Media Review

We Need to See Things by Asif Siddiqi

Peter Galison (Director). *Black Holes: The Edge of All We Know*. 2020. Distributed by Submarine Entertainment.

The historian and philosopher of science Peter Galison has gravitated recently to producing and directing documentaries. His newest film, *Black Holes: The Edge of All We Know*, in some ways extends his concern for how knowledge or objects can be isolated, obscured, and obliterated, either by natural phenomena or by design. *Secrecy* (2008), co-directed with Robb Moss, focused on questions raised by the regulation of information in democracies, and *Containment* (2015), also with Moss, looked at efforts to isolate and remove radioactive waste and toxic materials. Galison's latest explores our ability to visualize and understand one of the most mysterious celestial objects in the universe, black holes, where information itself disappears into oblivion.

Two parallel narratives structure the documentary. The first focuses on the work of the Event Horizon Telescope (EHT), an array of radio telescopes scattered across the globe that work together through a technique known as very-long baseline interferometry, collecting data on very distant objects in the universe (such as black holes). Using infrastructure dispersed around the world, the EHT effectively operates as a single telescope with an aperture the diameter of the Earth. Galison chronicles a roughly three-year period, culminating in April 2019, when the EHT team released to the public the very first image of a black hole—or, more precisely, an image showing the shadow of a supermassive black hole at the center of the Messier 87 galaxy. In perhaps a bit of hyperbole, *BBC Science Focus*, one of Britain's most popular science publications, called it "an epoch-making moment in the history of science."

A second thread in the film, juxtaposed but entirely independent, is the work of theoretical physicists to solve the black hole information paradox—that is, that the permanent disappearance of information within black holes implies a breakdown of the fundamental laws of physics. If such laws break down, the thinking goes, then many of our basic understandings of the workings of the universe would be dislodged, since we could no longer assume that common physical laws govern all matter and energy. The denouement of this story comes in the form of a formal mathematical solution to the problem: proving that black holes do, in fact, store certain legible information (beyond data on mass, electrical charge, and spin) in an infinite collection of what scientists call "soft hair." Where the EHT narrative concludes with the press release of the image to the public, the theoretical work ends in an abstraction—a mathematical solution—albeit one given form and materiality in a published paper and a book.

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The parallel framing of these two narratives of science—one about theory and the other on experiment—is juxtaposed with a third and less obvious one, philosophy—or, more precisely, the philosophy of science. The occasional musings of a number of philosophers of science sculpt the narrative in such a way as to direct the viewer toward a number of broader questions concerned with knowing about phenomena that resist knowing. As Lydia Patton, a philosopher of science at Virginia Tech, asks, "If what we're interested in are phenomena as they can be detected experimentally, [then] how, in fact, do we come to have knowledge about unobservable entities?" Galison's seamless integration of these three frames of reference collectively reveals a rich and heterogenous world of modern physics, one that it is unusual to see in documentaries meant for a general audience. In fact, although the tone, language, and presentation of topics—such as the use of talking heads, shots tracking the main actors deep in their work, and a striking use of animation—are squarely directed at a general lay audience, the film also speaks to historians and philosophers of science in more subtle ways.

Like many celestial objects about which human imagination falls short of comprehension, black holes are easy to describe but difficult to visualize. As places in the universe where gravity has become so powerful that nothing, even light, can escape from them, they imply a reality where certainty and predictability are paused if not obliterated. The enigmatic language that peppers the science of black holes—"singularity," the "event horizon," an "accretion disk"—adds to its allure, as if to provide a tenuous scaffolding to our limited understanding of these strange objects.

Stellar-mass black holes are the result of dying stars that go supernova and then collapse into a singularity, a single point of almost zero volume but near-infinite mass and density. These are almost impossible to see with Earth-bound instruments, but such is not the case for supermassive black holes, with masses up to 50 billion times that of our Sun, which reside at the center of almost every galaxy. The EHT project focused its global array on two such supermassive black holes: Sagittarius A*, about 25,600 light years away at the heart of the Milky Way galaxy and weighing 4.3 million times the mass of our Sun; and another at the center of the Messier 87 (M87) galaxy, this one much more distant—54.8 million light years away—and bigger by a thousand orders. Here, lovely animations fill in the gaps where we lack a sense of scale. A section where the animations, rendered in black-and-white sketches, move out from the Earth, into the solar system, and then into the galaxy and beyond beautifully conveys the scale of the universe as effectively as anything I've ever seen.

