“Blame it on the Black Star”: Black Holes in Culture

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Abstract

"Black holes" continue to compel the human imagination, as demonstrated by the public reception of the first images of a black hole produced by the Event Horizon Telescope in 2019 or the success of Hollywood science fiction movies like Christopher Nolan's 2014 film *Interstellar* that depicts what it might be like to fall into one. My study traces the discovery of "black holes" in the 20th century – collapsed stars with so much gravity that nothing can escape them, not even light – regarding how scientists talked about them and their emergence in popular culture. This begins with discussing how influential scientists weighed in on the concept and how the scientific community finally settled on the term "black hole." The study then considers various ways black holes have percolated into every aspect of culture: from TV to movies, popular science to modern rock. It concludes with a consideration of the more recent turn in the cultural meaning of this "exotic object," particularly as it relates to the myth of the lone scientist, women scientists, and the climate crisis, but also the risk of nuclear war.

Keywords: black holes, culture, women in science, climate crisis, Event Horizon Telescope, Christopher Nolan, Oppenheimer, nuclear war

This paper chronicles the rise of *black holes* – collapsed stars with gravity so strong not even light can escape – in the scientific discourse and subsequently popular science and culture throughout the 20th century and into the 21st. We begin by tracing the historical origins of what became known as black holes in the history of science and physics. This entailed three phases of historical elaboration, corresponding to the first conceptions of "dark stars" in classical physics in the late 19th century; their interpretation by theoreticians in the early 20th century coinciding with the development of modern physics; and post-WWII studies that referred to "collapsed stars," "frozen stars," and eventually "black holes" (Thorne, 1995; Hawking, 1988). Indeed, charismatic scientists such as Arthur Eddington and Albert Einstein initially resisted the notion of what became known as "black holes" and discouraged their study.

Next, we utilize qualitative content analysis to understand how "black holes" emerged as a fixture of culture and the popular imagination. We explain that "black holes" attracted the connotation of something that is ominous and negative, as a boundary beyond what we know and what we do not or cannot. We conclude with some reflection on current implications for black holes as "social facts" (Searle, 1995, pp. 33, 34) demonstrating a surprising trajectory. Since 2019, black holes have been directly observable through modern imaging techniques and photography (Figure 1). In relation to this widespread publicity, we suggest that "black holes" have accrued two more specific connotations in recent years: that of women in science on the one hand and ecological catastrophe on the other.

Figure 1

Black Hole in Messier 87 Photographed by Event Horizon Telescope, Which Appeared on the Cover "The New York Times", April 10, 2019 (Source: Wikipedia Commons)

Black Holes: Brief Origins of the Term

This section briefly outlines the origins of the term "black hole, of how it emerged in scientific discourse before being introduced into popular culture. The first descriptions of objects that would eventually become black holes occurred before World War I in the work of famous scientists like Mitchell, Laplace, and others who studied something called a "dark star," culminating in the description of a "dark star" by Karl Schwarzchild (Thorne, 1994). Next,

between WWI and WWII, famous scientists such as Arthur Eddington and Albert Einstein responded to Schwarzchild's idea with their thought experiments meant to refute it. Still, according to Thorne, these were not entirely rational. Finally, in the period during and after the WWII, research on "dark stars," "collapsed stars," and "frozen stars" by Robert Oppenheimer, Stephen Hawking, and Roger Penrose finally solidified black holes research as a credible field of inquiry (Thorne, 1994; Hawking, 1988).

Opposition to "Dark Stars": Einstein & Eddington

Interestingly, according to Thorne, in the 1920s and 30s, astrophysicist Arthur Eddington and theoretical physicist Albert Einstein, the two reigning experts on general relativity, objected to the concept of "dark stars." Einstein, for example, presented two thought experiments, or *Gedankenexperimente*, to disprove Schwarzschild, concluding that "The essential result of this investigation is a clear understanding as to why the 'Schwarzchild singularities' do not exist in physical reality" (quoted in Thorne, p. 136). Thorne dismissed these objections. Eddington was mixing Newtonian, semi-relativistic arguments and sheer "hyperbole," and Einstein did not understand that gravity overwhelms all other forces in the implosion process. He did not yet appreciate the full implications of his theory (pp. 136, 137).

