

SCIENCE GALLERY



DARK MATTERS

ACKNOWLEDGEMENT OF COUNTRY

The University of Melbourne acknowledges the Traditional Owners of the unceded land on which we work, learn and live: the Wurundjeri Woi Wurrung and Bunurong peoples (Burnley, Fishermans Bend, Parkville, Southbank and Werribee campuses), the Yorta Yorta Nation (Dookie and Shepparton campuses), and the Dja Dja Wurrung people (Creswick campus).

The University also acknowledges and is grateful to the Traditional Owners, Elders and Knowledge Holders of all Indigenous nations and clans who have been instrumental in our reconciliation journey.

We recognise the unique place held by Aboriginal and Torres Strait Islander peoples as the original owners and custodians of the lands and waterways across the Australian continent, with histories of continuous connection dating back more than 60,000 years. We also acknowledge their enduring cultural practices of caring for Country.

We pay respect to Elders past, present and future, and acknowledge the importance of Indigenous knowledge in the Academy. As a community of researchers, teachers, professional staff and students we are privileged to work and learn every day with Indigenous colleagues and partners.

SCIENCE GALLERY AT THE UNIVERSITY OF MELBOURNE

Exploring the collision of art and science and playing a vital role in shifting our understanding of science, art and innovation, Science Gallery Melbourne is part of the acclaimed Global Science Gallery Network pioneered by Trinity College Dublin. Science Gallery Melbourne builds on the success of the Network, bringing a southern hemisphere flair to its innovative models of engaging 15-25-year-olds with experimentation and creativity.

The University of Melbourne is Australia's leading university, ranked #1 in Australia and #34 in the world (Times Higher Education World University Rankings 2023). Our distinctive Melbourne experience helps graduates become well-rounded, thoughtful, and skilled professionals – making a positive impact across the globe. Our research helps solve social, economic, and environmental challenges the world is facing today and into the future. We're tightly connected with our communities, at home and around the globe – a connection that enriches our learning, teaching, and research.

DARK MATTERS is an exhibition created in collaboration with Arts at CERN and the ARC Centre of Excellence for Dark Matter Particle Physics exploring the fundamental essence of life and the universe, and how so much of it remains a mystery to us. Dive into the unseen, the unknown and the unspoken – will we ever fully understand the invisible forces at play in our own lives?

In this zine we bring together creative responses to the themes in DARK MATTERS from our curatorial panel and some of our advisory group.

