

Peter Galison

The Event Horizon Telescope,  
Art and Science:  
An Interview with Professor Peter Galison

Q

Tell us about the Event Horizon Telescope (EHT) image. How did you come to be involved in the project? And what is the EHT image, anyway?

A

The EHT started up in 2006 as a global network and collaboration of radio telescopes – dishes [at first installed] at the South Pole, in Hawai'i, Arizona, Spain, Chile, and Mexico. In concert they form a virtual, Earth-sized telescope. Imagine you had shards of a mirror distributed all over the globe to form one immense mirror. You need a device of that size to be able to image something as far away and as small in the sky as a black hole. The black hole the EHT was looking at is 53 million light years away in the galaxy called M87, which means, of course, it has taken all that time for the signal from that

object to reach Earth. An analogy in scale would be if you were standing in Boston trying to read, across a continent, the date on a coin in Los Angeles.

I got involved with the EHT project about five years ago with some colleagues here at Harvard. We launched an interdisciplinary centre for the study of black holes, because black holes challenge the limits of everything we know from mathematics and physics, astrophysics, and philosophy. I was especially interested in the imaging that the EHT was producing.

Q

Why that particular galaxy?

A

M87 is a very strange, attractive, and – with 100 billion stars – immense galaxy. It's named after the great eighteenth-century French astronomer, Charles Messier. He made one of the first catalogues of these celestial objects, which, like our own Milky Way, we now routinely identify as galaxies. M87 is one of the biggest galaxies that we know of. It also has an extraordinary feature, discerned since the early twentieth century. There seems to be, in radioastronomical terms, the equivalent of a huge lighthouse beam that comes out of it and travels a vast distance, many times the size of that galaxy. Suspicion grew that the colossal radio activity at M87's centre causing this phenomenon might be a black hole. And a special one. Black holes formed by collapsing stars can be ten, twenty or thirty times the size in mass of our Sun. But this one, M87, would be billions of times that mass. We're now finding these giants – called 'supermassive' black holes – inhabiting the centres of just about every galaxy we know about.

Q

The EHT image of that black hole in M87 is often casually referred to as a photograph; but is it actually one, as we understand photography?

A

I have a very expansive view about what counts as a photograph. Photography continues to change from its earliest days as a tonal imprint on glass in the mid nineteenth century to include analogue colour, and then digital technology in the twentieth century. Some might say, well at least photography involves a lens or a camera. But the art and technology of photography have continuously challenged that. You can make photographs as Man Ray did, without cameras, by putting objects on photo-sensitive paper. When you take a photograph with your cell phone camera – there's no film in that camera. I take a photograph of my cat on my cell phone, and I'm using highly processed digital information with electronics that convert light into small amounts of electrical charge that can then be manipulated by what is essentially a computer. I'm making something that would have been, in technical terms at least, quite unrecognisable to the founders of photography. Nonetheless, we still think of that image of my cat as a photograph. Additionally, modern art museums have been collecting

photography by people who may not have considered themselves to be artists, from fields such as photojournalism or scientific imaging. The Museum of Modern Art (MoMA) in New York has the photograph of the first footprint of an astronaut on the moon, taken by either Buzz Aldrin or Neil Armstrong on July 20, 1969. It also has the composite image of the moon's surface that was taken by one of the early satellites that went around the moon.

Q

The EHT image is now in a museum collection, is that right?

A

Yes. I have various collaborations with MoMA, and when I showed them a print of the EHT picture, they were very excited. There were more than two hundred scientists from the EHT project involved in making that picture. We were all thrilled. Some of my colleagues said that this is as great an honour as we've received, to have the image taken into the permanent photographic collection of MoMA.

Q

So, is the EHT image a work of art?