Meanwhile, Eddington tried to persuade a brilliant young, self-taught cosmologist named Subrahmanyan Chandrasekhar to study the motion of star clusters instead of "dark stars." In 1983, Chandrasekhar would be awarded the Nobel Prize, mainly based on his studies of the latter. He proved that the "Pauli exclusion principle" (which states that as particles are cramped into a smaller and smaller *space,* their *velocities* must *vary* more and more) could not halt the collapse of a star more massive than his limit. Today, this is known as the *Chandrasekhar limit* on the mass of a star beyond which it collapses into a black hole (Thorne, pp. 146, 148). In fact, in 1939, mere months after Einstein published a paper refuting the idea of black holes, J. Robert Oppenheimer and student Hartland S. Snyder published a paper in which they used Einstein's general theory of relativity to show how black holes form (Bernstein, 2007).[1] Oppenheimer (who would famously go on to become the Head of the Manhattan Project later) and Snyder first showed what happens to a star that exceeds the Chandrasekhar limit. The pair formally demonstrated that as the interior of a star collapses, light can no longer escape from its surface.

"Dark Stars", "Frozen Stars" & the "Black Hole"

While the Second World War put "dark star" research on the back burner in the race to invent the atomic bomb, it was later rediscovered. Between 1965 and 1970, British physicists Roger Penrose and Stephen Hawking showed that there must be a *singularity* inside the "dark star" – a point at which the customary laws of quantum physics break down. This led to the phrase

[1] Bernstein, Professor Emeritus of Physics at the Stevens Institute of Technology, described Einstein's attempts to discredit the Schwarzchild radius in his 1939 paper, noting: "I was much taken by the fact that the then 60-year-old Einstein presents in this paper tables of numerical results, which he must have gotten by using a slide rule. But the paper, like the slide rule, is now a historical artifact."

"God abhors a naked singularity" in academic circles, indicating that singularities were always obscured by black holes (Hawking, 1988, pp. 85–88). By the 1960s, the exotic object was being referred to by two names: a *collapsed star* in American circles and a *frozen star* in Russian circles (Thorne, p. 254). After work in the 1960s demonstrated that a black hole could, in fact, be formed by a rotating star,[2] Hawking showed in 1971 that after gravitational collapse, a "black hole" could be rotating but not pulsating, the so-called "no-hair" conjecture, that is, nothing bubbling on the surface (Hawking, p. 91, 92).

By 1971, they were called "black holes." General relativity expert John Wheeler was dissatisfied with *collapsed stars* and *frozen stars* because neither name emphasized the *event horizon* – a kind of Rubicon surrounding the singularity – which had become the focus of study in the 1960s. Thus, in a 1967 lecture to the American Association for the Advancement of Science entitled "Our Universe, the Known and the Unknown," he noted:

> [The star,] like a Cheshire cat, fades from view. One leaves behind only its grin, the other, only its gravitational attraction. Gravitational attraction, yes; light, no. No more than light do any particles emerge. Moreover, light and particles incident from outside…[and] going down the black hole only add to its mass and increase its gravitational attraction.
>
> (in Thorne, pp. 256, 257)

A star was born – a black star. Wheeler coined the term "black hole," and within months, it was being used by relativity physicists (except in France, where the translation, an obscenity, was resisted for a few years longer) (Thorne, p. 257).

Black Holes in the Press and Popular Culture: A Qualitative Content Analysis

This section examines how the term "black hole" moved from astrophysics circles into the vocabulary and the associations the term subsequently absorbed in popular culture. The method is a qualitative content analysis of key newspaper articles in the U.S. media, followed by select examples from culture (e.g., TV, music, film, young adult fiction, etc.). The method for this analysis draws from Krippendorff's definition (2004, p. 18) of content analysis as "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use." This is to distinguish qualitative content analysis from other qualitative methodologies, like *discourse analysis* or *conversation analysis* (Gheyle & Jacobs, 2017), which are closer to examining speech acts and the work of Searle and Austin, e.g., the examination of the scientific discourse. Referencing this definition also distinguishes the method employed in this section from *quantitative content analysis* (with its emphasis on counting). Indeed, many scholars interpret "qualitative" to be "interpretive," and, according to Krippendorff, "ultimately, all reading of texts is qualitative, even when certain characteristics

[2] This is the Kerr solution (1963) of Einstein's equations. Black holes were thus seen as substantially more abundant than previously thought (Hawking, 1988, pp. 91, 92).

of text are later converted into numbers" (2004, p. 16).[3] Hence, qualitative content analysis in this study refers to the selection of highlights from reportage on black holes in the news and their mention in popular culture, to demonstrate how they entered into mass consciousness.

