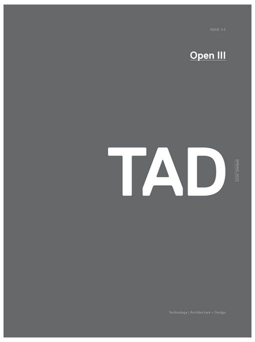

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Interview with Peter Galison: On Method

“Science is always about very practical things and more-than-practical things at the same time, as is architecture.”

Peter Galison
Harvard University

Winifred Elysse Newman, Interviewer
Clemson University

Interview Date: August 19, 2020

Editorial Note: Peter Galison is a University Professor in Physics and the History of Science at Harvard University. His publications, including *Image and Logic* (1997), *Einstein's Clocks, Poincaré's Maps* (2003) and, with L. Daston, *Objectivity* (2007), span theory, material cultures, the social histories of science, and include broad topics in the history and philosophy of science, art and architecture. He is also a documentary filmmaker who, with artist Robb Moss, directed *Secrecy* (2008), which premiered at the Sundance Film Festival, and *Containment* (2015). Galison's most recent film, *Black Holes | The Edge of All We Know*, premiered in 2020 at CHP:DOX. Galison has a way of presenting complex ideas with equal parts ease and laser precision.

Newman: *Paul Feyerabend makes a memorable claim in* Against Method: An Outline of an Anarchistic Theory of Knowledge*— he intends to "present events that dissolve the circumstances that make them happen." This resonates for me with most of your work. Today, I'm hoping we unpack questions about methods. You have perspective on methods that might be a parenthesis around some of the issues facing architecture research. I'll start with a question I've always wanted to ask you. What interests you about architecture?*

Galison: The governing question that's structured almost everything I've done is the relationship between the abstract and the concrete. This motivated my first book, *How Experiments End* (1987). At the time, most discussion of experiment focused entirely on experiment as a means for checking

◁ Figure 1. The shadow of a black hole seen here in the galaxy M87—surrounded by billion-degree-hot gas—is the closest we can come to imaging the black hole itself, a completely dark object from which light cannot reflect or escape. The black hole's boundary—the event horizon from which the Event Horizon Telescope (EHT) takes its name—is around 2.5 times smaller than the shadow it casts. If this black hole was in the center of our solar system, the event horizon would extend beyond Pluto. While this may sound large, this ring is only about 40 microarcseconds across—equivalent to reading the date on a coin held up in Paris...from New York City. (Credit: EHT Collaboration)

theory. I wanted to restore a kind of epistemic integrity to the laboratory—to see it as another way of knowing, not as an ancillary corrective to theorizing or the mere bricks out of which knowledge could be built. Rather I saw the world of science—my entry point was through physics—as composed of different communities of knowledge-making. Some had to do with instrument-making, some with experimental laboratory work, some with the practices of theorizing. Each of these subcultures embodied a different set of practices, of values about what was a reliable access point to the world. And the interaction between them was central to how knowledge was put together. Later I wrote *Image and Logic: A Material Culture of Microphysics* (1997). It was again about very different ways of approaching, even within the instrument-making side, how knowledge was gained and secured. I wanted to contrast machines that made pictures—like a cloud chamber, bubble chamber, or nuclear emulsions—with devices that counted and did statistics in the symbolic calculus of "A and B happened, but C didn't happen," and how these two forms of argumentation were built into the material. The instruments of the laboratory seemed to carry on in a traditional form—that's to say, passing from the cloud chamber into the bubble chamber, from the cloud chamber into nuclear emulsion in ways we could track through material and epistemic continuity and the skills involved.