Dr. Ryan Jefferies
Director,
Science Gallery Melbourne

Tilly Boleyn
Head of Curatorial,
Science Gallery Melbourne

Mónica Bello
Head of Arts at CERN

Alexia Yiannouli
Curatorial Panel

Ebony Ciarrocchi
Curatorial Panel

Elena/Eli McGannon
Curatorial Panel

Jess Vovers
Curatorial Panel

Teaka Williams
Curatorial Panel

Prof. Alan Duffy
Expert Advisory Group

Alicia Sometimes
Expert Advisory Group

Daniel Tapia Takaki
Expert Advisory Group

Diego Blas
Expert Advisory Group

Prof. Elisabetta Barberio
Expert Advisory Group

ARTISTS IN DARK MATTERS

Alan Bogana

Alicia Sometimes & Andrew Watson

Anne Pfeifer & Bernhard Kreutzer

David Hochgatterer

Jon Butt

Julijonas Urbonas

Lawrence Leung, Dr. Vyom Sharma
& Dom Chambers

Marc Vilanova

Patricia Domínguez

Random Quark

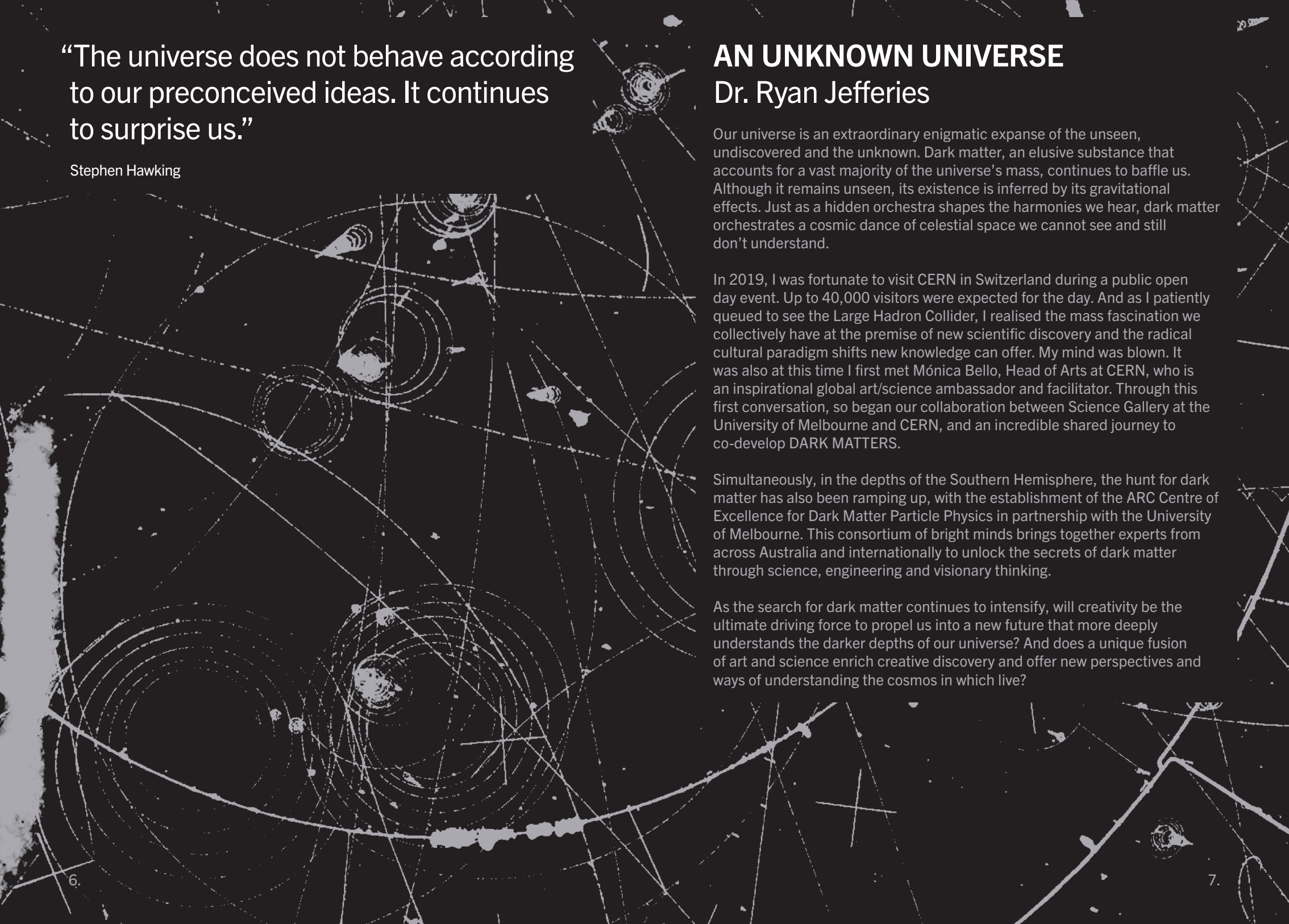
Robert Andrew

Semiconductor

Suzanne Treister

Yunchul Kim

This zine was edited by Bern Hall
and designed by Forde + Nicol



“The universe does not behave according to our preconceived ideas. It continues to surprise us.”

Stephen Hawking

AN UNKNOWN UNIVERSE

Dr. Ryan Jefferies

Our universe is an extraordinary enigmatic expanse of the unseen, undiscovered and the unknown. Dark matter, an elusive substance that accounts for a vast majority of the universe’s mass, continues to baffle us. Although it remains unseen, its existence is inferred by its gravitational effects. Just as a hidden orchestra shapes the harmonies we hear, dark matter orchestrates a cosmic dance of celestial space we cannot see and still don’t understand.

In 2019, I was fortunate to visit CERN in Switzerland during a public open day event. Up to 40,000 visitors were expected for the day. And as I patiently queued to see the Large Hadron Collider, I realised the mass fascination we collectively have at the premise of new scientific discovery and the radical cultural paradigm shifts new knowledge can offer. My mind was blown. It was also at this time I first met Mónica Bello, Head of Arts at CERN, who is an inspirational global art/science ambassador and facilitator. Through this first conversation, so began our collaboration between Science Gallery at the University of Melbourne and CERN, and an incredible shared journey to co-develop DARK MATTERS.

Simultaneously, in the depths of the Southern Hemisphere, the hunt for dark matter has also been ramping up, with the establishment of the ARC Centre of Excellence for Dark Matter Particle Physics in partnership with the University of Melbourne. This consortium of bright minds brings together experts from across Australia and internationally to unlock the secrets of dark matter through science, engineering and visionary thinking.

As the search for dark matter continues to intensify, will creativity be the ultimate driving force to propel us into a new future that more deeply understands the darker depths of our universe? And does a unique fusion of art and science enrich creative discovery and offer new perspectives and ways of understanding the cosmos in which live?



STEPPING INTO THE UNSEEN & UNKNOWN, TOGETHER

Tilly Boleyn

Experimentation is at the heart of Science Gallery. Not quite an art gallery, not quite a research laboratory ~ it is a different space that welcomes being in-between disciplines and knowledges. Sometimes a space of discomfort, exploring questions that connect humans across disciplines and invite them to spark off one another and collaborate on looking into the unknown. Curiosity and creativity are fundamental elements of both the scientific process and the artistic one... this is a connecting theme throughout the show... that sparks fly when there's collaboration between the two - inspiring questions and different ways of asking and seeing.

And yet, collaboration isn't necessarily an easy way to create – it takes more time, effort and humility. “Collaboration moves at the speed of trust” is an observation that still resonates with me regularly since I first heard it during a discussion between past SGM collaborators Adam Goodes, Angie Abdilla and Baden Pailthorpe. That statement really captures a key part of working with people and organisations. You never know how humans are going to connect. The invisible ingredients of a collaboration can spark magic or mayhem.

Luckily, this show was cocreated with the very best of collaborators on a multitude of levels: personal, artistic, scientific, creative and institutional. With Arts at CERN and the Centre for Dark Matter Particle Physics, the creation of this exhibition was only possible because of the brains, spark, generosity, good humour and excellent work of human delights all around the globe.

