its neighbours; in fact, it will only reach a few, propagating in an uneven and incomplete way. In a purely digital system, information is transmitted cleanly. In a physical system, by contrast, information is partial, noisy, and imperfect.

I should add a note to that. In the performance we will present later, some people might notice that we are using Wi-Fi routers and laptops — but this is only because we have developed, specifically for this occasion, a live mode in which we can control certain parameters of the autonomous algorithms from our laptops. Under normal conditions, when the work is running independently, none of this is present. All processing happens locally within the processors of each individual creature. In the live mode, we adjust some of these parameters on the fly, nudging the system in one behavioural direction or another.

Can we draw a parallel between your process and that of editing a film?

In a way, yes — and in another way, no. Film editing is very specific: it involves constructing a sequence, deciding where to make the cut, and determining what happens next. What we are doing, by contrast, is giving impulses to emergent behaviours. We are essentially shifting the boundaries, in real time, within which the swarm can evolve, but we do not control exactly what light and sound each creature registers — and that remains the primary driving force. So it is less like editing, and more like herding. Well, maybe it's more like directing a film, where the director would say: can you do this again, but a little bit more aggressive? We can say we want them a bit louder — but we can't control exactly what they will do.

I wonder what a film edited in this technique would look like. Perhaps not in traditional film editing, but in the context of artificial intelligence filmmaking, this is in a way what some programs allow you to do now. You can change the acting performance during the editing process. You can make actors speak in another language, you can blur them, or edit them out. These days one can do a lot on a low budget.

→ (127) [Dieter Vandoren + Matteo Marangoni]
" The P°litics °f Instruments" PART 2

Mike Rijnierse is an artist and educator working with light and sound as spatial and perceptual media. His practice focuses on immersive environments and sensory structures, exploring the relationship between perception, space and physical phenomena through experiential installations.

Mirror, Mirror

Mike Rijnierse

There can be scientific accuracy in artistic research. You develop algorithms and then transform them into a physical possibility — to represent something that in the field of scientific research is often thought of as impossible to represent. This interplay between the limitations of scientific knowledge and the possibilities of representation seems very urgent. Mirrors also carry a very strong symbolism. For some they are portals to other worlds — like for Jean Cocteau in Orphée, where Orpheus can reach Eurydice by stepping into the mirror.

The *Quantum Mirror* came together in a very non-linear process. I'm interested in precursors of cinema — it's an incredible domain of apparatuses. In my studio work I build light sculptures, and I'm fascinated by the behaviour of light on many levels. But of course, at certain levels you cannot enter without very expensive machines.

So I started materializing things with acrylic mirrors, and then we came to this optical effect. Discussing it with my collaborators, we came to this idea of cutting — this 50% that is cut out of this stainless steel mirror — which became the result of an algorithm based on wave function collapse. So it's basically a graphical representation of a wave function collapse, which is the mathematical equivalent of the collapse of a superposition. Then it was iteration, iteration, iteration — until, finally, we felt: okay, this is it. And once you place it in an exhibition, it begins to take on a life of its own.

Looking at the evolution of cinematic technologies and light-based technology, could you maybe trace back your work with light and how it evolved into the instruments you have built?

It started by coincidence — or maybe not, I'm not sure. I was making a wall painting for the exterior of a press company, and there, together with a graphic designer, I began referring to the *Artikulation* score — a graphical representation of an electronic music piece by György Ligeti, created by a German graphic designer. It's not a score you read. It was made in beautiful colours and shapes — a seventies print, a fantastic book I found in the library of the Royal Conservatory of The Hague where I was studying.

So we started working with complementary colours in the wall painting, such as orange and blue. When we finished, the sun was setting, and the colours in the atmosphere began to interact with the painting. It started to resonate from the wall — you could perceive this kind of subjective colour blending. And then I thought: okay, I can animate this. That became my final exam for my bachelor's degree, and I think it was the starting point for this entire body of work.

M°ving Shad°ws

I've read quite a lot about media archaeology and attended a number of presentations in media arts and fine arts. You can see how these worlds are sometimes very separate, sometimes overlapping — and how their forms of representation evolve over time.

I sometimes make the analogy — I was reading *The Discovery of Shadow* (Italian original 2000, English translation 2003) by Roberto Casati, where he describes how early street lighting was introduced not for convenience, but for surveillance. In the beginning, it relied on oil lamps. The flame would move with the wind, so before the advent of gas lighting, all shadows in the city were in motion.

Then the gas lamp arrived — and suddenly — poof — everything became fixed.

No more magic.

You can see this as well in the context of new media festivals, which in the nineties were very diverse — full of experimental installations and all kinds of approaches — until efficiency began to shape the industry. And then it gradually distilled into a stereo setup with a projector.

And now perhaps we are coming full circle back into moving shadows. Is there a vision that really transported you to another dimension or perspective?

I was really intrigued by *Ways of Being* (2022) by James Bridle — especially how it offers a perspective on a Western, colonial worldview and the ways in which it shapes these technologies. After all the books he wrote before, which were often quite pessimistic, this one feels remarkably optimistic — exploring how we might live in a more sustainable and hopeful world if we undergo a cultural paradigm shift. That book really stayed with me.

Sophia Bulgakova is an interdisciplinary artist working with art, technology and social structures. Her practice explores perception, cultural identity and imagination through immersive environments using AI, XR and sound, creating sensorial experiences that challenge conventional understandings of reality.

Mark IJzerman is an interdisciplinary artist exploring ecological systems through technology. His work engages with biodiversity, environmental change and planetary processes, combining artistic research, scientific collaboration and living systems to examine relationships between humans, technology and ecosystems.

Hallucinat°ry Cinema

Sophia Bulgakova **Mark IJzerman**

We cover our eyes, and we begin to search for our inner sound.

We started working on our collaborative performance — All Eyes On — in 2022, I believe. Visually, it builds on my prior research into sensory deprivation and sensory overload, specifically the Ganzfeld effect and related practices. The performance is essentially a live AV piece that inverts the projection screen and creates what I describe as an analogue form of virtual reality, projected directly onto the audience.

The audience wears translucent goggles, onto which the live visuals are projected. In this way, they become a kind of pixel within the screen, experiencing a sensory-deprivation-based, colour-driven environment accompanied by live music.

That is a brief description of what is happening. The work is a 30-minute live AV performance that we present together. I generate the visuals live using a combination of analogue synthesizers, analogue video mixers, and digital patterns, which are then projected back onto the audience. This creates a dual experience: for those observing from outside, it becomes a spectacle in itself; for those within the audience, wearing the goggles, it becomes something entirely different — a very specific sensory condition, potentially slightly hallucinogenic, shaped by the removal of the horizon line from visual perception, which is central to the Ganzfeld effect.

This is connected to psychological experiments from World War II, actually around the improvement or existence of telekinesis — which never proved itself. But the experiment itself is a stimulation of the brain to produce active hallucinations without using any supplements. The original experiment involves covering your eyes in some way, removing the horizon line and other visual triggers, and using stroboscopic light — especially red stroboscopic light, which is the most unnatural for our brain — together with white noise. Through this removal of spatial cues, the brain is effectively forced to generate its own perceptual framework, producing internally generated imagery — hallucinations.

While this is not necessarily the goal of the performance, it does alter how space is perceived and how one relates to the surrounding environment. My work specifically engages with colour and colour theory, and with how imagined spaces can be constructed through relatively simple technologies.

This forms part of a broader line of work exploring perception through colour and basic sensory conditions. The collaboration with Mark continues this trajectory, but extends it into digital virtual reality and into questions of ritual and ritual technologies.

In this context, I draw on abstract elements from traditional Ukrainian and pagan rituals, bringing them into dialogue with systems of meaning-making through symbols used in seasonal rites in Ukraine. From one body of work to the next, this forms a continuous development.

I think it's also interesting to connect this to indeterminism and the quantum. What we do composition-wise — because we are both working with feedback systems that we react to, and that in turn react to us — involves a great deal of indeterminism. So I think there is a strong connection there.

I've been making music for these two projects of Sophia's, and this is our collaborative work. My own practice is more connected to water ecologies and related installations. There is also a lot of indeterminism in that context, because you are often working with organisms, with specific species, and you can really only set up a framework and then see what emerges, since everything has its own agency. I think this is very often the case in both of our lines of work.

Lights and S°unds inside °ur Brain

The cinema inside your brain is coming soon. Technologies for moving images are approaching the eye, very slowly. They have evolved from a separate screen, to a screen we hold, to a screen we wear — and soon, perhaps, to a screen attached directly to the body, like a contact lens. And after that, most likely, chips implanted in our brain, which are then part of our physiology, may have the ability to generate images without any external device and offer a sort of *inner vision*. You could think of it almost as a controlled hallucination — and for sound the same may apply. It's only a minor technological advance from what is potentially already being developed.

I'm very much interested in personal perception and in psychological experiments around imagination. There is also a very simple question, for example: how do you imagine an apple when I say the word *apple*? There is a whole spectrum of how people actually see it in their minds. And there is also an entire area of research — which I encountered while studying colour — showing that we perceive and imagine colours differently.

It is based on the physiology of our eyes — how they are structured, even what colour they are — but also on where we grew up. It is shaped by the environments we come from, by how light is reflected there and how colours are perceived. It is very much determined by your background, your upbringing, and your physiology.

Colour is different for everyone. Even the number of colours we perceive is influenced by these factors. For example, how many shades of blue you can distinguish in a water environment — people who grew up by the seaside are often able to name many more, because they are used to it; it is part of their cultural context.