Early Appearances in Newspapers & the Press: 1960 through 1980

It is interesting to note how black holes first found entrance into newspapers. For example, in an April 14, 1968, article describing the newly discovered pulsars, *New York Times* reporter Walter Sullivan mentioned another exotic stellar object, "the 'black hole," where all physical laws seem to run amok." Pulsars are neutron stars that emit pulses of radiation at regular frequencies. Einstein's theory predicted them, and so among other things it was the discovery of pulsars in 1967 that really got the ball rolling for research on "black holes" to be taken seriously (Hawking, 1988, p. 93). According to Sullivan's news article, a black hole is a star collapsing into something infinitely small and infinitely dense" (Sullivan, 1968). The stage was set for black holes to be of major significance in validating modern cosmological theory. At first, black holes cropped up mainly in the context of science news. These included a range of perspectives, for example, criticism of black holes by two MIT professors who suggested a more straightforward, Newtonian explanation because "the evidence for them so far was ambiguous" (Sullivan, 1975), but later the suggestion that the inner core of the Milky Way might itself be a black hole (Sullivan, 1982). Black holes arose in the context of neutrino detectors (Browne, 1987) and were depicted as potential engines of galactic formation (Gleick, 1987).

Author Madeleine L'Engle was ahead of the curve when she described an object eerily reminiscent of a collapsed star in her 1962 young adult novel *A Wrinkle in Time* (2005), five years before Wheeler first used the term "black hole." The protagonist, Meg, is transported to the far reaches of the universe by hyper-dimensional creatures. She and her brothers ascend through the atmosphere of an unknown, earth-like planet into space to seek out their missing father:

> Meg looked. The dark shadow was still there. It had not lessened or dispersed with the coming of night. And where the shadow was, the stars were not visible. What could there be about a shadow that was so terrible that she knew that there had never been before or ever would be again, anything that would chill her with a fear that was beyond shuddering, beyond crying or screaming, beyond the possibility of comfort...The shadow was still there dark and dreadful.
>
> (L'Engle, p. 65)

[3] In a parallel to the idea that a "black hole" is what Lackoff and Johnson (1980) called a "container metaphor," Krippendorff suggested that the method of content analysis itself is a kind of "container" of meaning inherent to the text and crisscrossed by a certain interpretive tack between questions and evidence.

TV Popularization and Sagan's *Cosmos* (1980)

Gradually, everything from sports articles (the view from the press box was a "black hole") (Leonard, 1982) to politics (Riding, 1989) to literary snobbery (Taylor, 1989) evoked the "black hole" as knowledge of black holes among non-experts was becoming more sophisticated. This was as black holes had become a topic of discussion in popular science. When it debuted in 1980, Carl Sagan's Emmy Award-winning series *Cosmos* (Sagan et al., 1980) did a lot to bring the vision of modern cosmology into people's living rooms. The accompanying book describes black holes in the context of stellar evolution, galaxies, and quasars (Sagan, 1980, pp. 238, 239, 249–250). Sagan returned to the topic of black holes briefly in *Pale Blue Dot* (1994), noting that black holes might be one more exotic phenomenon awaiting observation as humanity moves into the stars. He speculated that they could even be a future energy source for space-faring humans, though it is uncertain that any lie nearby (i.e., within 10 to 20 light-years) (pp. 393, 394). More recently, celebrity astrophysicist Neil deGrasse-Tyson rebooted Sagan's classic series on Fox, to great critical acclaim in *Cosmos: A Spacetime Odyssey* (Druyan et al., 2014), during which he takes the audience on a tour of a hypothetical black hole rendered in CGI in his "spaceship of the imagination."[4]

Influence on Postmodern Thought: Jean Baudrillard

Black holes have notably also influenced postmodernism. In 1983, Jean Baudrillard (2005) referenced the physical concept of a "black hole" in his description of deterrence and "disappearance" in the same context as surveillance, advertising, and nuclear power. With deterrence, society will implode like a star.[5] The late philosopher also referred to black holes in his reflections on "the masses" of politics:

> The social void is scattered with interstitial objects and crystalline clusters which spin around and coalesce in a cerebral chiaroscuro. So is the mass, an in vacuo aggregation of individual particles, refuse of the social and of media impulses: an opaque nebula whose growing density absorbs all the surrounding energy and light rays, to collapse finally under its own weight. A black hole which engulfs the social."
>
> (Baudrillard, 1983, pp. 3, 4)

[4] deGrasse-Tyson wrote a book containing a key essay on the subject in 2014, *Death by Black Hole: And Other Cosmic Quandaries*.