Firstly, Mónica Bello, a professional powerhouse who's been a joy to work alongside on the development of this exhibition. Ebony, Elena/Eli, Jess, Teaka, Arie and Alexia, who came together on the curatorial panel to exchange ideas and made a significant impact on the direction and design of the show. The expert advisory group who generously connected and discussed different parts of the cosmos with us in moments of need... And lastly, but definitely not least ~ the community of artists, scientists, designers, academics and performers who came on this journey with the spirit of reciprocity. The questions raised in their work will draw you in and connect you to the invisible cosmos around you:

Yunchul Kim's affecting sculpture, CHROMA, created with materials derived from new techniques in collaboration with material scientists. It comes alive in response to the subatomic particles flowing through us and the Earth every moment of the day.

Suzanne Treister continued her work SCIENTIFIC DREAMING from across the globe - connecting to the creativity and unlocking the imaginations of expert scientific theorists at CERN and the Centre for Dark Matter Particle Physics.

Turning inward, Anne Pfeifer & Bernhard Kreutzer's work will jump into your world and bring you face to face with your inner demons, perhaps awakening your DARK SIDE?

How can we listen beyond our physical perception of the world? Marc Vilanova's CASCADE envelops your senses, using technology to reveal the imperceptible forces surrounding us, creating a focused entry into the centre of Dark Matters.

Behold Julijonas Urbonas' WHEN ACCELERATORS TURN INTO SWEATERS - a crafty creation transforming replica sections from the Large Hadron Collider into knitted sweaters. This work was inspired by his time at CERN learning about quantum magnetic levitation, a phenomenon that occurs when a superconductor levitates over a magnetic source. Stay tuned to see these beauties one day levitate - if anyone could do it, it would be Julijonas.

David Hochgatterer worked with the Curatorial Panel and selected a new voice for TIME TO X, inviting you to stretch and experience time to your own measure.

Singular Polarity, the combined force of Alicia Sometimes & Andrew Watson invites you to make your presence felt in IN THIS ROOM. EVERYWHERE. a live sonic sculpture exploring scientific narratives around dark matter with the help of Professor Alan Duffy, Dr. Ben McAllister and Grace Lawrence.

Jon Butt entices you to collaborate with the cosmos with μ MUOGRAPHY, a DIY muon detector that creates music with the some of the oldest known particles in the universe.

Alan Bogana asks if light can illuminate the invisible... and shows us the answer with IONIZE IONIZE! A work platforming the beautiful work of scintillators, encouraging us to think about how curiosity into the invisible helps shape human knowledge.

The MYSTERY BOX team of Lawrence Leung, Dr Vyom Sharma and Dom Chambers create an irreverent and fascinating work that blurs the boundaries of perception, questions biases and hacks minds.

Semiconductor duo Ruth Jarman and Joe Gerhardt take you behind the scenes and into the minds of scientists working at CERN in THE VIEW FROM NOWHERE - referring to the philosophical concept that science should remain an objective analysis of the natural world, if it's to be seen as having value.

What keeps you up at night? Became a guiding question within the show. A point of connection between you and other humans across the planet through NIGHT EXCHANGE from Random Quark, aka Jesse Wolpert and Dr. Theo Papatheodorou.

Yawuru artist Robert Andrew's work raises how the land both informs and records lived experiences across time - articulating the complexities of these ancient knowledge systems while challenging the dominant Western-educated assumptions of language use.

Patricia Domínguez creates a visual vocabulary of the invisible knowledges in a way to understand non-human intelligences.

Dark Matters connects all of us. What will you share? What connections or sparks of possibility will be revealed throughout the collisions within? Will the invisible and the unspoken reveal itself?

ARTS AT CERN, CREATIVITY ACROSS CULTURES

Mónica Bello

We live in unprecedented times when we have so much knowledge: we know so much about nature, and even our universe. Our technologies – and therefore our eyes - reach as far as deep space beyond the boundaries of our galaxy, or inside matter, to a point in which a fragment cannot be longer cut into pieces, becoming fundamental. There is an interest in the hybrid areas that exists between disciplines which offers a meaningful look at the world. Science and art collaborations across the globe are currently experimenting with models of dialog and cross-disciplinary exploration. In this context, artists and scientists help each other to imagine new scenarios, and they break down the barriers between disciplines and invite to imagine the invisible and the unknowns.

At CERN, the European Organization for Nuclear Research founded in 1954 in Geneva, physicists and engineers are probing the fundamental structure of the universe. The instruments developed for pursuing this goal take multiple forms and shapes, from discreet microcircuits to the vast scale of the Large Hadron Collider (LHC). Artists today are invited to confront and respond to an age of accelerating scientific and technological development and interact with the dynamics, complexities, and challenges of the fundamental research environment.

CERN is the largest laboratory in the world, and most artists who visit will never have experienced a place like it. With goals such as uncovering the true nature of the universe, matter, and reality, it is not surprising that artists have been attracted to the lab since its early days. Such is the case of an early visitor, artist James Lee Byars whose trace can be found at CERN archives in the 70s as the first and only artist to appear on the front page of CERN Courier, the monthly trade magazine covering developments in high-energy physics and related fields worldwide. Much later, in 2011 Arts at CERN was established as an official entry point to access the laboratory. This platform was brought about to bring science and art together in mutual inspiration and to nurtures artists' research with physics through a program of residencies and a platform for new art commissions. On entering the lab it immediately becomes clear that it will not be straightforward to comprehend the broad range of experiments, their scale and function, and the models that may be represented through deeply specialised theoretical models of our world drawn in mathematical language. Then why do artists want to spend their time at physics laboratories? By engaging directly with the theory and methodology

of answering fundamental questions, artists enrich and inform their practice and how they can inform their ongoing lines of questioning. To make sense of the intangible complexity of knowledge discovery and to make the invisible visible. At CERN they can see their work through the disciplines of others.