It was a different way of looking at the history of science that tried to recognize the practices and values defining these different communities of knowledge making. I started thinking about taking a very abstract idea—the central idea of time coordination in Einstein's special theory of relativity—and seeing how it combined purely theoretical aspects with very practical patent office ideas Einstein was involved with, for example "How do you send a time signal down the train tracks to keep trains going in opposite directions on the same track from colliding and killing each other?" These themes, taking abstract ideas and seeing how they related to very concrete procedures and looking at concrete procedures—like making an instrument—and seeing what epistemic or abstract ideas are embodied in them . . . this back and forth is central to what I've been concerned with and in many ways is central to my interest in architecture and the architecture of laboratories. For example, looking at what it meant for scientists to think of a laboratory as a church, or a nineteenth-century aristocratic country home in Britain, a factory, or venture capital firm. How does the structure of a laboratory convey, embody, and continue certain values, approaches, symbolisms that had an effective consequence for the way work was done? These questions helped redefine the identity of what it meant to be a scientist.

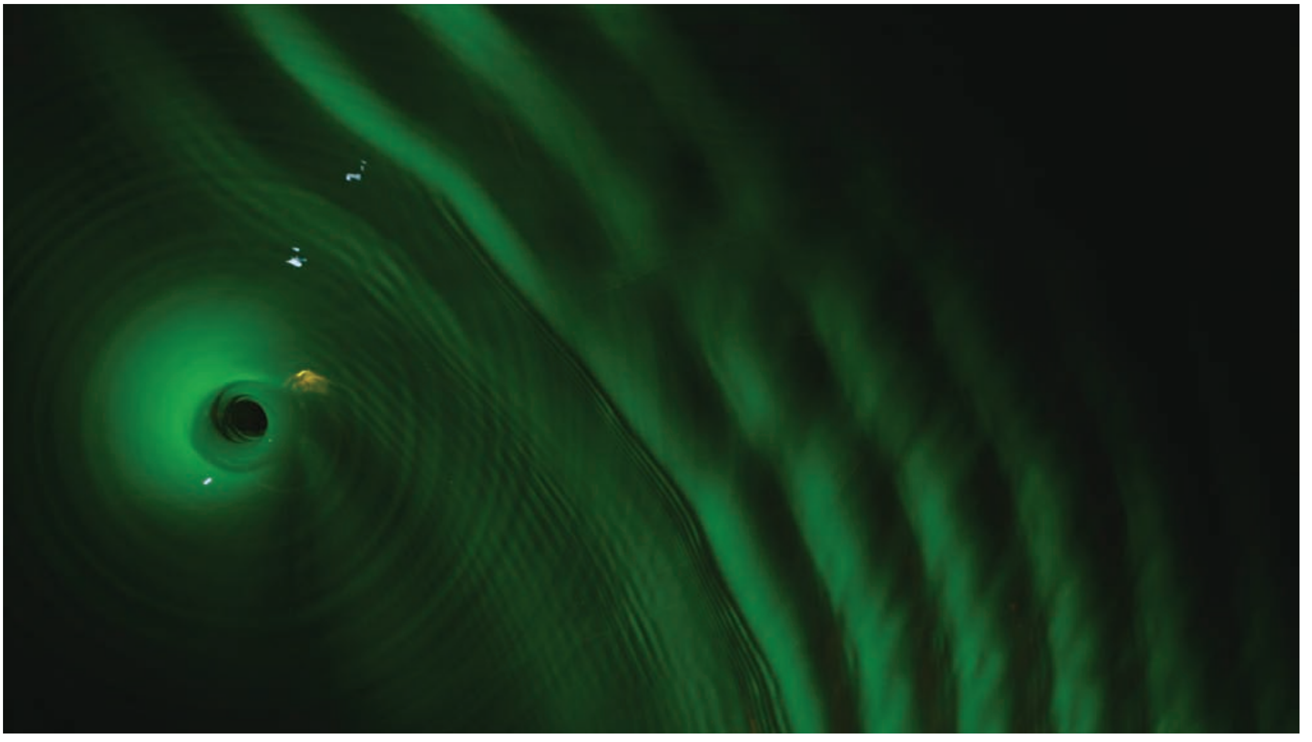
All of this ties back to my interest in the materiality of science, where science doesn't take place in a kind of Platonic heaven separated from the world according to universal rules. Rather, science is constantly changing, evolving in new and interesting ways in its embodied, real existence. An existence that also carries aspects of enormous abstraction and symbolic value—where we value this and not that—and it's conveyed in the kinds of instruments and spaces that we work in, the evidence we value and disvalue. All of these are part and parcel of the world of science. Science is always about very practical things and more-than-practical things at the same time, as is architecture.