I find this realm of personalised perception very interesting — and the idea of creating conditions for audiences to explore and discuss the variety of things they see. So when you talk about this hallucinatory cinema, or the integration of technology into the brain, I find it fascinating to ask: are we talking about universal experiences? How do we move from the personal to the universal? What does it become?

When working with these technologies — even through relatively simple but effective means — you can open up a conversation, or bring attention to the differences and similarities within shared, communal experiences.

It also makes me think of — when you say that we perceive the world in different ways — how many things we sense that are not actually there. You hear sounds that are not there. All these psychoacoustic effects arise from physiological processes — or visual phenomena like floaters or visual snow, which Sophia has also explored in previous work. This is something deeply biological, deeply human. And how does that connect to image recognition or image generation algorithms, which are becoming increasingly capable of generating objects?

This experience — the difference between you and me, the things we each perceive differently — is, I think, one of the most human aspects of perception, and something a computer can never fully grasp.

Bey°nd the Screen

You are expanding the projection space within the cinematic experience to encompass the audience. You are present in the space, facing the audience. Is there a call to radically change the way we experience moving images?

I had this childhood obsession — I always wanted to be a film director. Obsessively. And then, when I went to study in London from Ukraine, I saw how film directing was taught and thought: this is about creating a story, but I want to create an experience. So in the end, I turned to art — and to my, how shall I say, weird technological experiments.

But now I am working with Mark on a piece called *Otherworlds*, which is a virtual reality experience. The work is based on my research into Ukrainian heritage and pre-Christian rituals, reviving and rethinking them through contemporary technology. It is a communal VR piece — designed for six participants at a time — operating between mixed reality and virtual reality. You begin by seeing together, and then, gradually, everything shifts and dissolves into another world.

What I am working on now — or at least beginning to — is the second part of that research. *Otherworlds* focused on spring and summer — on revival, very much centred around flowers, and around Ivan Kupala, the Ukrainian midsummer celebration. Now I'm turning to the autumn–winter transition, which is more carnival-based and oriented toward collective, choreographic experience. What I am aiming to create is something closer to a form of cinematic performance. I don't think it will use VR headsets, but rather surround projections and interactivity, allowing people to enter and experience these worlds together. At least that is the intention — to create cinematic experiences in a deeply embodied way, where you are not just observing the ritual, but becoming part of it.

And more and more now — of course since the beginning of the invasion — I have been working with personal and communal memories, with documentation of war and disaster, transforming it into something else. At the same time, I continue this research on the preservation of culture and identity through rituals and certain rites. Bringing these elements into new technologies, in a way reclaiming them, is also central to my practice — as is their cinematic quality.

Usually, when you read a book or watch a film, much of it happens in your mind — you internalise it beyond the two-dimensional moving image. What I am trying to create feels like an embodiment of that process — as if everything that is happening is transposed toward you, physically, onto you.

I try to work closely with my own identity, but also with understanding how I relate to all of this. I think embodiment is often missing from more traditional media works when they remain screen-based or distant — when they are too far removed to be fully relatable. So my search is: how do you relate to something around you through physicality, through personal storytelling, through embodiment? Which elements can be combined so that it becomes part of your experience — so that you understand things on a different level, through a different lens?

In a way, it is also about self-searching.

Working in the environment and sensing the environment is somewhat also addressing this idea of expanding our own bodily perception.

I think when talking about cinematic experiences, Sophia and I have a shared interest in looking for some sort of collectivity, rather than the individual experience. I used to also do more around VR, but I really don't like the closed-offness of it — and I think this is something Sophia addresses with Otherworlds quite well.

In my own practice, I often create AV performances in collaboration with other artists — such as Sébastien Robert — focusing on ecological issues. For example, we developed a work called As Above So Below, addressing the decline of old-growth forests in Chile, and more recently a performance around the imminent deep-sea mining near Svalbard. These are topics you might encounter in the news, but the question is: how can you bring these experiences to audiences in a different way?

How can we experience the urgency of these topics, or relate to them in a different way? Experimental cinema on a rectangular screen is one approach, of course, but

in my own practice I have been exploring further possibilities. For example, I created a work around water pollution and older technologies in my hometown of Eindhoven, using a significant amount of archival footage. For that performance, I used old-school 3D glasses — the magenta–green kind — and placed the archival material within a virtual space, in order to reframe it and reflect on what we have left behind, and what might still be useful. In this way, I work with multiple projection methods that foster a more collective experience, rather than isolating the viewer through something like a VR headset.

→ ⑫⑨ [Sophia Bulgakova+Mark IJzerman] "Hardware Unbound" PART 2

Zanshin is an audiovisual artistworking with experimental electronic music and sound. His practice combines composition, sound design and spatial experience, exploring the relationship between structure, perception and atmosphere across physical and digital environments.

On the Materiality of Light

Zanshin

I'm primarily a sound artist. I never worked with visuals myself, but I have always been interested in them. A few years ago, I created an installation using Chladni figures — also known as cymatic patterns. There is an interesting connection here: these frequency structures, which resonate in a solid body, have harmonic relationships, and they are related to the shapes of a one-electron atom. The idea was to show the actual patterns formed by sand on a metal plate, and then transition from that to particles within a computer system. These shapes are very appealing on one hand, and on the other they are highly rigid — and I find that tension particularly interesting.

There is this scene in *Hiroshima Mon Amour* (Resnais, 1959), where dust falling on two people making love, and you see these bodies with all this sand that looks like metal sand and feels so dangerous. We have this paradox of something extremely beautiful and at the same time extremely violent.

Artists and scientists used to be one and the same. For me, there is always a very poetic dimension to this. I've been deeply immersed in — though it is a somewhat reductive term — what we call Eastern philosophy. Not in the sense of, say, German philosophy, which tends to dissect and analyse everything — perhaps in a way similar to physics. But rather in looking at the dichotomy between what we call reality, what is there, and what philosophers might describe as the all and everything. It's a very compelling idea. In psychology, too, there is this

notion of a split between an all-encompassing consciousness and a self-and-other consciousness. There is something deeply human in the desire to return to that more unified state. And when you look at quantum physics, perhaps it reflects a similar kind of dichotomy.

I am not a scientist — I know a little bit about quantum physics, but only on a superficial level. I have been talking to people who know a lot about it, and I find it very fascinating. Because, for example — have you ever asked yourself why one T-shirt appears white and another black? If you really go into the physics of light and reflection, and ask someone who understands it deeply, the explanation is far from simple. We don't usually perceive light as a particle or a wave — we just see how other things respond to it. We don't think of light as a substance. It's like air: we don't think of air as a substance either, because we breathe it and see through it — and yet, under certain conditions, it can become visible. I'm sure you've seen photographic experiments capturing light traveling through a bottle, where you can actually see it moving. With millions of frames per second, light becomes visible in motion — which is completely mind-blowing. And then you realise: of course, it's just our perception — it normally moves too fast for us to see. Sometimes we catch glimpses of it, when it reflects or scatters. And in phenomena like a nebula, you suddenly begin to understand.

There is always this drive — we want to know, we dissect, we want to measure everything. But does it actually help us to become more peaceful, or more accepting of the world? Science has, after all, also contributed to the development of weapons. If someone has money and seeks more power, they can use the knowledge of those they can pay to build them. That has happened many times. You must know the story of Richard Feynman, for example — and of other physicists who were involved in building bombs. It must be fascinating for someone in that position: you have this passion, this desire to understand, and then someone offers you the resources to pursue it, and you become invested in the work. But at the same time, you must also think — okay, what will this be used for? You have a moral compass. You must think: this could lead to harmful consequences. And I don't know how often in history — or at least I haven't heard much about it — physicists have said: no, I will not take part in this.

Many times. There is a famous Italian one — Ettore Majorana. But he disappeared.

I'm sorry, I was rambling — I'll come back to the performance itself. What I'm trying to do is give people who watch or listen to my work a feeling similar to looking at nature. Humans can often reach a state of heightened awareness more easily when observing nature than when facing crowds or busy urban environments. For many of us, it's easier to simply watch a river or a tree — to enter that calming state of not thinking.

At Civa Natalie Paneng said, "Thank you so much! I had a headache today, there was so much going on, and after your performance my headache was gone. I could completely relax." I was really happy to have had that kind of *therapeutic* effect. Sometimes I find poetry simply in nature, in what is already there. If you are in a meditative state of mind, it can feel as if you are witnessing a kind of living, ever-changing poetry. The universe — everything that exists — is, in a way, poetic, if you are able to see it like that. 33

Alien Sounds, Human Languages

Your images may appear as the construction of a language, in which multiple aesthetic choices converge. Is there a narrative component, are we looking at an alphabet, is there an actual story being told?

That's a very interesting question, because it depends on what you consider to be the story. If you are simply in the moment, there is no story. But on the other hand, a story might just be a sequence of moments — and in that sense, you can think of the sound as giving those images a structure, even if it is a very subtle one. It's a story without much drama — more of a calm, sustained state.

You could think of Chladni figures as an alphabet, although they are not always directly visible — they function more as an underlying structure. It's closer to geometry. And geometry is a language in itself: basic shapes that we can understand, while the more complex they become, the harder they are to grasp. Yet the dynamics between them remain legible as change.

Very simple relationships — bigger, smaller — can already provide the brain with a sense of structure and involvement. And the more

repetitive these patterns become, the more they can sometimes help us return to a relaxed state.

Think about *Story of Your Life* by Ted Chiang (1998), the original story behind *Arrival* (2016). This idea of a language that exists beyond time — it spoke to me deeply. As a sound designer, though, I really disliked how it was handled in the film. When the aliens speak, it sounds like pitched-down animals. Why do they sound like that? Yes, they resemble octopuses, but why would an octopus sound like a slowed-down lion, or whatever source they used?