Arts at CERN has gained worldwide attention and it's now a renowned model for art and science's engagement. The dialogue of our guest artists with scientists, engineers and staff of CERN helped us to broad our reach with equally creative communities. The truth is that both artists and scientists experience the same drives to understand what escapes our control. Artists and scientists employ different but often parallel methodologies with which to tease out the true nature of the universe and our existence.

I ask myself the reasons for which we are so keen to trespass beyond the limits of our disciplines and spent time developing new forms with which to understand the disciplines of others. What these two fields have in common is the will and ability to imagine, both are compelled to invent and imagine new forms, sounds, images, and languages for that which is to be known, the new and unknown worlds.

Art and science by nature are disciplines based on attention, alertness, and rapid response to phenomena or findings. Art and science work together based on symbiosis and mutualism, where values are common: ambition, inspiring catalyzing ideas, innovation-based in a multiplicity of views, the openness to other languages and tropes, and the interest to imagine and build a better future.

Excerpt from essay 'Arts at CERN, creativity across cultures', published in Sight Unseen (2023), Perimeter Books, Centre of Visual Art and Science Gallery Melbourne, The University of Melbourne.



ARTS AT CERN: EXPLORING THE INTERSECTION BETWEEN ARTS AND SCIENCE

Alexia Yiannouli

When you think of CERN, the largest physics laboratory in the world, you might think of a vast expanse of buried tunnels, unfurling the hidden mysteries of the universe. You might not think of it as a place of synergy between art and science. Nestled within the study of the fundamental structure of particles is the Arts at CERN programme; bringing artists from around the world and across artistic disciplines to the forefront of the laboratory, to explore ideas with physicists, combine conversations and interactions, and shape them into commissions reflecting the intertwining worlds of art and science.

During an exhilarating internship curating artists' residencies programmes and helping them navigate the complexities and hidden corners of CERN, I was able to watch the creative process unfold from tentative thoughts, to ideas, to actions. There are many corners of CERN that pique the interest of visiting artists. ProtoDUNE, a single-phase liquid argon time projection chamber, with its ambient orange hues cast across its expansive cuboid structure. Venturing almost 90 metres underground, the new tunnels of the High Luminosity project. Visiting these spaces allows artists the opportunity to explore creative possibilities, with many photographers and videographers capturing the brightly lit expanse of tunnels through their lens, built to explore the possibilities of the universe.

I listened carefully to conversations between scientists and artists, observing the ebb and flow of thoughts and an explorative exchange of ideas. From body and performance artists to sculptors, painters, and photographers, through forming connections with the artists and guiding their interaction with members of the CERN community, I gained a broader perspective of the artistic and scientific processes; highlighting the significance of the Arts at CERN collaboration, and its importance not only to arts and science, but to wider society. I was able to view the Arts at CERN programme through a perspective unclouded by bias, coming from a background of veterinary medicine and science communication, with art only as a hobby. From diving into the planning and organisation of each residency, tailoring each programme to ensure that the schedule was unique to the artist, being part of this process allowed me to not only explore my own creativity, but also question whether we are, in fact, limitless within the realm of art and science.

EXCERPTS FROM A CONVERSATION

with Ebony Ciarrocchi

You're lying in bed, staring at the ceiling and you can't get to sleep. What are you thinking about? I feel like that's a really a loaded question. I'm three years into a PhD. As if I can say anything else except for my PhD! [laughs] But honestly I'm kind of getting to the point of thinking about, God forbid, like, what is next? What career choice is going to come? Because I can't keep just studying and deferring that decision. So in a roundabout kind of way, I'm thinking about... **working for the rest of my life? And how that's something that we just have to do and have to be okay with.** And yeah, what that looks like, I guess for myself personally, because I've spent so much of my life in this industry that I think is flawed and inequitable and toxic and that that's probably not something I want to subject myself to long term or anymore. So yeah, I guess in essence, if I have to work until I'm 75, what is the least painful way of contributing to capitalism? You get to the end of your first grad degree and you're just kind of like, now what? For me, the logical next step after high school was uni and then the logical next step after that was post grad. And then the logical next step after that was I can either get a job or do a PhD and nobody will give me a job. So I guess here we are doing a PhD and that's kind of the end of the line.