There is much to learn about black holes from the film, but it's clear that Galison has other motives in mind in bringing this to the public—specifically, motives to do with the nature of modern science. We are shown, for example, the collaborative practices at the heart of contemporary scientific work. Given that biography and hagiography have held a firm grip on the public imagination of science for centuries, this is no easy task. Here, the EHT team is shown dispersed into different teams, locations, and institutions, collecting data and offering insight at key points in the process. We see independent groups working on the same problem, while within groups there are scenes highlighting the process of consensus-building. There is a wonderful bit that communicates the materiality of the enormous amount of data collected when hard drives containing the results of observations from the eight locations ("photons from Chile," as one scientist notes) are physically transported back for computer processing at MIT and the Max Planck Institute for Radio Astronomy in Bonn.

Yet, even as creativity is distributed among a vast group of talented scientists, one senses a tension—or at least the seduction of the individual star figure. We see this particularly in the outsize role of Stephen Hawking, one of the contributors to the theory that "soft hair" would allow us insight into the nature of information stored in a black hole. Hawking's presence provides a legible anchor for those who might not be familiar with the EHT or indeed anyone mentioned in the film, and his death in March 2018 casts a pall over research on the "soft hair." As one of his coauthors

notes, "One of the saddest things about Stephen's passing in the middle of this is that if it works, we can't tell him."

Controversies surrounding authorship and attribution—issues that have dogged many scientific discoveries—also marred the revelation of the 2019 picture of the black hole. After a striking image of one of the young scientists involved in the EHT team, Katie Bouman, spread rapidly online, many understandably saw her as an ideal role model for young women and girls, who still face considerable obstacles and discrimination in the scientific world. Early claims that seemed to credit Bouman's algorithms as crucial in producing the photograph of the black hole paradoxically reinforced the public's hunger for the "lone genius" narrative. Such claims, in turn, provoked a toxic backlash, as online trolls sought to debunk or diminish her role in the overall project—behavior that crossed into harassment. She herself emphatically emphasized the collective nature of the endeavor, writing in a Facebook post that "no one algorithm or person made this image." MIT soon backpedaled on its early championing of Bouman. In a carefully worded seven-tweet thread, MIT announced that it was "proud of the role . . . our alum Dr. Katie Bouman played in the development of the first-ever picture of a black hole," but that the algorithm that she developed in 2016, while important, was an early piece of the puzzle, inspiring work later done by the EHT team "with many contributing researchers." Galison's decision to omit this episode entirely from the story of the EHT is understandable on some level—to cover it is to dignify and perhaps perpetuate the problem and bring further negative attention to Bouman. Yet at the same time, for better or worse, the episode actually highlights, in uncomfortable but instructive ways, how unyielding and erroneous preconceptions and biases continue to shape the public understanding of science.

Galison is not a disinterested remote observer of this project. He himself is the director of the Black Hole Initiative (BHI), an interdisciplinary center at Harvard University that involves many of the key actors in both the EHT and "soft hair" threads of the film and, thus, many of the scientists shown in the documentary. Given his groundbreaking work (with Lorraine Daston) on issues of objectivity and the ways in which individual scientists are mobilized as part of scientific communities through deliberate choices about "knowledge, persona, and collective sight," the lack of any explicit acknowledgment of his own positionality is troubling. Although documentary filmmakers are not obligated to the pretense of objectivity, in the absence of any explicit admission of Galison's role the film is presented to the public as a kind of remote observational record of scientific practice. As a viewer, one wonders, How did his involvement with the work contour the narrative presented here? More precisely, what is missing?

Certainly absent are the many local frictions at the telescopes that make up the EHT: one of them, the James Clerk Maxwell Telescope (JCMT), is located at Mauna Kea in Hawaii, the site of a long-standing dispute between Indigenous Hawaiians, for whom the site is a sacred space, and scientific communities, which see these claims as marginal. Kealoha Pisciotta, a former telescope operator who has taken up activism as part of the Mauna Kean Hui group opposing construction of the Thirty Meter Telescope (TMT), believes that our priorities are in the wrong order: "We are not against astronomy. But it should not take precedent over things such as species that make up the biodiversity of the planet." Similar patterns play out at other spaces, including at the EHT's Atacama Large Millimeter/Submillimeter Array (ALMA) in Chile, where locals felt that they were being exploited by scientists. Local Chileans went on strike for over two weeks in 2013, protesting poor working conditions, low wages, and the lack of benefits. Scholars such as Leandra Swanner (a former student of Galison's) and Joseph Salazar have shown that these stories—steeped in settler colonial imperatives—are not simply appendixes to the history of ground-based astronomy but in fact fundamental to it.