I don't know if you've seen the *Alien: Earth series* (2025) — they use a very interesting approach for the alien voice: the sound of termites underground. If you knock on a termite mound, they begin to rattle their bodies as a warning signal, producing this high-pitched, vibrating sound. I first heard it in the series and then later saw a documentary about termites and realised — they used exactly that. It's interesting how, as sound designers, we often draw on animals from our own planet to shape the voices of aliens, as if they must resemble something familiar. But in reality, we don't know that at all.

It's very interesting to imagine languages that we don't know. Our perception of language is, of course, largely based on acoustics — and it becomes very different if you cannot hear. For people who use sign language, the way language is structured in the brain must be quite different, because it is visual. And reading lips, too, is a very different experience from hearing.

I've always been interested in what actually makes a language a language, not just sonically. Because sonically, of course, it consists of inflections in frequency. But these inflections only mean something because they have been repeated and learned over time. We learn language because someone tells us: "this is called a table." Imagine a Kaspar Hauser-type experiment, where a person is taught the wrong names for things. Then they encounter others who use the same words, the same phonemes, but do not agree on what is a table, what is a spoon. Who holds the authority in that situation? It is the majority that decides: this is called a table. If everyone called it something else, it would not be *table*. It is, ultimately, a collective agreement.

And that's the interesting thing about how languages evolve. In German, for example, it's very evident how migration influences the language. In English as well, you can clearly see how it is constantly transforming as new words enter. Who understands a language? Only those who know its vocabulary. If you don't, you might not even understand people thirty years younger than you — even though they speak the same language, they use different words.

To come back to the performance — I think it is more about losing your internal speech. Because what internal speech is — what we call thinking — is often what keeps us from simply experiencing. It is this continuous layer of referring, judging, naming, and describing, instead of just letting light reach your eyes, your brain, and allowing it to be what it is. Just experiencing.

There is always something that exists even before speech, or before thought. Our cells are constantly changing, everything in our body shifts over time, and yet something tells us that we are still the same being we were twenty years ago. We experience ourselves as a continuous entity. But how is that possible? Is it simply the interweaving of our memories? Or is it something like a spirit, or a soul?

The word *anima* — meaning soul — is very interesting. In our language, we speak of *animals*, yet we do not always see ourselves as animals. Or do we? Do we not have a soul, while they do? Or is it the other way around?

Maybe our soul is an animal.

→ ⑬⑤ [Zanshin] "Measuring Our Thoughts" PART 2

Miriam Hamann is a visual artist working with installation and sculpture. Her practice engages with scientific phenomena, systems of knowledge and their aesthetic translation. She reflects on abstraction, perception and the subtle material conditions that shape how reality is observed and constructed.

Structures of Reality

Miriam Hamann

My artistic projects oscillate between sculpture and installation. Across these approaches, the central question I ask myself is: what kinds of shapes and structures make up reality? What systems of order have we imposed on ourselves? Units like the second or the meter — where do they come from? Why do we rely on these kinds of constructs?

What I find particularly fascinating is that, when you think about time — although it is clearly a construct — its development was originally tied to natural phenomena, especially in the context of navigation. And these phenomena are not stable. Nature is in a constant state of flux; it is always changing. So while our systems of order are often based on natural constants that we assume to be stable, they are, in the end, not fixed.

In the 1970s, it became clear that the Earth's rotation is not constant. As a result, the leap second was introduced — occasionally added at the end of the year to synchronise solar time with atomic time. Without this adjustment, over very long periods, day and night would gradually drift away from the time system we know today.

It's also very interesting that there are these systems shaping our reality, while we go about our daily lives largely unaware that they are constantly being adjusted. During a residency in Paris, I was working on these systems of order — the meter, the kilogram, the second. The original standards are kept there, and people come together from all over the world to decide, for example, whether to add a leap second or not.

More recently, there has been a decision to phase out the leap second, partly because computer systems struggle to handle it. Some systems already distribute the adjustment into many small increments

over time. So we are living within all these constructions, all these systems that are ultimately based on something that is not stable. These are the kinds of questions that really interest me.

How does your research on time and the structure of reality translate into image making?

My work is highly abstract and formally reduced — minimal. Light often plays an important role, alongside an interest in space and materiality.

One work I made about the leap second engages with the visual language of a clock, and what you see is a time: 23:59:60. Technically, it is possible for a clock to display this, but you almost never encounter it. When a leap second is added at the end of the year, some clocks have actually shown this time — but only for a single second. The idea was to capture and freeze this ephemeral moment, this entire system of time, in a brass object. I chose brass because early measurement instruments were often made from it.

There is another work — not about time, but also about how we structure our reality. I made it for a solo exhibition in Berlin. It takes the form of an ellipse and refers to the rapid movement of the magnetic north pole. The magnetic north pole has always moved, but in recent years it has been shifting extremely quickly toward Siberia. No one really knows why.

This uncertainty is something that deeply interests me in my artistic work — that even within science, there are moments where there is no clear answer. The movement of the magnetic north pole is one of those open questions: perhaps it could indicate a future pole shift, but at this point, we simply don't know.

What does it mean that the north pole moves? What does it mean that we have a leap second? Even when we think about time, the moment we try to define it, it becomes difficult to say what it actually is. And yet we rely on systems built around this idea. For example, many of our navigation systems depend on the precise position of the magnetic North Pole. But as it continues to shift, we have to constantly update models like the World Magnetic Model — otherwise certain navigation systems would gradually lead us off course.

For the work on the magnetic North Pole, *Under the Pole there lies a bare rock in the midst of the Sea*, I calculated how far the magnetic North Pole moves in one hour: 6.28 meters. I then translated this distance into the length of an ellipse, which I realised as a sculpture.

I try to find forms that allow for a connection — perhaps in a poetic way, or in a way that can be directly perceived. A way of relating the body to a phenomenon we are usually unaware of, or that is so vast that it escapes our imagination.

→ ⑬⑨ [Miriam Hamann] "The Future of Time" PART 2

Carla Richter is a doctoral researcher working on the foundations of quantum mechanics, within an experimental research group. Her practice sits at the intersection of scientific research and interdisciplinary knowledge exchange.

Quantum Thinking

Carla Richter

What value do you see in cross-disciplinary conversations around quantum?

I think it's important to me that people outside of science begin thinking about quantum physics, because it is becoming more and more part of the technological reality that surrounds us. Of course, this is a slow process, and it is still far from the reality that is often advertised — but at some point, it will be. And I think it's important that everyone has at least a basic understanding of what this is about — what it is, what it can do, and also what it cannot do. 147

As it moves closer to everyday life, we have the opportunity — also outside of science — to begin grasping how these principles, which are fundamentally part of our universe, actually work, even if we don't perceive them directly. The arts, in this sense, offer a kind of open space in which to engage with these ideas. 155

When I look at the works by some of the artists in this publication, the first question is, of course, how they relate to quantum mechanics. But trying to explain them purely in those terms would not make much sense. It is not the task of art to be scientifically correct — it can be more than that. If it were only about accuracy, it would simply become a way of teaching science.

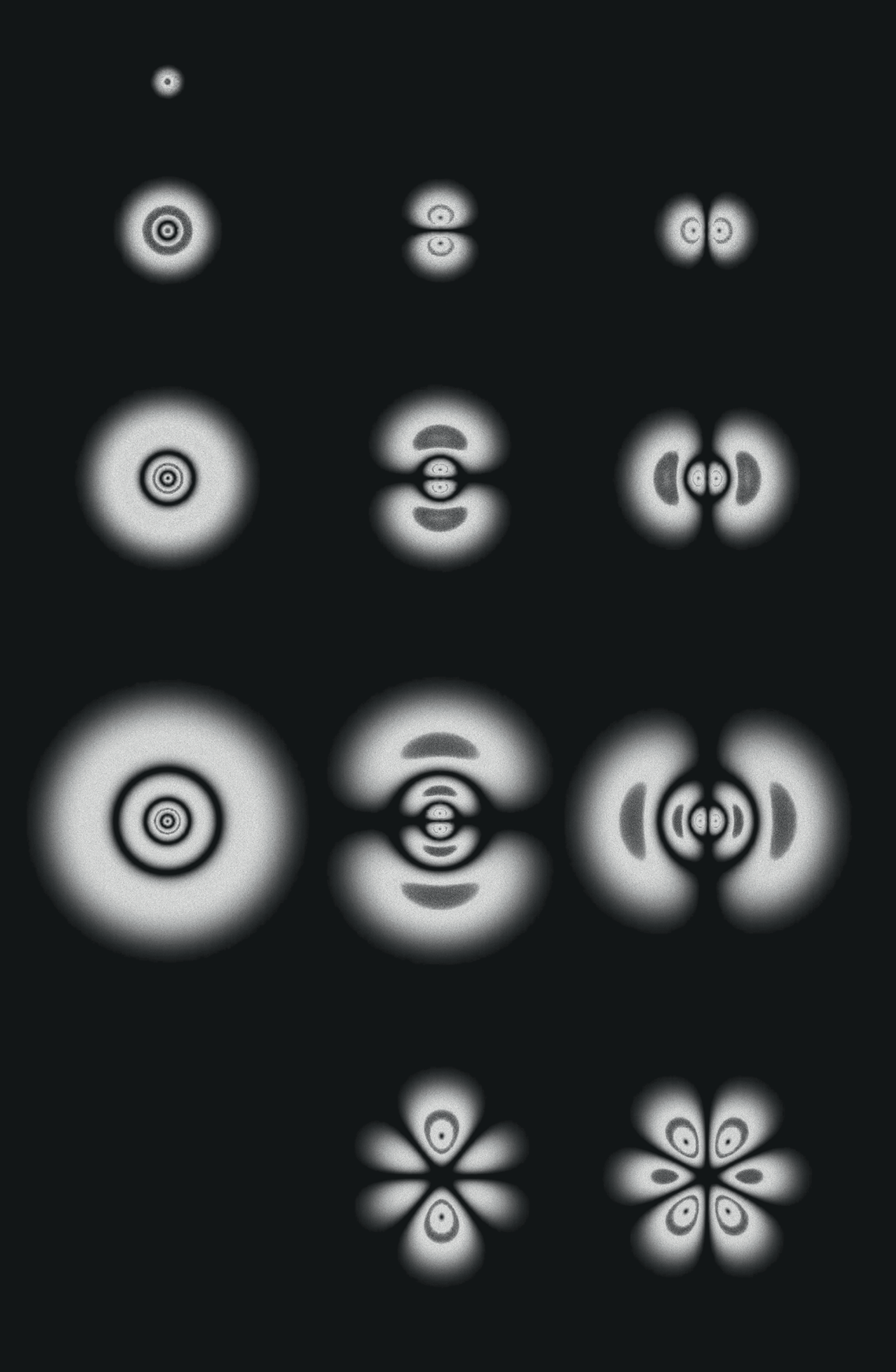
Instead, art can mimic certain modes of thinking that are specific to quantum mechanics, and take those principles somewhere else — into territories that science itself cannot reach. Having a sense of how these principles operate, and how they can expand creative thinking — that, I think, is the real potential here.