The end of something for sure. Definitely not the end of the line! Are there things you wish you knew more about? I wish I knew more about managing time honestly. I wish I was more confident in the way that I do manage time. Because I always feel a little guilty. Or feel like there's not enough time to do everything that we have to do or are expected to do. **Like, I can either be a good student or a good worker. Or I can be healthy physically and emotionally or I can like own a really nice, cozy home. But like those three circles, they do not intersect on a Venn diagram.** This is a tangent, but I've always said to my partner how nice would it be to be naïve? Like, how nice would it be to just be satisfied with a nine to five that pays the bills and having a family and not ever questioning any social structures. Wouldn't that be so peaceful? I heard this quote once talking about being queer and the kink community, and saying so many queer people are more involved in the kink community because the way that we are intimate with one another is already a divergence from this cis het narrative of how people have sex. And I really feel like that idea spills into every other area as well. **We're already having to question what our existence looks like in a world that's set up for cis hetero partnerships and narratives and relationships. It lends us an ability to empathize with people and be aware of different existences and be aware of different tensions and different ways of experiencing whatever we are here to experience.** It's almost like you can never reach that level of ignorance and you're always craving it, but it's like, how can I be this happy when I have this privilege, that privilege? How can I be happy when there is so much injustice and disadvantage? The world is not set up for everybody to achieve this thing that they say that everybody has to achieve.

And to finish, what do you enjoy most about being on the curatorial panel? Well, it's getting to have these kinds of discussions, to be honest. And being in a room of people that maybe I wouldn't be in a space with outside of this scenario, or this setting. And getting to hear all their different perspectives on these themes and things and issues and artworks. It's really fun, and it's awesome. Everybody gets to bring their own knowledge to the table to create this really cool discussion space.

SOMNIUM

Elena/Eli McGannon



Words by Elena/Eli McGannon.

Design assistance by James McGannon.

Inspired by Junji-Ito, sleep paralysis, and the reckoning of dysphoria.

DARK MATTER DECOMPOSITION

Jess Vovers

pressure and vacuum

in space the scale of creation and destruction becomes a study,
tiny chirps on massive detectors, stars scream and dissolve,
kilometres of magnetic forces colliding, fundamental particles undergoing infinitesimal change yet
profound,
astronomical.

we bend matter to understand, observe the warp of space around the reality that energy and
matter are one, these deepest sources of awe and wonder rendered compulsion to seek and find
and know. the lengths we go to to decipher
attraction, repulsion, tension, equilibrium.

go deeper, til the windows crack.

depth so profound

it is beyond the abyss.

in these darkest spaces, creatures are transformed under immense, unfathomable pressure
where fundamental structures must adapt to meet the reality of what is.

build armour, beguile and trap, generate bright lights, bodies made translucent.

chemical reactions and biological matter falling like snow,

breaking down,

becoming

the fascination and entrancing nature of existence where "nothing should survive".

become drawn in to dark matter decomposition

wandering the bush, I haven't seen so many dead things in one place before

trace the vertebrae, tooth, tail.

soft loam moss bed silent place, searching for direction among

paper leaf leaves

sheafs of it litter the forest floor and when it's met by spore

tiny particles with so much potential

threads fibres

broken down decay decompose matter into components reform catalyst, convert

energetic shifts

unravelling becomes molecular synthesis, atoms configuring bonds, become ordered, weave

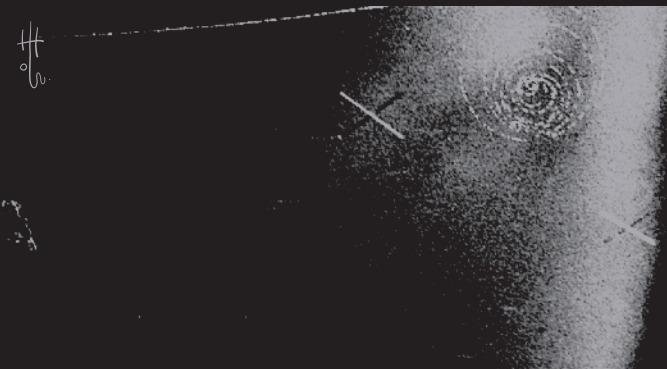
themselves into place

energy is useful and

walking in soft leaf filtered light

the soft bodies, things that grow in the spaces we make

I see the fruits of it.



EXCERPTS FROM A CONVERSATION with Teaka Williams

What keeps you up at night? The ocean. I'm scrolling TikTok and my for you page is full of sharks and whales. Sharks terrify me. Giant squid terrify me. I see shark attacks and whales doing things to boats and I'm like, oh my god. Lately I've been getting pet bunnies and rabbits as well. But it always happens at like 1 or 2am, the app is wanting to get to sharks. It's like it knows that you're going to bed. Here's your fear. I have a deep fear of the ocean; I don't go out in the water. Like, what is down there? The ocean is terrifying. I know some people are like, the universe is so big and unknown. It's the ocean for me. Not knowing what's there. The deep ocean is dark and so scary. I'm definitely afraid of the dark. The skies above – can't touch me, can't hurt me. The ocean is below and there's things in their natural habitat. I find it the complete opposite of space. I find space very fascinating and wild. I find the ocean intimidating.

Why do you like about being part of the curatorial panel? I come from a non-science background. So being part of a curatorial panel for Science Gallery, some of the stuff I see during selection blows my mind. I'm trying to grasp and understand how people even have those thoughts, and then how they execute them into things that are put into exhibitions. Trying to understand that thought process is a whole thing in itself for me and sometimes I don't understand half of it. But I get to see this whole other side that isn't wired to what I am. I don't know how to explain it. It's nice.