Newman: *There's an interesting overlap in ideas here, like the abstract/particular and the material/immaterial as they play out at the intersection of science and technology, echoed in the way you talk about instruments and the images they produce. For instance, your idea about mechanical objectivity as a kind of practice contextualized in the laboratory.*

Galison: There's a medieval saying attached to alchemy: to see down, look up. And to see up, look down. In the cauldron of mixing elements to transform base metals into gold, we could see something of a more universal truth. But I see this idea as very deep in some ways, going well beyond alchemy. To me, understanding abstraction requires looking at material particulars, and to look at material particulars, you recognize these never exist outside of a symbolic world. That's true of architecture as well as science. Meaning, we might think that it's just the material assembly of bricks. However, it's never just that. Great architectural spaces are always simultaneously material and symbolic, which is also true in the scientific endeavor.

As far as method goes, there was a moment in the history and philosophy of science when an abstract label, the "scientific method," identified with a kind of hypothetico-deductive process: given some hypothesis (*h*) and set of conditions $\{C_1, C_2, ...-C_n\}$, take the hypothesis instantiated through $\{C_1, C_2, ...-C_n\}$ and get some measurable experimental consequences—but in a way that never corresponded to anything in scientific practice and led to a lot of idle gear-spinning in philosophy of science. To get out of that it required the philosophy of science to engage with scientific practice. In the analysis of architecture, I see much the same promise for studies that foreground the varieties of work that contribute. One thinks of Emily Thompson's work *The Soundscape of Modernity*, for example, on the reworking of interior spaces around the control of sound and noise—even when the exteriors were left untouched.[1] Certainly the emphasis on work practices was on my mind when a group of us focused on laboratory design, tracking the shifting practices and ideals of sciences from the Renaissance through big science wartime projects into the present moment of venture-capital biotech.

For almost two decades Lorraine Daston, my co-author on *Objectivity* (2007), and I, worked to try to focus our views about scientific objectivity. It's not that we wanted to say that there's no such thing as objectivity, or conversely that objectivity is the alpha and omega principle of science. Instead, we



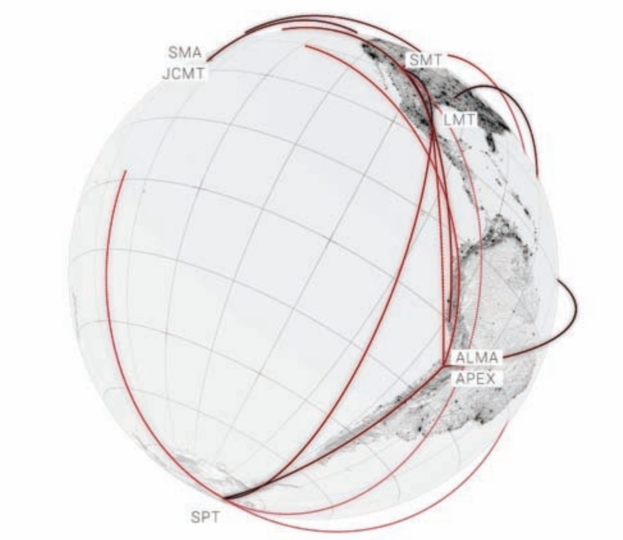
△ Figure 2. Surface waves around a vortex in water, modeling, analogically, waves traveling around a rotating black hole, from *Black Holes | The Edge of All We Know*, directed by Peter Galison. (Credit: Collapsar LLC, 2020)