A

It is an image in the most expansive sense of photography. While quite different from what you might think of classically as a film camera's product, the EHT image does have features which cross over between aesthetics and science, and which I think are the case with scientific images more generally. For example, in the EHT image of M87, the differences in brightness of the different parts of the ring correspond to variations in the temperature from millions to several billions of degrees. You could produce the image in black and white, and capture that same variation in value. Equally, you could output those values in tones of blue or another colour. My colleagues and I had a discussion, for example, over the visual effects of blue and red-orange. One view was that since the hottest part of a flame (such as a gas jet) is the blue part, blue should be used to indicate the hottest temperatures of the event horizon ring. In our daily lives, of course, we think of red as an index of heat, but blue is indeed a higher energy photon than a red photon. In this respect, red is cooler than blue. On your refrigerator, however, blue is used as an index of coldness. Designers don't make the trademarks and symbols and advertisements for refrigerators using orange and red! Eventually, we settled on orange for the index of heat, which I totally supported. But that was ultimately an aesthetic decision, based on an understanding of the cultural associations rather than the physics alone.

Q

The EHT image is not only a scientific description or evidence; it has an aesthetic significance. How were the art and science of the image coordinated?

## A

The Event Horizon Telescope picture is composed of enormous amounts of data taken from many different sites, and this data has to be coordinated. One telescope may start recording a strong signal that gets weaker for some reason. There will be minute variations in the exact moment that a wave front is registered between different radio dishes. Remember, these are scattered across the rotating Earth, and this black hole is 53 million light years away. It required immense mathematical processes on a supercomputer to bring all this data into alignment. And then beyond that, to get that data to form an image. And you have to test the reliability of the method of making that image, testing it against artificial data. We did this by comparing its outcome to the recreation of an artificial image of our own making – an image of two discs. We knew what to look for there, so if the process accurately output our artificial image, then it might be correctly processing the data from M87. We also tested the method by providing artificial data to teams that did *not* know what they were looking for. In one case, an image of Frosty the Snowman. This was like the way you point a camera at a test pattern to make sure you can reproduce that test pattern accurately, before using the camera to photograph something that you had never seen before. You want to persuade yourself that your lens isn't creating artificial entities. Then you can assure yourself that you have indeed seen something unusual.

And we did! About nine or ten months before the image was actually released to the world on April 10, 2019, we saw something that knocked our socks off. We had four groups, each working independently. We got together, sharing these images to see if they looked similar. And they did. That was a moment of immense excitement. Over those months before publication, there was a furious amount of work testing to see whether we might be fooling ourselves. Could this actually be a disc, but we were making it seem like a ring? Could it be distorted in shape? The variations in brightness on the lower part (much brighter than the upper part); were these artifactual or were they real? They're something that we modelled but that we're also observing: a swirling gas that is moving towards us at the southern end of the image, and as such gets brighter and more intense, with the rest less bright because it is flowing away from us. And there are aspects of the image that provide a kind of map, giving us information. For instance, the diameter of the dark part of the black disc at the centre gives us a way of measuring the mass of the black hole. We now know it's about six billion solar masses.

On the other hand, there is the sheer astonishment and wonder we feel in our response to this image. We'd had good theoretical reason for expecting what a black hole might look like. Some of the scientists in this collaboration had been working on this theoretical depiction for much of their lives. But we all wanted to see a real picture of one, as if that would be the final, super-definitive step in showing that these things really were out there. And when we did see it there was a sense of awe, almost of fear, that comes from realising that we're actually gazing at a black hole ... something the size of our solar system. And we're seeing this billion-degree hot gas that's orbiting not very far from the black hole's event horizon. It's just amazing.

Q

In your career, you've worked a lot with artists, notably William Kentridge.