EXCERPTS FROM A CONVERSATION with Professor Alan Duffy

When I was growing up in Northern Ireland, there was not a lot of light pollution ~ that's a nice positive way of framing having a low population and not a lot going on. Right? ~ **But you had stars.** And of course, as with any future astronomer, I was obsessed by that... but for me it was the darkness between the stars that was fascinating... was that because there were no stars there? Was that because there was something there that was **blocking** the stars? Or was there in fact, something that I couldn't see, that was actually there? And it turns out, it's all three.

Now, that idea of an invisible counterpart to our lives, the gravity of which **is the reason we are here** that has literally sculpted, pulled together, the material that would one day become a galaxy... And unlike some astronomy, which is very much out there it is right here we are traveling through that material. So, the ability to connect to this very simple question that I once pondered to the very latest in the fundamental understanding of our universe ~ that connects from the very largest scales of clusters of galaxies to the very smallest of particles, we suspect as one of the candidates ~ is still fascinating to me.

And it's this idea visually, and you have to almost remind yourself of this truth when you look at these pictures of galaxies, and you see this beautiful spiral that is **the tip of the iceberg.** And there's this vast halo that is fundamentally invisible to you, stretching out far beyond the visible extent of these galaxies. And there's something deeply interesting and exciting of that prospect that you're about to reveal.

Dark matter is like a ghost. It's able to travel through solid walls ~ and the entire earth without collision ~ we can't see it ~ it's invisible. If it is ghost like in nature, it has even less chance of hitting real atoms like our detectors than we have assumed. This ghostliness means we could detect it now, in five years, or a completely unknown amount of time. In other words, we have built this incredible detecting technology and dark matter could still remain just out of reach. There is an article of faith that you will get the answer in your lifetime because nature might be kind. But really, nature does not care about me [laughs] or my scientific career. **No one said nature has to be kind or obliging to me.** It may not allow me to be part of this discovery. **I'm part of the journey.** What keeps me up at night is that the discovery may not be in my lifetime.

GRAVITATIONAL LENSING

Alicia Sometimes

Our eyes crave baths of light —
flickering playgrounds of shivering stars

an image of a blue arc on the rim
coiling around clusters of galaxies

the vivid shimmer behind you in the garden
as the torch frames your silhouette in dusk

We long for a glimpse of planets slow motion
counting them long into the balcony of night

so, after we see quasars at distance, distorted
we want to understand how mass bends light

How dark matter halos — convene over time
their complex webs continually cushioning

baryonic matter or black holes, inferring
their presence from distant stars or flowing

accretion discs. Gravity flexes the structure
of spacetime (warping light's straight line —)

as if a universal river pools at the sides
of invisible stone — brightness delicately lit

from behind. When a large galaxy assumes
the front-view focal point — those far off

are magnified, curved, arching at the sides
Strong or weak lensing enhance surrounding

or further set stellar hives. If foreground mass
background and observer are perfectly aligned

this Einstein ring resembles an imprint, a cereal
bowl abandoned for morning play, a seemingly

concentric stain. We try to see beyond what is
immediately visible and illuminate what is known

but concealed. Our bare eyes, in the coldness
of midnight, peering through a telescope, unable

to locate most of the weight of the universe —
missing out on all the things we cannot see

COSMOLOGY

Diego Blas

Cosmology is a part of astrophysics, the science that deals with the universe as a whole. It explores the properties of the universe as seen in the biggest scales. Even galaxies themselves, from a cosmological point of view, are reduced to very small points in cosmological space. It is the most macroscopic vision of the universe.

We have a gift from the universe, in light. We can see the universe as it was when it was very young because of the way light travels at a set speed. **When we see things which are far away, we are also seeing things in the past.** This means that we have seen the universe at different times, so we can build a picture of how it evolved. **It is like archaeology in a sense. You dig out traces of the past and you try to make a coherent history.**

Think of Rome, you start digging and you are finding history. **So here we are digging through light as it travels, bringing us information from different times.** We witness other galaxies and see things that were emitted long ago. This is the way the field evolves.

Previously printed in *Seisma Magazine*, UK, Issue 2 in 2021.

95% OF THE UNIVERSE IS A MYSTERY

Professor Elisabetta Barberio

Around 95 per cent of the universe is still a mystery – unknown new exotic particles and forces await discovery.

Looking at the sky, we observe that on the largest scales, matter is organised into galaxies and clusters of galaxies. Galaxies contain stars, planets and gases. All the visible universe – the Earth, Sun, stars and galaxies, everything that makes ‘us’ – is made of protons, neutrons and electrons bundled together into atoms.

Throughout human history, we have built an incredible body of knowledge about the universe around us. We have devised beautiful mathematical formulae that describe the cosmos at its most fundamental level. We know how the universe began. We have powerful telescopes that can see very old galaxies and the beginnings of new ones. We know that apples fall from trees for the same reason that the Earth orbits the Sun. It is a simple and elegant picture.

The quest to answer the most basic questions about the universe has reached a singular moment. All the knowledge we have amassed tells us that we still only know about a tiny fraction of the universe. Astrophysical and cosmological observations have revealed that our picture of the universe is incomplete.

Perhaps one of the most surprising discoveries of the twentieth century was that ordinary matter makes up less than five per cent of the mass of the universe. The rest of the universe appears to be made of a mysterious, invisible substance named dark matter (25 per cent), and a force that repels gravity known as dark energy (70 per cent).

The exotic unknown substance named dark matter does not appear to absorb, reflect or emit light, rendering it ‘invisible’.