wanted to underscore and analyze the set of practices corresponding to what medical doctors, natural philosophers, and now scientists identify with "objectivity." The term in something like our present sense arose around 1830–1840, was challenged in the late nineteenth to early twentieth centuries, and changed its form. Our approach was to recognize that objectivity had a history, and in fact changed over time. Very roughly, in the eighteenth century stress fell on creating an ideal image, one depicting the ur-form of a leaf, a cloud, a body—one that would go beyond the vagaries of individual variation. In the nineteenth century the virtue of objectivity reversed this reliance on the genial vision: instead, the scientist aspired to transfer, as well as possible, nature (a leaf, a skull) to the page. And in the twentieth century, scientists came to acknowledge, even celebrate, that part of objective depiction involved the deployment of well-trained judgment (not genius but training). Our aim was to separate this shifting set of those epistemic virtues that made up objectivity from science—full stop. There are lots of epistemic virtues in science: prediction, quantification, pedagogical utility—we want many things from our science (precision, robustness, accuracy, pedagogical utility, quantification, among others); objectivity is an epistemic virtue (no doubt very important) but one among others. In its nineteenth-century heyday, the idea of mechanical objectivity, aspirationally, was to find a protocol for transferring nature—a leaf, a bug, the track of a cloud chamber—onto the page with minimal human intervention. This initial concept of maximizing the automaticity of the transfer from the world onto the page played, and in some ways continues to play, a vital role in the history of our effort to gain and secure knowledge. But it is not always so; it is not universal, and as scientific objectivity is supplemented and emended, it is not forever.

Newman: *Now we have machines that produce machines that produce data. This suggests questions about human agency versus a kind of machine agency where machines produce outcomes, information, or knowledge we can't predict or weren't seeking. What happens to methods then? It seems we were simply looking/designing with tools hoping we'll see patterns and maybe those patterns will be useful.*

Galison: It's interesting. I think we take data and we make it into images, and we take images and we decompose them into data all the time. For the last five or six years I've been very involved with the Event Horizon Telescope (EHT) project trying to make an image of a black hole. In many ways it was a project I couldn't resist. It had to do with massive amounts of data—the data collected on a given night of observation were gathered in quantities never before seen in the entire history of science.[2] The goal of making an image was central. One of the things I thought through with my colleagues was how to satisfy ourselves we were looking at something real, and not at an artifact. That this image we were making was really there. That it had an objective status.

We came to think of this in two stages, very much like stages of the history of objectivity. People like Goethe, [Berhard Siegfried] Albinus or [William] Cheseldon, even if they gained an image by



△ Figure 3. Baselines among various stations of the Event Horizon Telescope, from *Black Holes | The Edge of All We Know*, directed by Peter Galison. (Credit: Collapsar LLC, 2020)

tracing or using a camera obscura, would correct it to try to capture an ideal. Mechanical objectivity was an attempt to get away from the imposition of ideals. In the twentieth century there was an increased sense that judgment was needed—"expert judgment"—and it could be trained; we learn, in a way that is robust (other trained analysts make the same distinctions), how to separate a grand-mal seizure on an electroencephalogram from a petit-mal seizure.

Among the EHT team there was a phase where we gave data to four different groups who didn't speak to each other and said, "Use your expert judgment to form the best image." Then we got together and saw if we actually produced the same image—that corresponded in some way to expert judgment. We thought: What if we are somehow distorting this by our desire to see a ring around a dark disk at the center? Can we get the computer to search all the different settings? Sort of like telling the computer to reset the camera f-stop, focus, and shutter speed in different combinations to see the best way of reproducing a known object (like a test pattern) before we used it on something unknown. This mechanical form of systematic study was a second stage. We wanted to do something mechanically in addition to proceeding through expert judgment. When we came up with a reproducible ring in this way, as well as the comparison of isolated expert judgment groups, we became persuaded; this was something reliable and we could go to the scientific community and say, "We are seeing this. This isn't going to go away when someone tries it in a slightly different way." So, although there's massive amounts of data and supercomputing involved, in the end we also wanted to preserve a role for our capacity to look at things and compare them to see what was salient and pick out unexpected patterns. This tacking back and forth between judgment, sometimes visual judgment, and the more mechanical-procedural-computational side remains central, even in this age of super high-tech science with massive amounts of data.