[5] Political and social systems, he argues, parallel black hole formation in astronomy: "The stellar systems also do not cease to exist once their radiating energy is dissipated: they implode according to a process that is at first slow, and then progressively accelerates - they contract at a fabulous speed, and become involutive systems, which absorb all the surrounding energies, so that they become black holes where the world as we know it, as radiation and indefinite energy potential, is abolished" (Baudrillard, 2005, p. 72).

Baudrillard also evoked black holes with a somewhat romantic metaphor:

> To love someone is to isolate him from the world, wipe out every trace of him, dispossess him of his shadow, drag him into a murderous future. It is to circle around the other like a dead star and absorb him into a black light.
>
> (Baudrillard 2008, p. 135)

Thus, as the adoption by the provocateur Baudrillard shows, the concept of a "black hole" was simultaneously gaining visibility within the broader intellectual community, including media studies and the social sciences.

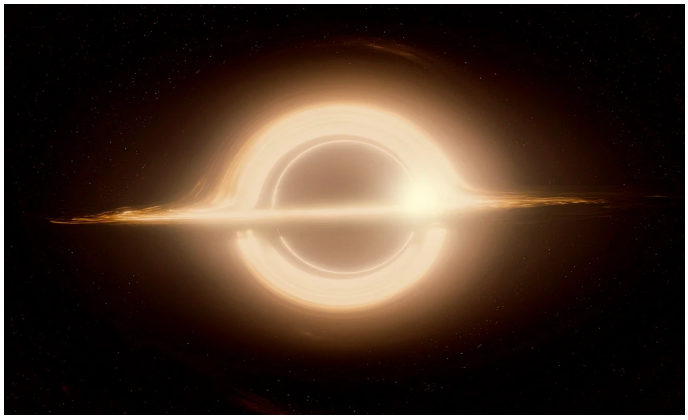
Hawking, Thorne, TV, Radio & Film: 1988 to Present

Like Sagan and *Cosmos*, Oxford Physicist Stephen Hawking's *A Brief History of Time* (1988) also made black holes accessible to the layperson. His book won him international fame as well as cameo appearances on primetime TV shows like *Star Trek: The Next Generation* (Taylor et al., 1993) and even *The Simpsons* (Groening et al., 1999). At the end of the episode that included his cameo, Hawking and Homer Simpson chit-chat while enjoying Duff beers:

> Hawking (in monotone computer voice): Your theory of a donut-shaped universe is intriguing Homer. I may have to steal it.
>
> Homer (burps): Wow, I can't believe someone I never heard of is hanging out with a guy like me.

After Sagan's *Cosmos* and Hawking's book, in 1994, Kip Thorne wrote *Black Holes and Time Warps* to bring general relativity to a "literate lay audience" (Thorne, p. 15). More recently, Thorne consulted for Christopher Nolan's blockbuster film *Interstellar* (2014) about an astronaut who falls into a black hole to save humanity. Indeed, the visual effects in the movie closely parallel descriptions of a black hole in Thorne's 1994 book, including some of what the astronaut goes through when he falls beyond the "event horizon," or point of no return (Figure 2).

Figure 2
The supermassive black hole "Gargantua" depicted using CGI in the film "Interstellar" (2014). (Source: Paramount Pictures)



References to black holes also began to appear in popular music in the late 1980s, early 1990s, and even today, particularly in indie music. Here are some examples:

- The creature in the sky/Got sucked in a hole/Now there's a hole in the sky/And the ground's not cold (Pixies, 1989)
- Black Hole Sun/Won't you come?/And wash away the rain (Soundgarden, 1994)
- Blame it on the black star/Blame it on the falling sky/Blame it on the satellite/That beams me home (Radiohead, 1995)
- I'm a black star way up on money I've got game (Bowie, 2015)