How do you feel about the way we teach science and the humanities in school right now?

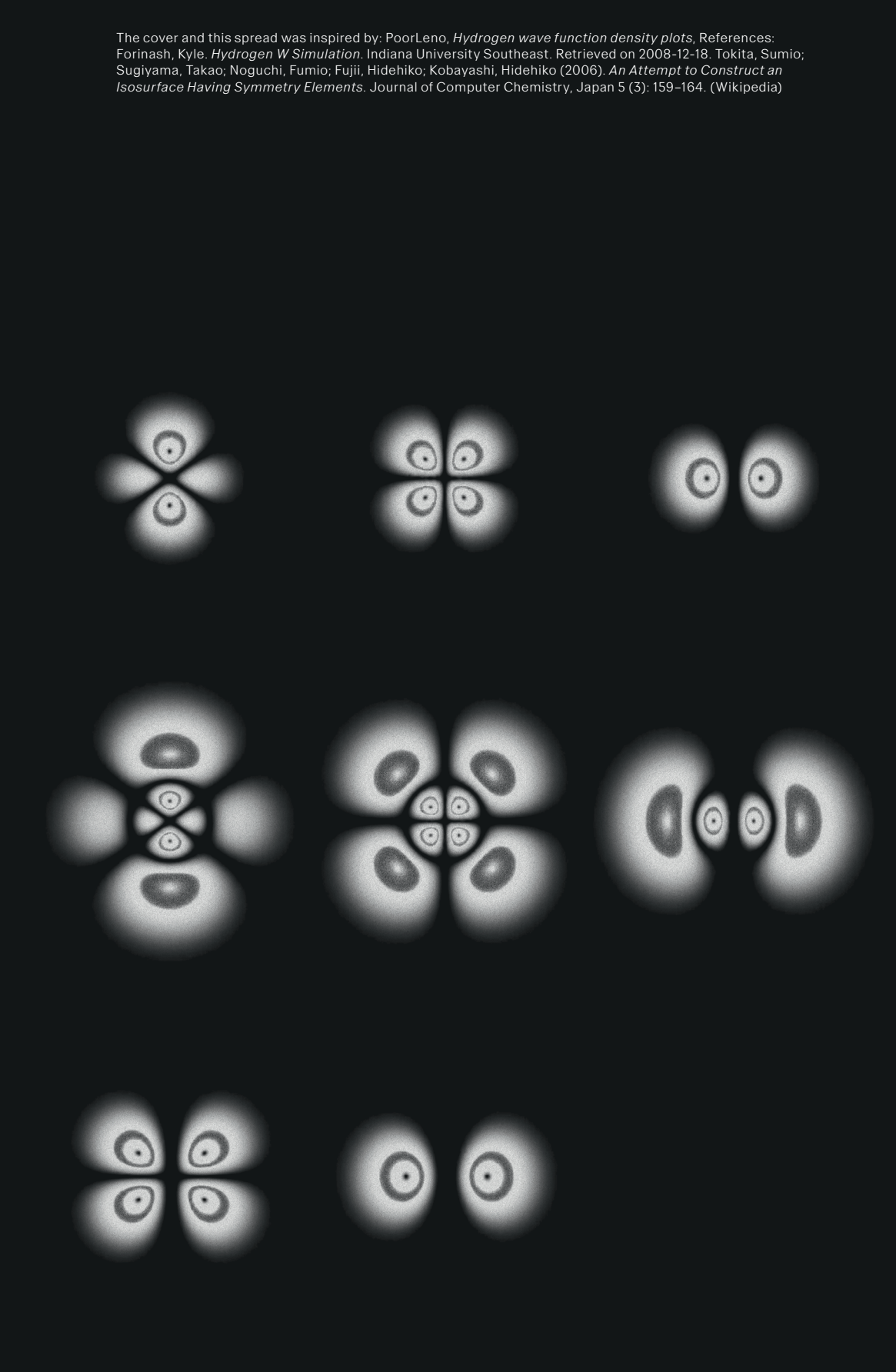
I think that in our society we may be focusing a little too much on a certain kind of knowledge. If you ask about the value of education, the answer you usually get is that it helps you get a good job. But that is not the real value of education — not in science, and not in any other discipline. Its value lies in helping us develop an understanding of the world around us, and in learning how to think about it. And I don't think this is really taught in schools, at least not in the way I experienced it.

During my studies, I also worked as a tutor. Some of the students I taught came from schools without traditional grading systems. They had very open, flexible ways of thinking. But when they moved into more conventional systems with grades, they often became so stressed that they struggled to cope — even though it was clear they had strong abilities and talent. We need both approaches, but it is difficult to find a balance between them.

→ (137) [Carla Richter] "Intersecting Imageries" PART 2



The cover and this spread was inspired by: PoorLeno, *Hydrogen wave function density plots*, References: Forinash, Kyle. *Hydrogen W Simulation*. Indiana University Southeast. Retrieved on 2008-12-18. Tokita, Sumio; Sugiyama, Takao; Noguchi, Fumio; Fujii, Hidehiko; Kobayashi, Hidehiko (2006). *An Attempt to Construct an Isosurface Having Symmetry Elements*. Journal of Computer Chemistry, Japan 5 (3): 159–164. (Wikipedia)



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PART 2

In Praise of Forgetting

We are building new tools that may allow uses that are still unimaginable now.

Obviously, there is an ethical dimension to quantum. We can hardly grasp what it is, and we don't really have the language to fully describe what it does, or what it might do. So there is a great deal of space for experimentation and imagination. But at the same time, we know it will likely give an advantage to certain governments or groups — whether through the ability to crack encryption or to develop new forms of military technology. This is, I think, at the core of the position that Manuel and I take in relation to technology: trying to avoid mystifying it, sometimes actively demystifying and normalizing it, but also revealing its material complexity.

Imagine a world in which all the messages you have ever written could be easily read and analysed by a quantum computer. We are talking about a world where errors — or rather, the ability to move past them — are no longer possible. As humans, we constantly make mistakes. We say things and later wonder why we said them. We regret them, we change our views. And socially, there is also a kind of forgetting — things fade, conversations are not remembered in full.

But imagine if all those messages — everything you have written on social media or in private chats — could be fully accessed and analysed. There would be no amnesty. A government could know exactly what you supported, when, and where, and could hold you accountable in different ways: denying you a visa, or even prosecuting you for beliefs you may no longer hold.

We are talking about the total analysis of everything — and that, I think, is deeply worrying. Forgetting is essential.

I was interested in the question of memory. In the end, the promises of computation are to record everything, to have access to everything — for everything to become a dataset. And, of course, all the infrastructure that makes AI and high-frequency computing possible comes at a cost: a huge expenditure of plane-

tary resources, and communities that are affected by the presence and operation of these data centers.

What we also know is that this data — which carries the promise of permanence, of outlasting our fleeting existence — in fact degrades, much like our own bodies. [25]

There is something we find compelling about quantum in this regard: so far, quantum computing relies on forgetting. The processes of quantum states, before they become measurable and are translated into the zeros and ones of classical computing, cannot be recorded. That data simply does not exist in an accessible form. In this sense, we might say that knowledge depends on forgetting.

This idea is very important to us — the right to forget, as it is often called, but understood in a much broader sense. For whom, and for what purpose, is data preserved? Who benefits from this vast accumulation of data on which certain companies depend? And how do we, as a society, remember meaningfully when we are confronted with such an overwhelming excess of information?

There's this great short story by Jorge Luis Borges that I really like, called Funes the Memorious (1942). It shows how important forgetting is. In the story, Funes falls from a horse and has an accident. After that, he remembers absolutely everything. He recalls all the shapes of the clouds at every single moment he has ever seen them. But because he remembers everything, he cannot distinguish the cloud at 4:10 from the one at 4:20. He cannot grasp that it is the same cloud, because each moment is entirely distinct in his memory.

In a way, he is cast into the infinity of the present. If you perceive everything in absolute detail, it becomes infinite.