Newman: *A couple of things strike me: first, a role for aesthetics. And second: narrative, even the narrative that you told yourselves about the process.*

Galison: Absolutely. Narrative is a good term for it. Just as we sometimes have hoped there was a formula for scientific method, we tend to think there's a formula for stories. But narrative is a much more capacious category. We narrate to ourselves in many different ways. A multiplicity of narratives. We could have different ways of passing through a physical space, each corresponding to a different narration. We're learning more and more to respect this multiplicity. For example, in the set of papers introducing the black hole, we talked about it as telling a story: we have a set of instruments, here's how they work, this leads us to data, and the data has to be understood and corrected to rid it of known artifacts; we get rid of, correct for, the fact some antennas point in the wrong direction. We have the making of the image, then testing it with models and then some kind of theoretical interpretation. But we thought of it as having a narrative arc and talked in that language of "telling a story" people could follow.

Even in the guts of scientific argumentation we talk about narration. I think about it all the time with film. Film functions differently than written text and differently again from physical installation. Certain things are easier to do in one medium than in another. With a text you can write encyclopedically. Film is a time-based medium that, while not completely constraining now because of the way we can jump around digitally, nonetheless has a kind of sequential structure. You watch film in a different way than you read. There is a way the materiality in film tells you over and over what physical presence is. You can't easily do that in writing. You can't simultaneously present that density of information. But text has the ability to cover ground and expand capriciously and skip back and forth between times and places. I think of film and text not as incompatible, but instead as representing in certain kinds of ways; each lends itself more easily to certain narrative forms. But I don't want to overstate it. The aim, so it seems to me, is to take advantage of certain things these do while recognizing there's no sanctity of media specificity. Architecture does certain things for us: I would never say architecture can't do x. I would say architecture does certain things more felicitously than other things.

Newman: *Relate this to Kant's* sensus communis *where aesthetic value is determined through a kind of consensus. It seems that's at play in all these modalities—observing is also structuring. I'm reminded of a lecture on atlases where you talked about the choice between the representation of ideal versus typical specimens.*

Galison: We have these pairs of words: text and context. You know what goes with text, but we really need a parallel pair for other domains. There's a kind of con-image and a kind of con-architecture. Architecture always exists against other things, with other things in the surrounding. When scientists make images, whether for a scientific atlas or journal article or a presentation, a question that's very crucial to ask—that art historians are always asking—is: What else are they looking at? What are the images that travel with it? Looking at the scientific images of the past or our contemporary moment, we have the same decisions to make. There was a moment— coming back to black holes —where we in the EHT Collaboration wondered whether it was objectively reproducible? We spent at least a year trying to see if it would go away if we assumed this or that. In the end, it proved robust: anybody with the data would come up with a spectrum of brightness to darkness corresponding to temperature in the surrounding hot gases swirling around the supermassive black hole at the center of Galaxy M87, this gigantic black hole the size of our solar system or even bigger weighing 6.5 billion times what the sun would weigh.[3]