We live with black holes as an ambient concept: on a recent trip, Soundgarden's "Black Hole Sun" video played in the airport Hard Rock Café while I ate dinner. Black holes have also featured prominently in many movies since Wheeler first coined the term. For example, Disney's family film *The Black Hole* (Dir. Nelson, 1979) depicted a team of astronauts who ventured through a black hole, only to emerge on the other side, which resembles heaven. On the other hand, the horror movie *Event Horizon* (Dir. Anderson, 1997) imagined that a team of scientists opened a portal to Hell through a black hole. *Donnie Darko* (Dir. Kelly, 2001) explicitly referenced *A Brief History of Time* and used the book as a prop in the film.[6] Interestingly, in a 2002 essay that articulated his "Chronology Protection" conjecture (i.e., the laws of physics do not permit time travel because the universe will always intervene to preserve causality), Stephen Hawking evoked pop culture to describe time travel at the quantum level:

> In particular, there will be histories in which the particle goes around and around on a closed loop in time and space. It would be like the film Groundhog Day, in which a reporter has to live the same day, over and over again. (in Hawking et al., 2002, p. 103)

[6] *Wormholes* (black holes directly connecting two distant points in space) is a central device in *Donnie Darko*.

By another kind of loop – a feedback loop – it would appear that popular culture not only reinterprets physics but that physicists reinterpret popular culture! Hawking's notion of "Chronology Protection," as well as black holes and parallel universes, are all themes in the successful Netflix original series *Dark* (Friese & Odar, 2017), produced in cooperation with German TV, which (spoilers follow) centers around a young couple whose ill-fated romance follows a timeline through a black hole that initially emerges over a nuclear power plant (Figure 3). Such examples illustrate the persistent popular appeal of black holes, which are frequently interpreted as something ominous, related to ill-fated human events, and, more recently, environmental themes, such as in *Interstellar* and *Dark*.

Figure 3

Black holes feature prominently in the Netflix original television show "Dark" (Friese & Odar, 2017), which also contains apocalyptic themes associated with environmental degradation. (Source: Netflix)

Netflix's original program *Lost in Space* (Drake & Chow, 2018), a reboot of the 1960s original (Allen, 1965) presents another recent example that connects black holes with environmental issues. In the show, the Robinson family is part of a future expedition heading for the Alpha Centauri star system because of the degradation of Earth's environment, but they get lost on route. In one episode, they believe they have found a safe planet, until the mother character, an aerospace engineer, researches strange weather patterns on the planet, ascending in a high-altitude balloon to take some readings (Figure 4). Her instruments indicate, much to her horror: "Hawking radiation detected."[7] The planet's star is in a death spiral with an invisible black hole, and their new home will soon be torn apart. It is interesting that the female scientist is the one to first detect such a cataclysmic threat to the expedition's survival.

[7] According to Hawking (1988), black holes emit radiation and glow with infrared light, the "Hawking radiation."

Figure 4

Maureen Robinson (Molly Parker) ascends above the atmosphere of a remote planet, only to discover the Hawking radiation from a black hole that is rapidly consuming the planet's star in Netflix's "Lost in Space" (2018). (Source: Netflix)

Fleck (1979) defined discourse as a constrained sequence of texts connected to specialized systems of people (pp. 1-20). Members of a scientific community (physicists, for example) participate in a discourse. Fleck suggested that popularization makes a scientific discourse palatable to the general public and also entices new talent to join the discourse to provide fresh perspectives (pp. 154-165). This is how scientific popularization fits into the larger concept of scientific discourse defined by Searle (1995). Ferris (in Hawking et al. 2002) argued that scientific popularizers play an essential role in socializing people to the modern scientific picture of the universe to reduce "anxiety levels" in developed nations (p. 153). Science is a "white hole" that gushes information (p. 168), much like the one from which the protagonists of Disney's *Black Hole* emerged. Despite the early skepticism of notables such as Einstein and Eddington, the preceding examples demonstrate how the concept of a "black hole" won the hearts and minds of the public. Black holes have become so well integrated into the popular imagination as to make them a household term synonymous with Stephen Hawking. Yet, they are also a phenomenon with ominous popular associations: an unbreachable boundary, death, doom, and ecological catastrophe. And now we know that they do exist through direct observation.