So forgetting is essential in that sense, because it creates space for processing. It is in these gaps — like the intervals between the 24 frames that make up a second of moving image — that perception and interpretation emerge. It happens in this non-continuous space.

Now we rely on algorithms to do the work of processing, because there is such a vast amount of data that humans can no longer process it alone. So we depend on these extensions of ourselves — algorithms — and that

says something about our own capacity to process, to develop knowledge, and to think. New ways of thinking are emerging.

The more troubling side of this possibility of forgetting is the possibility of inducing selective memory. This connects back to the idea of transforming our reality into datasets. When we think about moving images today, we are constantly confronted with the growing — and increasingly difficult to challenge — power of large platforms. A central concern, both for creators and for audiences, is that we are being fed certain narratives shaped by data analytics — converging into constructed ideas of preference.

So it is not only about what we are allowed to forget, but also about what we are encouraged — or conditioned — to remember. This happens through carefully crafted images. And I don't necessarily mean at the level of overt narrative, but also at the level of micro-references embedded within a visual architecture, each serving a purpose. They guide perception, subtly shaping how we relate to others — to our parents, to political ideas, or to individuals, companies, or governments.

This is the more sinister side — the other side of forgetting.

There is a profound tension between remembrance and forgetting. That tension is always present, and there is no clear right answer. David Rieff, for example, wrote a book called In Praise of Forgetting (2016). He reminds us that one of the earliest memorial movements in the United States was led by the United Daughters of the Confederacy. They sought to reframe the American Civil War not as a war about slavery, but as a struggle for states' rights and regional power.

This shows how remembrance can also serve to preserve narratives that are deeply problematic — narratives we might not agree with today. In this case, it contributed to the idea of the "Lost Cause," shaping how the Civil War was remembered for generations.

What is at stake is that there will always be movements trying to reinterpret past events — whether to understand their origins, or to define commitments for the future. In Spain, for instance, after the Spanish Civil War — a war waged by fascist forces against a democratically elected government — tens of thousands of people disappeared. They were silenced for decades: during the dictatorship, and even throughout a long and incomplete transition to democracy.

So it is crucial that today there are efforts to revisit and redefine

that past — for relatives to recover the remains of their loved ones, and to come to terms with what happened. It is a way of reclaiming history from perspectives that were previously suppressed.

But this is not exclusive to that case. You see it in many contexts — in Colombia, in Bosnia. We are always, in the present, confronting past events that were selectively forgotten, yet continue to shape who we are.

There was a Black president in Colombia in 1861, and for a long time, almost no one remembered him, partly because he was in power for only six months. When the official presidential portraits were produced in France, he was painted as white. It was only about ten years ago that this was brought to light, when the historian Orlando Fals Borda came across a portrait that seemed unusual to him. So we are talking about the possibility of erasing the memory of a president from the history of an entire country. And if that is possible, what happens to everyone else — to day laborers, to enslaved people? If a president can be erased, what chance do they have? 29

The Politics of Instruments

There are lots of different ways of working with technology, and that's an important part of the Instrument Inventors Initiative. You're producing something that has a very strong innovation component and a series of capabilities that you share with the world. Maybe more as a question to you as a collective: have you seen, over time, ripples of your work reaching the mainstream tech space? Ideas that may have influenced larger organisations who make commercial technologies.

In our collective, the idea that we are artists working with technology is based on a fairly intuitive principle: we cannot simply leave the development of technology to large, for-profit companies with their own interests. We need other forms of engagement.

In our case, we engage with technology as artists in order to create our work. Of course, we do not have the resources of companies like Google or Amazon, but it is nonetheless our craft. So we try to be highly competent and take seriously the challenge of developing these instruments at a high level. 153

The work we are exhibiting now took two years to develop, but it is rooted in a slow process of more than ten years. This kind of approach is very challenging in the arts, because there are usually neither the resources nor the time for such long-term development.

Every circuit, every line of code takes weeks or months to fine-tune, in order to arrive at exactly the technology we need for this system. And it is not something we can simply buy — because no one else is building the same thing.

We have published several versions of our work as open source, so they are accessible. We also rely heavily on open-source tools ourselves. We work within that community, and that is important to us. Whether this feeds back into the commercial sphere — I'm not sure.

What I would say is that it's really about practice. Research — and the role of the researcher — is a form of practice. Perhaps we shouldn't draw such a strict line between research and the commercial sphere, but instead think in terms of a broader research ecosystem.

I would say that there is a strong desire to show that technological development is not something only governments or large corporations can engage with — but that individuals can also have agency within it. And by demonstrating this through our work, we hope others begin to feel the same.

People don't have to feel powerless in the face of developments like AI just because they don't know much about them — because you can learn. You don't have to be an engineer. You can educate yourself, experiment, try things out.

There isn't always a real barrier — often, we create these mental barriers ourselves. Here in Vienna, for example, there is a small fence around the museum. We wanted to place our work outside on the grass, but we weren't allowed to — because suddenly it falls under a different bureaucracy. It's prohibited, which feels a bit absurd. But it's similar in our professional lives. We think: I'm not competent, so I can't do that. Through our work, what we hope to inspire is the opposite: don't wall yourself in. Be courageous, be curious, be adventurous. We can all move more fluidly between these domains.

Maybe that is the ripple effect — that through cultural engagement, people begin to feel that even if they studied music and not artificial intelligence, they can still engage with it. And then, perhaps, everyone can participate in some way.

Corporations would like you to believe that technology is something you simply purchase from them. At III, we try to encourage a different mindset: that technology is something you can have agency over.

Hardware Unbound

We haven't exhausted the possibilities of the technologies we have dismissed. There is still enormous potential, and it is visible in the revival of different technologies. In the same way that, until a few years ago, we saw a resurgence of analogue filmmaking, vinyl, Polaroids, and so on — we are now beginning to see early digital cameras becoming vintage objects, and the early digital aesthetics of the four-megapixel camera returning as a kind of counter-movement to 8K machines.

I worked more in the media art sphere, where virtual reality was still at a very early stage and there were not so many works being presented. Then I made a VR work, and suddenly I was in contact with festivals all around the world — the major festivals dealing with virtual reality. It still amazes me how much potential there is in this technology. It is not ideal — it is quite difficult to work with these headsets — but at the same time it is also relatively standardised in terms of what festivals expect from the technology.

What fascinates me, and also scares me, is: why do we have this machine of almost limitless possibilities — something you put on your face, where you can create any kind of illusion?

And then there is the question of story and linearity. There are many VR pieces, and they are wonderful, with beautiful animations and everything, but they still follow a logic of film — a logic of the screen — which is a format limited by technology. You have one screen, one surface, things happen over time, you have editing. But here you actually have to think differently, because the technology allows you to think differently. It is illusion-based. And there is still very little work, and very little conversation, about how to use it to its full potential, which I find somehow disappointing.

Not to mention that, when we talk about the hardware, Meta is the standard — and maybe next year it will be something else — but it is very closed off. Knowing a bit about what it takes to build something for these headsets, it is often quite opaque what can and cannot be programmed, what can and cannot be influenced, where certain data comes from, and so on. Sometimes the headsets need to be connected to the internet. Why does a cinematic experience need to be connected to the internet in order to work? Only because these big

companies provide it like this. You don't have that when you buy a projector for your cinema.

There is a double issue — not only the technological monopoly on the hardware, but also how it is marketed and presented. There was this whole situation with Germany and other EU countries that could not sell the Meta Quest 3, because it requires you to have a Meta account to use it. Under EU regulation, you cannot sell technology that requires you to log into a specific platform. So you cannot use it without giving your data to Meta. And there is no other physical device in the industry at the same level at the moment — in terms of quality, usability, and the physical experience. And if you try to propose something else for a project, it is not accepted.

When I wanted to work with virtual reality, my first idea was to make an absolutely abstract VR experience — with not a single 3D object, no physical objects at all, completely based on colour and patterns, detached from the laws of physics. A completely different world. The whole process was very challenging. No hands, no tables, no ground. That immediately triggered difficult conversations about how you keep people oriented, how you build an environment.

Also, there still needs to be a strong narrative, rather than a strong experience, in order for the work to be shown within film festivals. I had a lot of experiences with documentary film festivals — somehow virtual reality and expanded cinema are closely associated with documentary formats. Often my work is "too abstract" for them. I find that reasoning fascinating.

Another problem is that I wanted to present the work both as an installation and as virtual reality, and many film festivals unfortunately do not work well with physical spaces. They do not have the infrastructure, the budgets, or the capacity to produce installations, even if they really like the work. 93

How can we rethink physical spaces?

In the Netherlands there is an organisation called 4DSOUND, a spin-off of the Utrecht School of the Arts, where I also studied. The founders of this company went very deep into spatial sound — into how you can create a space where you can move freely. It is not a cinema setting, but still there are sound objects around you.

I experienced it a few times. One experience that will always stay with me was at TodaysArt Festival in The Hague. It was a session where you could sleep overnight — they gave everyone a mattress, and you could lie down in an old electricity factory. They had this whole setup and invited artists to perform

throughout the night. I remember falling asleep to the sound of a person walking in high heels in a hallway, back and forth. And over time, the hallway seemed to expand — or the person seemed to move further away and then closer — so the whole room felt like it was expanding and contracting. It was such a strong experience to fall asleep to.

The spatial sound experience also became a very powerful collective experience — you arrive, walk around, explore the space and the sounds, understand how it works. Then you get a mattress, make your bed, and lie down for the night while listening to the live sound for several hours.

Dancing Equations

You explored the act of writing and debating equations with a collaborative performance involving quantum theorists. How did their perception of their own process change?