But the *color* was completely our choice. The image is made with a form of electromagnetic radiation captured by eight radio telescope arrays at six sites around the world. We could've made it pink or blue or orange. We had a discussion in the image group: "What should we do?" Some people said, "Well, you know blue, the hottest part of a flame is blue. These are billion-degree gases—we should use blue." Others of us said, "Ah, but orange—we think of orange as hot, right? If you were putting a sticker to sell your refrigerator, you would shade it blue to convey its coolness. And if you were making a warning sign for a stove, you wouldn't use blue, you'd use orange." We're familiar with the idea of orange as hot from burning embers or hot iron. And even though we know the tip of the flame is hot and blue, nonetheless there's a kind of conventional meaning to color that comes out of everyday life. And that choice, which was ultimately aesthetic—aesthetic in a broad sense—was, I'd say, logically arbitrary considered in isolation…but *not* arbitrary relative to the *sensus communis*. Color was fixed by things *not* in the data.

Even the term "aesthetics" means two opposite things. On the one side we think of aesthetics in the most ethereal notions of beauty: rightness of proportion, symmetry, asymmetry—the kinds of things we think of as the principles of design and art. At the same time aesthetics has, in its root, touch. It's material. And I think that takes us full circle to where we began: that aesthetics, and nowhere more present than in architecture, has this simultaneous, profound attachment to the material and a symbolic, elusive structure always taking us elsewhere. That resituates us as an entrant into a building or city, where materiality, metaphor, meaning, and value are always part of aesthetics. Freud in frustration famously said, "Sometimes a cigar is just a cigar," but a building is not just a building and a black hole is never just a black hole. It seems to me that's why people are interested in architecture. When artists like Frank Stella say, "Well, I used to be a house painter—I'm just painting"; when an architect says, "It's just a shed. It's not a building"; or scientists say, "It's just the equations"—it's never just the equations and it's never just a shed. And even if it's a shed in defiance of a more decorated object, it's "defiantly" defined relative to these other things.

Newman: *Speaking of weighing black holes reminds me of [Buckminster] Fuller's "How much does your city weigh?" Cities are as inescapable and mysterious as black holes.*

Galison: I think these things are attached in a way that's endlessly interesting. There's no end to this question of the relationship between the material and symbolic side of aesthetics, the material and symbolic side of science—or architecture. It's always worthwhile pushing harder, pushing on the material to the inexorably present abstraction that is always there.

Newman: *That's a great place to close. The materio-physical question in architecture entangled with virtuality, practice and the symbolic—you're pointing to this in multiple contexts. Maybe we need to get used to looking at the world this way.*

Galison: In this particular moment in which we're speaking, I sometimes think we're instantiating [Gottfried] Leibniz's idea of monadology—we exist in our monads and our windows are our screens. We try in constantly shifting ways to get these pixels and framings to capture our (provisionally) lost encounter in the architecture of workplaces, universities, city streets, parks, cafes, museums, restaurants. We make "rooms," and "lecture halls," "tables," and "offices." We see our friends, family, students, and colleagues; we collaborate, through the screen. It's a kind of gigantic planetary experiment in screen-based monadology, but in a new key. A key that, however successful, incessantly reminds us of how much we gain from the built, material world.

Notes

1. P. Galison and E. A. Thompson, *The Architecture of Science* (Cambridge, MA: MIT Press, 1999).
2. Observations were made by nine telescopes over seven days. The team used the principle of interferometry to combine their telescopes' capacity thus creating a 'virtual' telescope the size of the Earth. The data collected was five petabytes in size, equal to 5,000 years of MP3 audio, stored in 1,000 lbs. of hard drives. It was so much data it was inefficient to send it over the Internet, so it was shipped around the world between collaborators. From "Astronomers Capture First Image of a Black Hole," Event Horizon Telescope Collaboration, April 10, 2019, https://eventhorizontelescope.org/press-release-april-10-2019-astronomers-capture-first-image-black-hole.
3. EHT measured the black hole's mass to be 6.5 (±0.7) billion solar masses and measured the diameter of its event horizon to be approximately 40 billion kilometers (270 AU; 0.0013 pc; 0.0042 ly). Because of the lensing of light, the horizon is several times smaller than the shadow that it casts.