Dark matter interacts very weakly with normal matter, its existence is inferred due to its gravitational effects on galaxies. Its fingerprints appear only when we look to the sky at the galactic and super-galactic scales, at about 10 million times the distance between the Earth and the Sun.

Exploration of this unknown ‘new’ universe necessitates the discovery of the laws of physics underpinning the fundamental particle nature of dark matter. While astrophysical observations study the macroscopic properties

of the universe to infer the existence of dark matter, terrestrial physics experiments are essential to study its quantum properties and consequently the fundamental laws of nature associated to dark matter.

Dark matter very rarely interacts with normal matter and is invisible to light and other forms of electromagnetic radiation, making it impossible to detect with current instruments. To build scientific instruments in order to ‘see’ dark matter, we need to hypothesise about what dark matter is. Our very limited knowledge about its particle nature makes building machines to discover it very challenging. That is an adventure on its own.

Earth is perpetually flying through a diffuse cloud of this mysterious substance. We face a constant shower of dark matter particles: every second, hundreds of thousands of dark matter particles zip through our bodies. However, dark matter particles interact so weakly that they pass right through us, leaving almost no sign of their visit.

Sometimes, very rarely indeed, a dark matter particle will collide with standard matter, which can be detected in carefully designed direct detection experiments.

These interactions are so rare that looking for the signal produced by dark matter collisions is therefore like looking for a needle in a haystack.

Experimental particle physics allows humankind to explore the secret of the universe at its fundamental level and to build machines that will enable this exploration.

We have come to understand the fundamental building blocks of ordinary matter, and what we know of the universe is only a tiny fraction of what is out there.

We know only 5 per cent of the universe. The remaining 95 per cent is still a mystery – an unknown universe of new particles and forces awaits discovery.

Even if these unknown particles and forces are, at present, invisible to us, they have shaped the universe as we see it today. We are taking part in not only a scientific revolution, but also a revolution in how human beings see the universe.



Biographies

Dr. Ryan Jefferies

Ryan is Director of Science Gallery Melbourne and Associate Director, Science and Academic Engagement in the Museums and Collections Department at the University of Melbourne. He has over 20 years' experience within the cultural sector and as a research scientist at leading Australian and international institutions. Ryan is a passionate advocate of the blurred intersections between arts, technology and science and the bold promotion of social change through disruptive and speculative creativity.

Tilly Boleyn

Tilly is a massive nerd, curious about the world and everything in it. She is a collaborative creature at heart and heads the curatorial team at Science Gallery with a mixture of organisation, chaos, humour and sassy backtalk. She loves connecting people, making space for thought, and challenging people to back up their opinions in an imagined recreation of Mad Max Thunderdome. Her background is in museums, galleries, education, festivals, broadcasting and research. She is delighted by blurring the boundaries between science, art, design, medicine, technology, maths, engineering, large-scale-batteries-powered-by-human-urine and doing things she's told aren't allowed.

Mónica Bello

Mónica is an art historian and curator. Since 2015 she is Curator and Head of Arts at CERN at the European Laboratory for Particle Physics in Geneva. Under her role she leads the arts programmes of the Laboratory: artistic residencies, art commissions and exhibitions, as well as the partnerships and international collaborations. She is curating the exhibition Exploring the Unknown at CERN Science Gateway, opening in October 2023. In 2022 she curated the Icelandic Pavilion at the 59th Venice Biennale with the artist Sigurður Guðjónsson. Previous appointments were the curation of Quantum/Broken Symmetries; as guest curator of the Audemars Piguet Art Commission for Art Basel; artistic director of VIDA at Fundación Telefónica, Madrid, and as head of the Department of Education at Laboral Centro de Arte, Gijón.

Alexia Yiannouli

Alexia is a veterinarian-turned-science communicator currently working at CERN, in IdeaSquare, the innovation space at CERN. Growing up in the north-east of England, she has a confusing combination of a northern English accent, a Greek name and Hungarian heritage. Having realised that her passion lies more in writing and communicating with people than cutting animals open, she diversified into the world of science communication and writing - writing for vets, particle physicists, IT specialists, and the general public. Alexia previously worked with artists in the Arts at CERN programme, exploring the process of intertwining the worlds of art and science. Although her work now isn't directly related to art, she can always be found drawing, decorating her bullet journal or embroidering anything and everything. When she's not doing those things, she's always looking for animals to pet and befriend and/or finding some nature to be in.

Ebony Ciarrocchi

Ebony is a full-time PhD student and part-time show pony. She spends a large proportion of her daylight hours researching marsupial reproduction at the University of Melbourne, but when the sun is down, you can find her deeply immersed in the queer performance world; dancing with the Real Hot Bitches 80s dance troupe, teaching dance classes or on stage as her drag king alter ego, Basil Bush. Ebony has been working with Science Gallery for just under a year, initially as part of the Sci Curious advisory group and now also as a Teaching Fellow in the Academic Engagement team.