This collaboration was between the PhD Arts program at Leiden University — one of the few artist research PhD programs in the Netherlands — and the quantum theory program at Leiden University. It developed over the course of one year, with regular meetings, bi-weekly or monthly, focused on sharing each other's practices and processes. Within this process, it was quite interesting that we first had to learn and understand this entire body of knowledge around quantum physics — what it means, how quantum mechanics developed, how theorists and experimentalists collaborate, and what their working processes are.

By sharing our own process — practices that are deeply process-based, where we try to understand, allowing the material to influence the practice, and letting theory and practice inform one another — this development of new ontological ideas prompted them to reflect more consciously on their own ways of working. I think this was the most significant exchange, and the main value they gained: realizing that what they do also constitutes a form of practice.

This became particularly clear when they returned to the blackboard and recognised that chalk and blackboard are their preferred materials. Calculating on a whiteboard, however large it may be, is not the same as working with chalk on a blackboard.

They became more aware of this situation — of six, or sometimes up to eighteen people standing in front of a calculating device, the blackboard as a surface, as an interface — writing things out, trying to understand what they are writing, stepping back, negotiating what they have done, which rules they applied and why, and then moving to the next step, testing in theory what they are doing.

Then, moving into the laboratories — where what the theorists calculate is carried out — they also became more aware of how they select a device, how they position it within the experiment. This is actually crucial for physicists: to construct the experiment and test it, because we are still in the process of trying to understand which parameters can be meaningfully grasped. 75

Tuned In

There is a choreographer and artist we've been recently obsessed with, since we're talking about dreams, nightmares, obsessions: her name is Eiko Otake. She was born in Japan, and her research is around atomic literature — she goes to places like Fukushima and brings her historical studies into a movement laboratory. You are a dancer: what question are you wrestling with right now when it comes to perception and embodiment and your own research?

I think what is there is doubt — doubt shaped by stress, by not having enough time, by everything that needs to be done. The agenda-driven mind, moving almost algorithmically from one bullet point to the next. And on the other hand, there is this sense of wondering — where the next good idea might be hidden, what has inspired me. And both of these tendencies seem to lead to the same thought that relaxes me: that there is a kind of field of ideas, and a field of technology, from which — if you are tuned in the right way — you can receive something. And if you are tuned differently, you receive something else.

This connects to an idea I came across in the book Other Minds by Peter Godfrey-Smith (2018), where the evolutionary process of very early life is described. Before there was ice, when everything was still in the water, there were only particles, molecules, and tiny organisms. And yet, at a certain point, multiple organisms developed eyes — more or less simultaneously. Why? Because there was a need for eyes in the world. It is almost as if this capacity exists like a kind of idea-technology, and different organisms access it at the same time.

This connects, in a way, to the fact that around 2,600 years ago, Laoist thinkers in China and Siddhartha Gautama in India — thousands of kilometres apart — both arrived at a conception of the self as a kind of thinking pattern. More or less in the same century, they developed philosophical approaches to the nature of the self. It feels as if there is some kind of transmission — a kind of "radio," a tuned system — that we can connect to, if we are attuned in the right way.

It's similar with artistic ideas. As Mike Rijnierse said the other day, once you create an object, once you make an artwork, it begins to take on a life of its own. It exists in the world, it moves through it. It will be seen when it is ready to be seen, and it will travel when it is ready to travel. And the only thing you can do is let it go. And that calms my mind.

Measuring Our Thoughts

When you said that if you're just in the moment, there is no story — that struck me. In *When We Cease to Understand the World* (2021), Benjamín Labatut says that for the practice of writing you need longing — that Buddha wouldn't be able to write, because writing requires this dynamic state of thinking.

Do we think with words, or with images? Do we make sound visible in our mind? Like with those instruments that detect gravitational waves and turn them into signals that materialise technologically into sound.

We only hear because we have a kind of drum in the ear. It's just air moving something. And of course, you could say gravitational waves in the universe are influencing the air as well, but our hearing is very limited.

After waking up, I very rarely think about something I heard in a dream. I'm not even sure if I have sound in my dreams — it's more like images, or not even exactly images, more like stories. But there are people who have very audio-influenced dreams. 107

Some things we don't want to measure. We want to think that we are all in the same time, in order to survive together. You asked, does quantum help to measure everything?

And this story about quanta being measurable but not measurable at the same time — that you can only know one of two things about them — says a lot about us as well, I think. That we even want to measure it. We want to go smaller and smaller and smaller. Where does it end? Does it ever end? We don't know. And if it's infinite, what is the actual…

In a way, I find this idea very interesting in connection to language. I don't know if you've heard about the concept of the Metatron — it's also in the movie Dogma. It's this idea of an angel being the voice of God. Because God does not speak, there has to be a channel to communicate with people.

The idea that you have an entity — because we are always trying to find names for everything — we have this language, and also mathematics, that we use to describe what is happening, or not happening.

This idea that there might be an entity that knows all the names — that is also the story in the Bible, at the beginning, where God creates the world and gives everything a name. Because only if you can refer to everything, you have the most power. If you are the one who can name everything, you are a kind of superpower.

And then the idea that this entity cannot communicate directly, but needs someone else to do it — like a translator. This also connects to meditation, because if you sit in front of a pile of small pebbles, you might just think: pebbles.

You know the idea that people who live in very specific environments have more names for what surrounds them — people living in snow have many more words for different kinds of snow. If you are more involved with something, you need more names for it. Whatever field you work in, you have words for things that others don't.

If you are sitting in front of pebbles, there aren't many people who need a name for each one. But maybe it's your thing and you know every pebble by name. Then you have this ability of naming them — but maybe it's not really a superpower, because no one else is interested.
There's this question I once saw — if the devil comes and says, I grant you one wish, what would you wish? And someone said: all languages. And I thought, yes, of course.

It's interesting now because with AI, instantaneous translation is becoming very significant. I read about that and it fascinated me. What is it going to do to languages? If people in different countries speak their own language and rely on AI to translate, without learning other languages — what happens then? Do languages change less, because they are less influenced by each other? Does it lead to more separation, more nation states, even more than now? I don't know.

Intersecting Imageries

Artistic research is not a way of giving oneself the license to be incorrect. But it's neither just about scientific knowledge coming out of the lab, arriving in the artistic field and being used to create artworks. And it is also not just about using art to educate.

The question is: can we create a space for productive exchange, one where artistic research also finds its way back to the lab? What place does image-making have in the lab? Does it need to be mediated? 85

I think that's a very hard question. I don't think I can give a definitive answer. I also cannot really predict how this impacts me right now. What I do believe is that once a certain kind of thinking — the kind that comes with science — spreads through culture, it eventually returns to the beginning, to the way we think.

If you consider when clocks became more present, suddenly everything — even the human body — was described as a clock. You see those images from the end of the 19th century. Then there is the steam engine, and again, images of the body shaped by that — how humans understood themselves through that machine.

And if you go further, you have the internet, and suddenly, if you look around, everything becomes somehow web-shaped — the illustrations we create, but also the way we think about things. I often imagine society as a web, and I sometimes wonder whether this comes from the back-and-forth between the images we receive from the World Wide Web and the way we structure our thoughts.

And I'm interested in what happens if quantum mechanics reaches that stage — where it begins to shape how we observe and think about things. I sometimes wonder how it may have already changed my own thinking, simply by learning it. I find it quite difficult to say, but I find it very interesting to observe what happens.

The Future of Time

A leading physicist at the Atominstitut Wien, Thorsten Schumm is developing a new prototype of a nuclear clock, a device with the potential to be the most precise clock ever built. What changes after the discovery of more precise time?

I once calculated the total number of seconds in a year, and I made a book where I integrated all of them as dots. Every dot in the book is a second, and every page appears as a grey monochrome surface — but if you look closer, you see it is made up of all these dots. Each dot is a second, and the whole book is a year. My idea was to thumb through a year — because if you think about a second, it is already gone. I believe you cannot really grasp time.

In our conversation, Thorsten Schumm said: "You know, you can imagine that what we are doing is dividing one of your dots into a certain number of even smaller dots." It's very interesting — they are developing such a precise clock that, I suppose, soon becomes the reference for our timekeeping. But at the same time, he told me that the measurement systems we currently use cannot yet integrate this level of precision, because they don't know how to handle it.

What he said — and what is interesting to him — is this idea of digging deeper into something. And I think that's something I can strongly relate to: this question of how reality is shaped, why it is shaped the way it is, why we have constructs like time. There are people in the world who do not live with these precise measurements of time. And also — is time even something we can truly measure?

Your book project reminds me of kineographs — pre-cinema flipbooks that used paper and mechanics to generate the illusion moving images. Some of these questions in your work are also being asked by artists working with time-based media. What are the implications for time-based media?

We live in a constant state of change, in a constant state of flux. When we perceive movement — or even an image — it is not only a question of physics, but also of perception. I researched the documented retrograde motions of Mars and translated these trajectories into new works using neon.

At certain moments, when the Earth overtakes one of the outer planets from its inner orbit, it appears as if we are seeing a backward

motion — but this is also an optical illusion. The work becomes even more dynamic on a physical level, as photons are continuously emitted from the neon.
Everything is in constant transformation, and this is something artists often engage with in time-based work: the tension between what we perceive and what is, in fact, always changing. 97

New Paradigms

How do we balance imagination and education, mediation and research?