Black Holes Revealed

Much physical data supported the existence of black holes before their direct observation in 2019. For example, neutron stars were discovered in the form of pulsars in 1967, when John Wheeler coined the term "black hole" (Hawking, 1988, p. 93). Hawking also gave further examples of "exotic objects" which have since been observed. For example, the pulsar PSR 1913 + 16 is a binary neutron star predicted by Einstein's theory. The two stars lose their energy at a fantastic rate as they spiral toward mutual destruction by the warped space between them (p. 90). Hawking also referred to the observation of 3C273, the first Quasi-stellar Object (or Quasar) in 1963 (p. 93). Astronomers studying the galaxy RX J1242-11 over a decade confirmed that its center is a supermassive black hole (Britt, 2004).

In a *Gedankenexperiment,* or "thought experiment," Thorne (1994) illustrated how an astronaut could probe the event horizon of a black hole based on simple physical data: its mass, spin, and charge (pp. 23-30). Furthermore, detecting the black hole's after-images, tidal forces, space-time warpage, gravity lensing and red-shifting of light would be possible.[8] Thus, evidence for a black hole was initially indirect, but it could also be thought through in a "thought experiment," such as those initially used by Einstein.

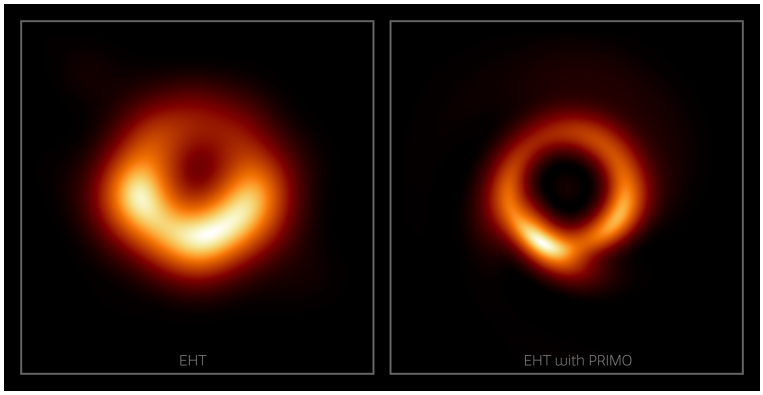
The question whether a black hole can be directly observed has by now also been answered. An international research team revealed the first-ever image of a black hole on April 10, 2019, shown in Figure 1, above. This image has since been enhanced using a different imaging algorithm (Figure 5 below).[9] The black hole depicted in the image is at the heart of galaxy Messier 87, which is 55 million light-years from Earth. According to *The New York Times* (Overbye, 2019), Harvard-Smithsonian astronomer and project director Shep Doeleman announced at a press conference in Washington, DC, that, "We have seen what we thought was unseeable," evoking Virilio's notion that the task of technoscience is to "make the invisible visible" (2007). The image provoked a comparison by *The New York Times* to the "Eye of Sauron," the villain in The Lord of the Rings (Dir. Jackson, 2001), and the article is peppered with references to the paradoxical nature of imaging something "unobservable." Harvard scholar Peter Galison, also a project member, described "a wonderful open-ended sense of being able to see something," not just statistical data.

[8] Indeed, with a really big black hole an astronaut could approach the event horizon without too much of the pain that is due to the tidal forces of the warped space-time (Thorne, p. 37). He or she could measure these tidal forces and the warping of space-time: as the astronaut descends closer to the event horizon the circumference of their orbit is no longer in a 2π ratio with the radius. They would also observe the night sky above contract into a disk of light as if the black expanse of the hole were welling up around them, but this would be due to the light bending in a gravity field (p. 43). Finally, he or she could drop a robot probe with a laser beacon into the black hole. In the final fractions of a second before the probe vanished beyond the horizon the frequency of the light beam would zoom out of the visible spectrum, from x-rays to radio waves and into oblivion – blackness (32, 33). All this is depicted in a scene in *Interstellar* (Dir. Nolan, 2014), for which Thorne was a consultant, when an astronaut played by Matthew McConaughey descends past the event horizon of a black hole called Gargantua in a last-ditch effort to find a new planet for humanity after Earth's ecosystems have been devastated. Note here, as well, the ecological association of black holes, as we discuss in the conclusion. In his 1994 book, Thorne also elaborated on the interior structure of a black hole. The singularity itself is smaller than a nucleus; the rest from the event horizon down is utter void (Thorne 23–30). According to Thorne, near the singularity space-time oscillates with enormous, chaotic tidal forces. It could be a centimeter thin and light-years wide (p. 36). The interior of the event horizon is also shown in *Interstellar*, though McConaughey's character escaping death by "spaghettification" (i.e., when something is pulled by a black hole's intense gravity into a long string of atoms) is more a matter of poetic license (and, for his character, luck)!