Science as presented here is also global and diverse, not only in its literal geographical breadth but also in the composition of the EHT experimenter groups and many of the commentators invited in as talking heads. Galison's obviously deliberate selection of outside commentators—only

a few of them are old white men—on the surface is a welcome strategy highlighting a diversity of voices, but it also obscures the legitimate charges of sexual and racial discrimination that have dogged the field of astronomy in recent years. Curiously, when people are identified as participants in either the EHT or "soft hair" narratives, their disciplines are listed instead of their professions (e.g., "philosophy of science" instead of "philosopher of science"), a subtle distinction that de-emphasizes personalities in favor of disciplines. At the same time, I would have preferred to see institutional affiliations (e.g., MIT, University of Arizona, Radboud University, Virginia Tech, Barnard, etc.) noted rather than affiliation to the project (EHT), an approach that effaces the enormous institutional diversity of these participants.

One of the leading participants in the EHT project (although this is not clear from the documentary), Heino Falcke, a German physicist, distills perhaps the most important thread running through the research on black holes: "We need to see things." Galison, of course, has long been interested in how scientists acquire knowledge through the visual ("how the visual participates in the epistemology of science," as he put it in an interview with the Harvard Museums of Science and Culture). One central question here is about *persuasion*—or, as Galison might put it: How are scientists persuaded of their particular positions through images of phenomena? As one might guess, astronomers by and large have a strong attachment to the visual register, and the lack of images, as in the case of black holes, has been a perpetual challenge, robbing us of a sense of their physicality, their scope, and their nature. Although Galison never explicitly suggests it, there is also a theatrical dimension to scientific discovery, what the historian Michael L. Smith once called the "display value" of science and technology and particularly the ways in which objects are "unveiled" to the public. The EHT saga, as shown in this documentary, ends with simultaneous multinational press conferences with media in attendance and a dramatic unveiling of the image of the black hole. There is a theatricality to this process, verging on artifice, that feels forced. Here, the value of the scientific discovery is fundamentally inseparable from its media treatment.

There is a symmetry between the nature of the black hole itself and the ways in which we (the public) understand and perceive such things. Because black holes represent a kind of "boundary object" where information is at a premium, they also represent, as a tautology, "black holes" of information. This phrase has been with us for a long time. A simple Google Books Ngram tells us that the term "black hole" has had a fairly stable rate of incidence in English-language books since the 1800s, some of it offensive (e.g., "black hole of Calcutta"), but took off around 1967 and continued to increase unceasingly until about 2013. Undoubtedly much of this relates to both popular science and science fiction depictions of such objects, including the many visual representations in film, TV, and art. With a few clicks, one can now watch over a dozen other documentaries on black holes, all using visually striking albeit speculative digital animation, making up in imagination for what we lack in reality. All of this has shaped our expectations. Not surprisingly, when the EHT image of the black hole was finally issued in April 2019, there was a striking disconnect between the undeniably incredible achievement and the spareness of the image itself. On the one hand, we had a strangely beautiful image of an object nearly 159 trillion miles away from us that no human had ever seen before. Speaking of the solid black circle at the center of the picture, the University of Arizona physicist Feryan Özel, who headed one of the EHT modeling teams, noted in an interview that "the hole [in the image] is a part of our Universe permanently screened from view. A place where our current physics cannot reach." Yet perhaps that blackness was an impediment to the lay public's investment in this unveiling. Expectations having been shaped by a vast canon of popular culture, this first image of a black hole seemed strangely static and underwhelming (as many media commentators noted at the time). Galison avoids this particular unresolved tension. As the ability of computer graphics to depict fantastic representations of our celestial surroundings has advanced by leaps and bounds, perhaps the "real" visual representations will inevitably fail to live up to our cultural imaginaries?

These are open-ended questions, and it is no slight on Galison that this beautifully made documentary leaves them unanswered. As with all science at the cutting edge, we are left with more questions than answers. But we are also left with some profound insights and beauty—that, flawed and destructive as we are as human beings, some of us continue to seek knowledge at the very edge of our existence, even about phenomena that seem fundamentally unknowable. At a time of great uncertainty, I find this idea deeply comforting.