This is the art of doing science. On one hand, you need this big picture, this vision, the moonshots — what can I do with the technology? But on the other hand, you have to divide your work into digestible pieces: things you can do in the next six months, things you can do in the next twelve months, that are also representable at the scientific level. Everyone can speak about the power of quantum computing and moonshots — that's nice. But finding a piece of work that you can actually do, and proving that it works, or that it doesn't work, or how it works in a certain area — this is what truly makes it interesting for me to be a scientist.

I'm very happy to come into the office in the morning and talk to my PhD students and postdocs, because I'm constantly interacting with them, trying to identify these digestible pieces of work that we can pursue as scientists.

My approach to quantum computing came from classical infrastructures. At some point I understood that this field was not going to grow anymore — at least not at the same pace — because we are reaching physical limits. So I started to look into alternative infrastructures.

I think the first time I really began to look into quantum computing was during the first lockdown in Austria. The world was so insecure — everything was breaking down, everything felt like it was falling apart. The world we knew was suddenly unstable. Maybe I also started because I finally had time. The classical schedule — office work, conferences — stopped. And I began to think about it. Then I called some colleagues from the physics department and asked: I have to combine quantum computers with classical machines — who can explain to me how to do that?

"I'm not the right person, talk to someone else." I called another. "I'm not the right person either." And then they pointed me to someone else. They were in Innsbruck. We talked for three hours. Okay, let's do something — this is a good idea. They explained to me how this machine works. I explained to them how data centres work. Let's write a proposal. We wrote a proposal. We got six million Euros. And then we started working.

Sometimes you have to be pushed. Sometimes you have to be in an uncomfortable situation. Sometimes you need this insecurity, this instability in your life, to look in another direction. And that was, for me, the push. During the second lockdown, we still were not allowed to be

in our offices. So I had meetings with physicists while walking through Vienna — it was so empty — and we discussed. It was a personal crisis, a global crisis, that pushed me to look in a new direction. I don't know — maybe if we hadn't had that first lockdown, I would not be doing what I'm doing today.

If we try to imagine the coexistence of quantum and traditional computing in terms of its physical engine and data infrastructure, what would it look like in the near future?

We are already building the first hybrid classical-quantum machine. When we started, it was one of the first in Europe. It's called HPQC — High Performance Integrated Quantum Computing. I started looking in that direction because I realised we need some fundamental change in computer science.

What I have perceived since then is a certain fear and resistance within computer science, because people don't want to engage with this topic — it is so different. Computer science is a very rigorous discipline. You have to understand every tiny detail and verify everything. And this is something completely new. I feel the resistance, I feel a lot of scepticism in the field. This is justifiable — no one knows whether this is going to take off in a way that is commercially viable.

I personally believe that even if we have this highly efficient technology with the potential to change how we do science and operate our society, there is not going to be a free lunch. To make it usable, a lot of infrastructure has to be built around it. In the long term, there won't be a free lunch when it comes to commercial success and utilization. But we still need it, because the old systems are no longer sufficient. 47

When classical and quantum machines coexist, what kind of problems could we solve and what resources would we need?

The best case — when we talk about quantum advantage and what quantum machines could do for us — is to find problems that are not solvable on classical machines. Something so complex and so difficult that it simply cannot be solved classically.

If you translate this into something useful for society, it would mean simulating climate change in a way that demonstrates conclusively that it is real and happening. That would be extremely valuable — large-scale simulations that are not possible on classical machines, creating scenarios that everyone could verify. You couldn't simply deny climate change anymore.

Another scenario is personalised medicine, and eventually preventive medicine — identifying diseases such as cancer before they even begin to develop, and intervening early. You need enormous computational resources to simulate the human body, organs, and processes. This is also likely beyond classical machines. But it would be profoundly beneficial — something we cannot achieve today.

It's not a matter of quantity and computing power — it's the nature of computing itself.

Yes. The machines need a completely different level of efficiency. This goes beyond simply being faster or more powerful.

In the worst case, quantum machines will not take off. We might not find any commercially viable applications in the next 10 or 20 years. But even then, science will still benefit from what we are doing. We are developing new skills and approaching problems in fundamentally different ways. I already see it everywhere — this strong interdisciplinarity, where physicists, computer scientists, and mathematicians work together.

Even in the worst case, we are developing capabilities that might lead to something even more advanced in ten, twenty, or thirty years. We are developing new scientific practices.

Going back to the connection with the social sciences — perhaps through this lens of developing new scientific practices, new modes of intuition, new ways of building realities, new ways of speculating about what's possible... What is the most productive interaction between your research and the social sciences that you hope for?

I want to see the interaction with the social sciences expand. What does it mean, on a societal level, when we have this kind of infrastructure? What does it change?

We are already seeing that to excel in a field like quantum, you need collaboration across disciplines — mathematicians, computer scientists, electrical engineers, and others.

One key area of interaction is education. I think we need to rethink classical education systems. I come from a scientific background, so I'm very aware of how the current system works. And fundamentally, not much has changed in the last 150 years — the same 45-minute units, the same class structures, around 25 students. But today, there are so many opportunities to rethink this.

We can use AI to create personalised learning environments, allowing people to learn at their own pace. Some students are more advanced, others less; some speak German, others don't. We no longer live in homogeneous societies. In Vienna, for example, you have children from many different countries who don't speak German. How do we respond to that?

These infrastructures could fundamentally transform how we educate people. How do we make learning more engaging? How do we use virtual environments? How do we create individualised learning paths?

Then there is the medical system. People are living longer — which is good — but we don't have enough caregivers. How do we design systems that allow people to age healthily and remain independent for as long as possible?

There are fundamental aspects of our society that no longer scale. Ideally, every child would have an individual teacher — but we don't have the resources. Computational infrastructures could help address this — in education, in healthcare. And here, the role of the social sciences is crucial: to help shape these systems responsibly.

This also applies to how we generate and share information. Media has changed dramatically. Twenty years ago, information was filtered by journalists. Now anyone can publish anything. How do we ensure reliability and verification? Everything has changed. The question is how we can use new technologies — including quantum computing — to understand this shift and develop new models of information sharing.

It's not just about communicating the results of your research in a digestible way, but also about providing use cases for further research.

You need social science as a mediator between all stakeholders: politics, society, education systems. These stakeholders require mediation.

In a way, this already answers the question about new ways of world-building. The classical reductive definition of art–science interaction — art inspired by science vs. science explained by art — has guided much interdisciplinary research so far. What you're describing is more complex: a dynamic interaction, a reciprocity.

I see art and science as equal partners — finding their own space of interaction, and needing to remain equal.

Quantum Advantage

Quantum advantage is not just about getting an upgraded engine for economic and technological progress, but also activating a catalyst of further inequality. If our education infrastructure is designed to achieve quantum advantage, perhaps it ought to consider how it affects daily lives too. Is this where the opportunity lies for new forms of storytelling?

You're expanding the definition of advantage, and I think that's a very good point. Currently, when companies or the media discuss quantum advantage, they refer to a very specific moment — the point at which a quantum computer outperforms a classical computer at a particular task.

As storytellers, we should consider a broader definition of advantage when it comes to new technologies — not just quantum, but also AI and supercomputers, since these technologies will likely operate together. The question is: how can people use these technologies effectively, and how can they share their stories in ways that help educate the next generation? I find this perspective interesting, and it's not discussed often. Perhaps we need to look at it differently.

I am personally very curious to know when quantum advantage will be achieved, as it is a crucial milestone. Many people are dedicating their entire careers to making this technology work. As a science journalist, I've always been interested in covering physics — especially stories and experiments that unfold over a lifetime.

I believe quantum will be different, though. I think we will reach quantum advantage relatively soon, given how close we seem to be and the milestones that suggest these machines may surpass classical ones. If we look back just ten years, the progress has been remarkable — it was far from obvious then that we would be where we are today.

The search for dark matter offers a useful comparison. Scientists have been investigating it since the 1930s, and despite numerous experiments — both on Earth and in space — it has not yet been directly detected. We have indirect evidence, but no confirmed particle. Many researchers have devoted their entire careers to this search — some have even retired without seeing a definitive result — and still, the search continues.

What I find fascinating is that even negative results are valuable in science. They provide constraints and help refine the direction of inquiry. With quantum, however, it feels like we are converging toward a breakthrough that could have a significant impact across many fields.

If we fast-forward 15 or 20 years, quantum may become a mundane technology. People might use it through the cloud without thinking about how it works. A pharmaceutical company could discover new drugs at the press of a button, with quantum computers operating in the background — without much awareness of the underlying processes. It could become an ordinary part of everyday life.

But we are not there yet — and that is precisely what makes this moment so exciting for storytellers. We are in a position to narrate the past, present, and possible futures of quantum. [141]

The Limits of Interdisciplinarity

We ask artists how ideas around quantum theory and computing are informing their practice, because we are interested in understanding what a meaningful interdisciplinary collaboration looks like. From your perspective, what is the value of connecting different frameworks of research?

The first thing is — it's very flattering to have so much attention given to my research field. Since I started my studies 10 years ago, the field has evolved dramatically and has come much more into focus. That's also a bit scary. Suddenly you're not just doing research anymore — there is a political dimension to what we do. There are also conversations about this in the arts. It's fascinating to see quantum physics from different angles.

There's a difference between simply doing research and engaging with it more broadly. In the end, research is grounded in a mathematical foundation. If I'm a theorist, I have to formalise the thought I'm having at some point — otherwise it's not considered reproducible, not properly formalised, not a theory in physics. At that point, you move a bit away from easy collaboration with artists, because the mathematical aspect of the work can become a kind of barrier.