A

This has been very important to me. I'm constantly talking about these collaborations with my wife, who is a Professor of Art History at MIT, and we have for many years written and worked on projects together at the nexus of art and science. William Kentridge and I worked on a piece called *The Refusal of Time*, a sculptural installation with five video projections with voices and music. It was originally going to be integrated with a performance, which we then hewed off into a chamber opera called *Refuse the Hour*. That project began when I saw a show of William's at MoMA. He read a book of mine called *Einstein's Clocks, Poincaré's Maps*. We found a common fascination with the aesthetics and technical world of modernism in the early twentieth century, which we talked about, meeting every week for months in New York while he was doing another opera at the Lincoln Center. I mentioned a hilarious story that, in Vienna and in Paris in the nineteenth century, they pumped time in pipes under the city. Yes, compressed air was pumped through long pipes when it was, say, twelve o'clock, and that pumped air would reset the hands of a clock in front of each of the city halls that governed the various *arrondissements* of Paris. This idea of something so mechanical, so 'pumpable', as compressed air and something so abstract as time just appealed to me immensely. William immediately loved this idea too, and we began discussing ways to use long-distance control of drums and other devices with compressed and decompressing air. I was interested in Newtonian absolute time and Einsteinian relativist time, and then the destruction of time in black holes. *The Refusal of Time* and its associated chamber opera has this structure: absolute time, relative time and the destruction of time. So, it was about the aesthetics of black holes and how that might be thought of in the associative, open-ended way that Kentridge does so beautifully. That was a great thrill and enormous fun for me.

Q

Are there times, in your experience, when collaboration between art and science is difficult, when it collides?

A

There are difficulties. I know early on in the collaboration with William Kentridge, he said, 'You know, Peter, I don't want to make an illustrated science lecture.' I told him that I totally agreed and didn't want to be the science advisor to an art project in order to give it the air of being authentic, the way an ex-police officer might be used to make a TV series on police procedure seem authentic. I don't want to lay down rules for what counts or doesn't as a good collaboration. There are many different connections between art and science, but what appeals to me is when art and science can work together in a way of advancing understanding. It's a mode of enquiry. Not to make art into a research endeavour that simply imitates laboratory work on black holes, for instance, but to say or to explore what the meanings of black holes are for us.