[9] In 2022, the same team released the first-ever image of the supermassive black hole at the center of our galaxy, Sagittarius A* (National Science Foundation, 2022).

Figure 5

Black hole in Messier 87 photographed by EHT from April 2019, and the 2023 enhanced version using PRIMO imaging algorithm. (Source: National Science Foundation)



Even if one photographs a hole, it is still an absence as, again, by definition, a hole is just an "opening" or an "area where something is missing" (Merriam-Webster, n.d.). What has been rendered in the picture is the accretion disk of superheated charged particles and gas that surround a black hole, demarcating a point of no return, the *event horizon*. Writing for *The New York Times*, Overbye (2004) reiterated that despite it being predicted by his equations for general relativity, Einstein was unwilling to accept the concept of a black hole. However, as predicted by his equations, the shape of the event horizon is circular. Kip Thorne noted in an email to the *Times*: "It is wonderful to see the nearly circular shadow of the black hole. There can be no doubt this really is a black hole at the center of M87, with no signs of deviations from general relativity." The effort required yoking together nine radio telescopes around the globe to turn them into one enormous earth-sized telescope, as well as the actions of 200 researchers. The network was called the Event Horizon Telescope (EHT).

Eight of these radio telescopes watched the galaxy in Virgo for ten days in April 2017, and it took two years to analyze the collected data, during which the researchers reduced and collated. There was so much data that it could not be downloaded through the Internet but had to be put on stacks of hard disks and flown back to M.I.T and the Max Planck Institute in Germany (the South Pole data took until December 2017 to arrive because of the Antarctic winter). Meanwhile, Katie Bowman, a Caltech computer scientist and assistant professor, was a lead researcher on the EHT team who wrote a key imaging algorithm. She initially became involved in the project while she was a graduate student at M.I.T and went on to become the face of the project after the image of the black hole in M87 was made public in April 2019.

Discussion: Shifting Connotations in Culture

Since Wheeler first coined the term "black hole" in 1967, the concept has blossomed both in popular science and popular culture, as demonstrated above. But the connotations of that term have also taken on a darker meaning as something ominous and dangerous, something to be feared and regarded as unknown. In this section, we argue that the idea of a "black hole" has

taken on at least two newer connotations in recent years. The first is that Katie Bouman's participation in the EHT project as a representative of black hole research really made her into a feminist icon and linked black hole research with a broader debate about women in science and the myth of the lone genius. The second connotation that I will argue is more recent: that black holes are associated with ecological catastrophe, that they have become symbolic of the climate crisis, and the growing awareness (particularly among global youth) of imminent environmental catastrophe.

Black Holes & Women in Science

After the Event Horizon Telescope photographed a black hole, project lead Katie Bowman emerged as a larger-than-life figure. This made a new, surprising connection between black holes research and women in science and, concomitantly, evinced public fascination with the role of women in the massive, distributed effort of computation required to render such an image. These two issues are not independent.

As the issue of women in science gains greater traction worldwide, it is fitting that Bouman should become the face of the Event Horizon Telescope, with its throwback to the pre-mechanical objectivity of composites. Her recognition reflects not simply public wonder at the image of a black hole but also with the imaging techniques used to produce it as a team effort. In this way, Bouman's fame undercuts the myth of the lone (predominantly white male) science genius. As is well known today, scientists more frequently make discoveries as part of a group or team (Dunbar, 1997).

Unfortunately, this also explains why, after achieving recognition as the representative for the EHT working group, Bouman became the target of online attacks by trolls who disputed the idea that her algorithm was crucial to the project (Lou & Ahmed, 2019). *Vox* interpreted this to mean that the public needs more images of successful women scientists to counterbalance the notion that women often do not feel welcome in science (Resnick 2019). In the rendering of an actual image, our discussion of the popular representation of black holes takes an unanticipated turn into feminism and women in science. The public fascination with black holes has brought a corresponding turn – that is, from viewing black holes as *ominous* to an association with the role of women scientists and computation in the production of objective science, and indeed, in such a way that it references Daston and Galison's notion of pre-mechanical objectivity.