Elena/Eli McGannon

Eli is a photographic artist, producer, and bowerbird from Naarm. Portraiture, form and movement are heavily intertwined with their work, but they are usually found behind the scenes documenting, producing, and collaborating with musicians, architects, activist groups, and performing artists. They have previous curatorial experience as a member of the Urban Animators Swanston Street art installation reference group, and have also been a part of the curatorial panel for Science Gallery's BREAK THE BINARIES exhibition. They are a zealous member of the SciCurious advisory group, and have lent their voice to Hello Human on display within the SciGal MENTAL exhibition at Art Science Museum in Singapore. They are deeply passionate about queer advocacy and bringing trans joy into every possible space. In their free time you can find them crafting table top roleplaying games and lifting heavy things.

Jess Vovers

Jess is a maker, potter, secret poet and doctor of biochemical engineering. Outside of their research in sustainable extraction of pharmaceuticals from plant matter, Jess is a scifi-fantasy dork nerd who is passionate about diversity and creativity in STEM. They seek to explore the plurality of queer, neurodiverse, regenerative futures and how we can enmesh art and science

to cultivate them. Jess is also a hair model, avid meditator, experienced speaker, and Leonardo for Science Gallery Melbourne. They are propelled by curiosity, awe and connection, and can often be found settling in with clay in soft coloured lighting, or wandering along the Birrarung with a thermos of tea searching for mushrooms and fluid dynamic patterns.

Teaka Williams

Teaka is a freelance creative, part time artist and full time pop culture consumer. A proud Gunditjmara woman, she is always adding to her ever-growing portfolio of design skills. Teaka is part of a First Nations art collective, Narrun Yana, where she contributes works predominantly in photography, both digital and film. Previously, she has studied interior decoration and completed a curatorial traineeship at Science Gallery Melbourne. Avid video game player and professional day dreamer, in her spare time you'll find her streaming over on twitch or writing poetry with an iced beverage.

Professor Alan Duffy

Professor Duffy is the Pro-Vice Chancellor of Flagship Initiatives at Swinburne University of Technology, bringing together diverse research teams with industry and government stakeholders to undertake transformative programmes in Flagship sectors of hydrogen, renewable technologies, AI, space and aerospace, medtech and health innovation. He was the inaugural Director of the Space Technology and Industry Institute at Swinburne, finding ways to use space and AI to help companies and communities on Earth. His research background in computational astrophysics saw Alan model universes on supercomputers to understand how galaxies like our Milky Way form within vast clouds of dark matter. He is trying to find this dark matter as a Chief Investigator in the \$35M ARC CoE for Dark Matter Particle Physics and SABRE, the world's first dark matter detector in the Southern Hemisphere, at the Stawell Underground Physics Laboratory at the bottom of an active gold mine in Victoria.

Alicia Sometimes

Alicia is a writer and broadcaster. She has performed her spoken word and poetry at many venues, festivals and events around the world. Alicia is one-sixth of the ABC podcast, The Outer Sanctum. Her written pieces have been in Best Australian Poems, Best Australian Science Writing, New Matilda, The Age and many more. In 2014 she was a Fellow at the State Library of Victoria. Alicia is passionate about arts and science. She is director and co-writer of two art/science planetarium shows, the latest being Particle/Wave that enjoyed a sell-out season during the 2018 Melbourne International Arts Festival.

Daniel Tapia Takaki

Daniel is a high-energy nuclear physicist and associate professor of physics at the University of Kansas. He has worked for the ALICE and CMS collaborations at CERN’s Larger Hadron Collider, studying strong gluon fluctuations in the proton and lead nuclei to understand Quantum Chromodynamics and to determine the initial state of ultra-relativistic protons and ions at high energies. For his research, he has utilized the strong electromagnetic fields produced in multiperipheral collisions instead of ordinary hadronic collisions. As part of his IARI fellowship with the Spencer Museum, Tapia Takaki is working with mathematician Angieszka Międlar and artist Janet Biggs on a collaborative project that explores how methods in linear algebra, nuclear physics, and video installation might inform one another.

Diego Blas

Diego obtained his PhD in Physics in the University of Barcelona (Spain) in 2008. He was a postdoctoral researcher in the group of Prof. Shaposhnikov at the École Polytechnique Fédérale de Lausanne till 2011. After a short research period in New York University, he moved to the Theory Division of CERN as a fellow in early 2012. He became Staff Member of CERN in 2014, until 2018 when he moved to King’s College London as Senior Lecturer. Since July 2021, he is a Beatriz Galindo Distinguished Researcher at UAB. The main research areas of Diego Blas are theoretical cosmology, gravitational physics and tests of physics beyond the standard model with astrophysical probes. He is currently working on searches for new physics (dark matter and gravitational waves in particular) with quantum devices and in the extreme environments of pulsars, novel ways to understand how cosmological observations can teach us more about dark matter properties and fundamental properties of quantum gravity.

Professor Elisabetta Barberio

Professor Barberio is the Director of the ARC Centre of Excellence for Dark Matter Particle Physics and initiated the underground direct detection dark matter program in Australia, which led to the construction of the first underground laboratory in the Southern Hemisphere, the Stawell Underground Physics Laboratory (SUPL) in Victoria. SUPL will host the SABRE South experiment, the first underground Australian dark matter direct detection experiment led by her. She had an important role in the discovery of the Higgs boson particle at the Large Hadron Collider. Professor Barberio was a researcher at CERN, the European laboratory of Particle Physics, where she performed measurements that confirmed the theory describing fundamental particles behaviour to an extraordinary degree of precision.

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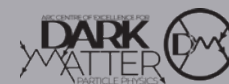
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