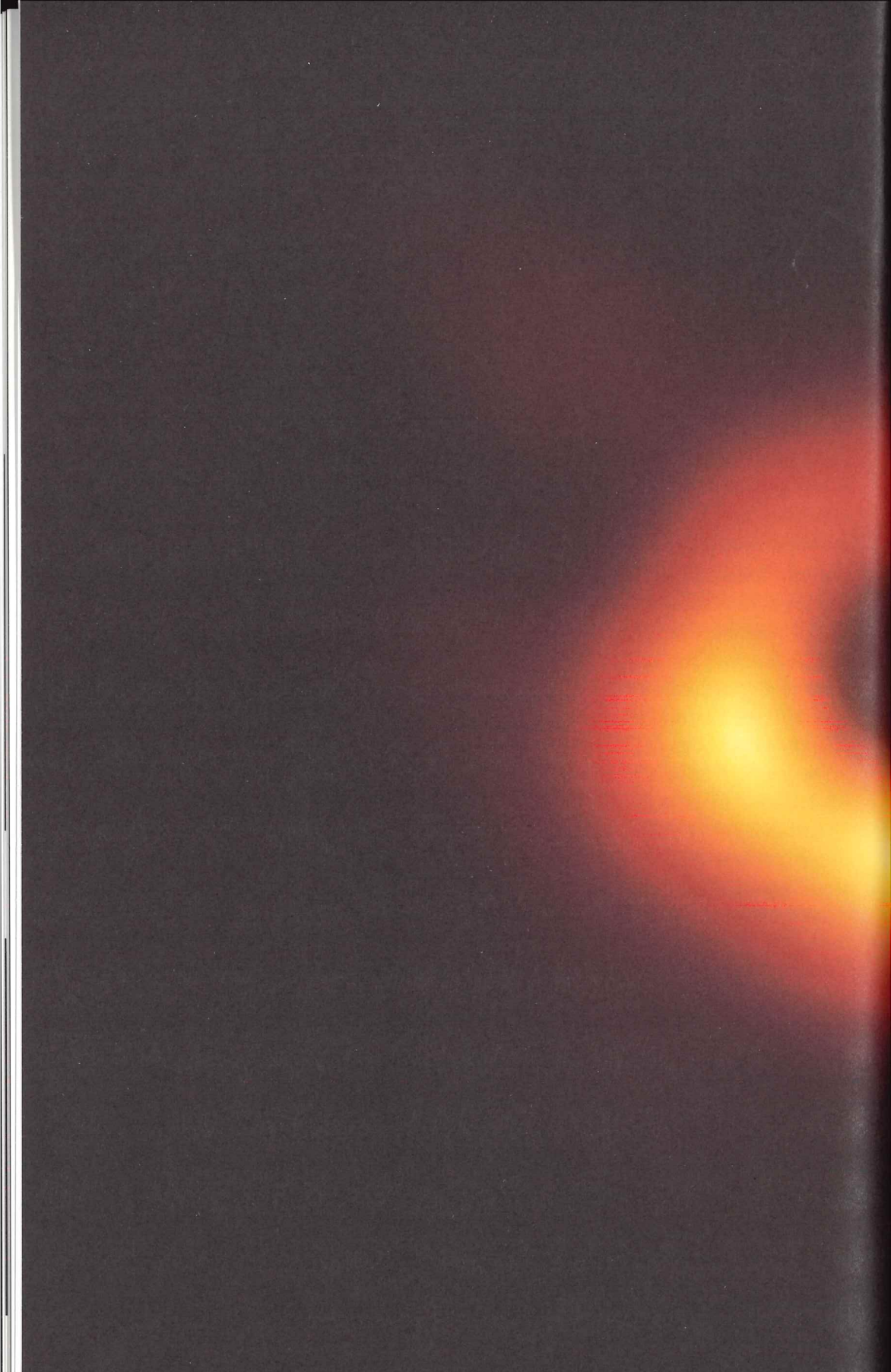
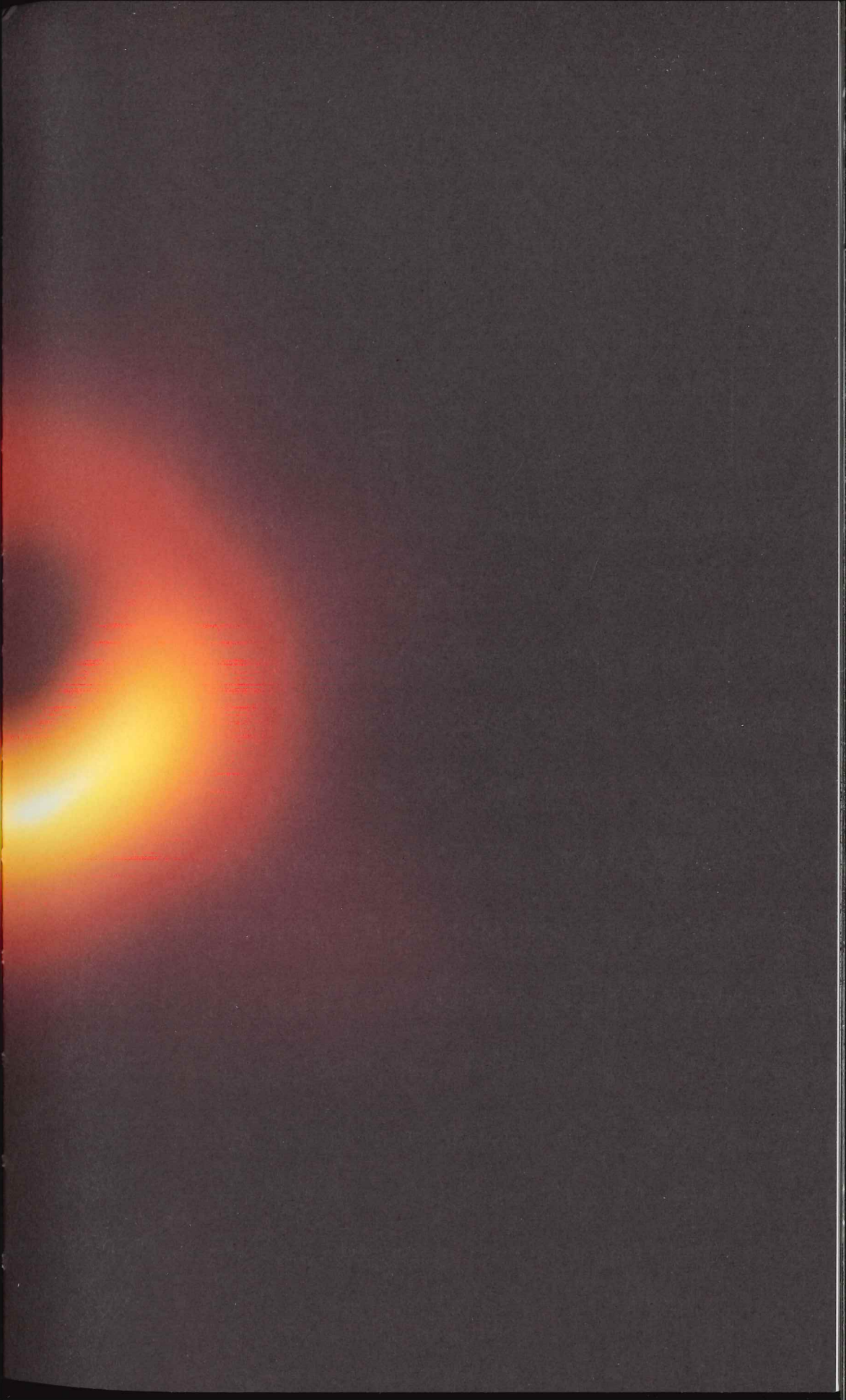