On the other hand, when you think about how to present things, and how to reflect on yourself as a researcher — that's something I personally learned a lot about, especially through what you might call artistic practice. Take the idea of the "dance of calculations" that we filmed. We took intermediate snapshots at regular intervals — a kind of long-term photographic series of us calculating on a blackboard — and it really does look a bit like a dance. If you make a film out of that, it's quite funny to watch, but also interesting, because we see things in it that feel very natural to us. When we showed it to artists, they asked: how does this actually work? How does this small group of three or four people calculating in front of a blackboard communicate? That outside perspective is really interesting to me.

I was thinking about the role of the outside. When you said quantum has been moving with you — what perspective did you bring to the field when you started?

If you're studying physics, the first time you really encounter quantum physics is usually in your third or fourth semester of a bachelor's

degree. Then you can decide whether you want to continue with it in your master's. I did, and during the PhD you begin to scratch the surface of new topics.

About a year into a PhD, there is a somewhat unsettling feeling: have I actually learned anything at all? The problems are difficult, and progress is slow. After one year — which is already the full duration of a master's research project — you often feel like you've achieved very little.

The moment I realised that I had actually learned something was when I started talking about it. They call it an inverted summer school — instead of going somewhere to learn, you go to teach. You still learn from others, but you are also expected to teach. Suddenly I realised that I could speak about my research topic for two full lectures, and I wasn't even afraid. That was when my perspective shifted. It was an empowering experience.

The biggest leap I took was with a friend who was also doing a PhD at the same institute. We started a two-and-a-half-week program on quantum for high school students in Germany. The course began with very basic concepts — what a matrix is — and two and a half weeks later, we were programming a quantum algorithm with them. In terms of complexity, that means going from the first semester of a bachelor's degree to the second semester of a master's in just two and a half weeks. It was a lot of fun, and it worked.

From there, we began to branch out. We worked on a book project, discussed with students how to create a comic book about quantum physics, and later I started collaborations with Anke Haarman and Leon Lapa Pereira.

It's a gradual process. You become more and more familiar with the kinds of formats through which you can talk about physics in an understandable way. You also learn to find a level at which you can communicate with others. In everyday academic settings, we use terms like Hilbert space operators, entanglement, entropy — very specific concepts that structure our arguments. But there is also a way of speaking about physics without relying on that terminology. And I think that's what fascinates me — that you can talk about physics without overwhelming people with jargon. 27 115

Quantum P°p

A lot of popular culture has been growing off the back of some of these quantum ideas. You are in a unique position to witness many perspectives, working with theoretical physicists, quantum researchers, filmmakers and artists, all in the same context at CERN. So much over there — literally and metaphorically — remains beneath the surface. How do you see these interactions evolving?

There is a physicist I particularly love: David Bohm, a theoretical physicist who also worked in quantum theory in the 1970s. He had a somewhat unconventional approach to understanding reality, matter, and consciousness. He always argued that to grasp the abstract concepts of quantum physics, we need metaphors, images, and stories.

Thinking about what you were mentioning around pop culture, there is a video essay by Günseli Yalçınkaya, a writer, artist, and researcher who has been tapping into the influence of quantum "woo" on social media. This phenomenon translates into many different interpretations through memes and visual imagery, circulating with the virality and speed we are used to today. She makes this beautiful argument that quantum enters culture through narratives, not through science, because we don't have the capacity to understand science — so we need those narratives, whether through memes, a video essay, or a poem. That's how we actually try to understand, or begin to get closer to, these ideas.

At the same time, science — quantum physics in particular — does not exist in a vacuum. It exists within a very specific cultural and political fabric from which it emerges, and at the same time it also acts as a cultural driving force. So it becomes a circular loop. We sometimes think artists and scientists have different languages, and that they navigate and articulate their work in very different ways. There is this constant circulation — they need each other to fully understand what their own practices are about, especially given the abstraction and complexity that quantum physics entails, as well as the philosophical and political implications it carries.

Generative Reality

What is the spark that starts a film project for you? Where does it begin?

It normally begins with a text. And the text, to be honest, comes less from me wanting to talk about something specific, and more from an almost pure stream of consciousness. Each chapter happened almost — not accidentally, but I didn't have a plan when I started writing. I wasn't thinking, now I want to talk about this or that. It just happened. And I guess it coincided not only with what I was reading or thinking about at the time, but also with a response to whatever was happening in the world.

Even though this film has been made over two years, the AI software has been the same throughout — but there have been new upgrades with each chapter. So you can see how my own AI practice has evolved very quickly 67. We went from very basic, animation-like images a year and a half ago to now achieving almost photorealistic moving images, which I never thought I could produce from my living room just a few years ago.

And in this last year and a half, we also went through two different administrations in the US, new wars, a massive shift in mentality around geopolitics. So I guess everything feeds into the movie — this idea of how unstable reality is becoming. For the last twenty years, I think everyone has been living between the physical and the digital world. And now it feels like we are adding a third layer — this generative reality, which is still pretty new and we don't really know what it is yet. So the movie also reflects those anxieties, but also hopes — a mix of both.

Has your process become more solitary?

That's what has changed. The core of my practice, since I started making work, has always been moving image. And up until now, most projects have had at least 20 people working on them — often 30 or 40, and sometimes crews of over a hundred. And now I can work without leaving my house, for the first time ever. I don't quite know what to think of that yet, but it's pretty amazing.

Open Stuff

What was it like to be an early tester in the OpenAI Alpha Artist community?

I've always been an advocate for open source workflows. In 2022, for my first movie, I worked together with AI system architect Onur Olgaç, and we developed custom open source workflows that we ran on our own machines. So I really understand what it means — in terms of computation and energy — to create an AI-generated film.

Somebody from OpenAI saw the film at a festival in Japan, and I believe that's how they contacted me, although I'm not entirely sure. In the beginning, it was a bit of a struggle, because even though they are called OpenAI, the system itself is not open — it's a proprietary tool. For many ethical reasons — the same ones that led me to work with open source tools — I was initially reluctant. But at the same time, I'm curious. I'm an artist, I want to explore new tools, and I'm also aware of the limitations of my own hardware compared to the infrastructure of a large tech company. So in the end, I accepted their invitation.

As artists, we were invited to test Sora, their tool for generating moving images. There were around 100 to 200 participants — a kind of community — including designers and others engaged with the philosophical discourse around AI. The idea was to push the limits of the system, to explore how it works and what it can do. This was also for the benefit of their developers, who do not experiment in the same way — they wanted us to engage with the tool through artistic exploration. Most of the time, the exchange with other artists revolved around experimentation — trying out new approaches and possibilities. There was rarely a deeper philosophical discussion about the risks or implications of AI. And of course, OpenAI itself did not encourage that kind of focus.

Quantum Gh°sts

When we look back at the history of science, there are very interesting moments where you can say that scientific paradigms fail, come to an end. In these very special moments, interesting creatures like ghosts, demons, or other so-called supernatural beings are often introduced by scientists. Science has a long history of explaining away supernatural entities and providing rational narratives for their existence. Yet again and again, ghosts make their way into scientific theory-building.
Right now there are many unresolved issues in the natural sciences — in physics in particular, and even more so in quantum physics. Quantum physics is teeming with ghosts and demons and other curious entities that point us toward areas where unresolved issues remain, where we still need to push the frontiers of our knowledge.

The field of quantum physics introduced a new substantial level of indeterminacy in scientific research. Is this what brought the ghosts out of the box?

Yes. These indeterminacies or uncertainties arise from many different angles. I couldn't point to one direction and say, here is where all the problems come from. It's really a curious manifold of issues on very different levels — foundational issues. We still have no clear understanding in quantum physics of what space is, what time is — and yet these are the very basic entities you would usually need to start building a scientific theory. Even though there are still so many loopholes in the foundations of quantum physics, it works, and we use it on an everyday basis. That's a curious combination, I think.

I think quantum physics is just another paradigm shift in physics that we have witnessed over the last 200 years. In Newtonian physics, for more than a hundred — even two hundred — years, people were certain that everything functioned like a big clockwork. That kind of science made sense and was totally predictable. It was seen as God's creation, therefore it was perfect. By the end of the 18th century or the beginning of the 19th century, physics was considered complete. There was just one tiny question left to answer, and no one was very enthusiastic about physics

or expected anything new to come out of it. That was a major misconception.

That one small question shook the foundations of physics. Quantum physics, as it emerged in the 1930s, was one of the ripples produced by the debris of an explosion of an entire system of thinking. It began with rays — with the invisible. It doesn't feel intuitive to learn that there are rays — electromagnetic radiation, atomic radiation, radio waves — things you cannot see that pass through your body and make your bones visible. People did not expect that.

Marconi, the Italian radio pioneer, used electromagnetic waves to broadcast around the planet without really knowing how it worked. I think we are somewhat in the same position now. We can point to certain things and say, okay, this works in an experimental environment — but the rest is still missing.

The whole idea of this ghost world of spiritism emerged at exactly the same moment. That's not coincidental — they are two sides of the same coin. Today we tend to mock these ideas. But if you read Marie Curie's diaries, she was part of a spiritist circle in Paris, and she was convinced that radioactivity might open doors to the afterworld. And if you read the biographies of the pioneers of radio technology, you will find that many of them were spiritists.

We can downplay this, but I think it's necessary to allow this kind of wild thinking — to have an unlimited imagination. Because only these ideas create stepping stones into the unknown. I see myself as a chaser of ideas, following them from where they started to where they are today. And that is the objective of our work — to show that certain ideas are actually necessary to produce progress in science and technology.

If you think you have reached the end,
take another path...

“Nothingness is not absence,
but the infinite plentitude of openness.”

Karen Barad, *What Is the Measure of Nothingness?* (2012)

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