Image of Messier 87 generated from data gathered by the Event Horizon Telescope.



Scientists don't live outside a world of metaphor. They don't live outside aesthetic assumptions about the way images function and circulate. And artists don't live outside the world of scientific, technical or medical concerns. I think there are ways to collaborate, but it's not simply a matter of making a scientific diagram look attractive. The internet has tens of thousands of terrible kitschy pieces that are simple aestheticisations of scientific work. What scientists are after and what artists are after will sometimes be different. There are ways in which the intersection of art and science can misfire, but there are also ways that we can learn from each other. We can explore these issues and deepen our understanding, recognising that we do live – in some ways – in the same overarching world: scientists learning from the aesthetics of images that artists have produced, and artists learning from the concerns that scientists bring forward.

*Sight Unseen:*  
*Visualising the Unseeable through Art and Science*

CoVA × Perimeter | Art + Science

Published by the Centre of Visual Art at the  
University of Melbourne, and Perimeter Editions,  
Melbourne, Australia.  
unimelb.edu.au  
perimetereditions.com

Editors:  
Edward Colless, Suzie Fraser, Ryan Jefferies

Design:  
Daly & Lyon

Copy editing:  
Edward Colless, Dan Rule

Proofreading:  
Justine Ellis, Ash Holmes

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or photographic, may be reproduced without  
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of Visual Art, and Perimeter Editions.

The Centre of Visual Art (CoVA) was established  
in 2018 to facilitate innovative and sustainable  
research and collaborative projects in the visual  
arts at the University of Melbourne.

Distribution:  
Perimeter Distribution  
perimeterdistribution.com  
Idea Books  
ideabooks.nl

Perimeter Editions 073  
First Edition of 800  
ISBN: 978-1-922545-18-3  
Printed by Wilco Art Books, Netherlands

# Sight Unseen

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# Visualising the Unseeable through Art and Science

CoVA × Perimeter is a collaborative publishing initiative curated by the Centre of Visual Art at the University of Melbourne and independent publishing house Perimeter Editions. Foregrounding experimental and otherwise innovative discursive outputs from three key streams of enquiry – Postnational Art Histories, Feminism and Intersectionality, and Art + Science – the program spans research-in-progress, academic dialogues, artist responses, and essays, working to reframe scholarly research via a multiplicity of new perspectives and lenses. The Art + Science series, supported by Science Gallery Melbourne, creates a space for shared and collaborative conversations and research between scholars and practitioners across the arts and sciences internationally. The series broaches some of the critical challenges facing humanity – from climate change to artificial intelligence and gene editing – through a dialogic exchange across scientific and artistic disciplines and modes.

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