Galison's participation in the project is notable because he researches the history of objectivity in science. In *Objectivity* (2007), Daston and Galison map different types of objectivity that emerged throughout the history of Western science. Objectivity as a category is, then, historically contingent. According to Daston and Galison, whereas 19th-century scientists attempted to represent nature by cataloging prototypical specimens in "atlases" of knowledge (for example, human skeletons), by the mid-20th century, particle physicists offered the snapshot of a bubble chamber as a form of mechanically reproducible objectivity. Thus,

different forms of evidence predominated in different historical epochs to satisfy the criterion of objectivity.

Note the image of the black hole references this earlier notion of pre-mechanical objectivity because it is a composite image. The production of that image was a feat of data storage: five petabytes of data stored across multiple hard drives. According to *Vice Motherboard*, this is "the equivalent of 5,000 years' worth of MP3s," and a cheeky image of lead developer Katie Bouman grinning over the stacks (Figure 6) went viral in the aftermath of the debut (Gault, 2019).

Figure 6
Lead EHT developer Katie Bouman smiles over five petabytes of data containing the image of the black hole. (Source: Katie Bouman)

As such, a reference to Haraway (2018) and the historical scientist as "modest witness" is apropos since Bouman's role as a feminist icon that does networked science extends to the black hole by association. Scientific giants in history may not have anticipated such dimensions now that an abundance of evidence, physical and theoretical, has established black holes as what Searle called a "social fact," whereas before black holes were depicted as ominous, yet feminism and distributed computing for advanced imaging techniques are now just as much a part of the "social fact" of the black hole as anything.

The "Black Hole" of Climate Crisis

Black holes have become part of the vernacular and synonymous with physicist Stephen Hawking. However, the pop culture and even some of the technical references noted above illustrate another connotation of black holes – that they constitute a boundary beyond which no information can be retrieved. While technically this is not true because black holes emit Hawking radiation, the popular symbolic interpretation of the black hole is that it is somehow *"dreadful"* (L'Engle, 65), the source for universes that should have never existed, to begin with, as in the Netflix show *Dark* (2017), and beyond these connotations of something dark and mysterious, this is precisely what a black hole represents to modern physics – a so-far irreconcilable breach between gravity and the atom. The singularity at the center of a black

hole is where our understanding of modern physics breaks down. In this case, the black hole represents a literal boundary for *all modern cosmology and physics*.[10]

This part of the study requires some reflexive self-report of "lived experience" in the spirit of autoethnography (Bunde-Birouste, Byrne & Kemp, 2019) to better illustrate the relationship between black holes and climate crisis. The renewed inspiration for the present study (initially begun in 2007) came from a personal experience. One morning in early April of 2019 – a bright morning when the cherry blossoms were in full bloom – I waltzed into a Starbucks near where I lived in Portland, Oregon, and almost spilled my dark roast. There it was: the image of the black hole in Messier 87, right on the cover of *The New York Times*, a reflection of humanity's inner darkness as if some shift in the collective unconscious.

At that moment, I imagined a metaphorical *syzygy* of a black hole, rising authoritarianism, and climate crisis. That the black hole image should appear just as the pillars of democratic society were being challenged globally and as the world teetered on the brink of ecological oblivion seemed like what Jung had called a *synchronicity* (2010). This was no mere coincidence, however: Donald Trump's rhetoric feeds both, simultaneously bolstering authoritarianism (a real threat to democracy) (Ingraham, 2020; Ross, 2016) while ignoring the existential crisis of climate cataclysm, a real *existential* threat (Haque, 2022).[11] Trump literally appeared as a shadow when he made his debut at the 2016 RNC in silhouette. Thus, the image of the black hole beamed back to earth took on uncanny significance for me, a harbinger of where our world seemed to be headed politically and *ecologically*. To elaborate on the quote by Searle (1995), and thus refine our understanding of the difference between a "brute fact" and "social fact": "Something can be a mountain even if no one believes that it is a mountain…but for social facts, the attitude we take toward the phenomenon is partly constitutive of the phenomenon" (p. 33).

To unpack the latter, I will go back even further to one of the events that led me to Oregon in the first place. I had the good fortune to witness the 2017 North American solar eclipse reach totality, surrounded by good friends in the mountains of Oregon. It's been over five years, and I remember looking on dumbfoundedly at a black hole in the sky ringed by a frozen wind of plasma a million miles high. Two years later, I marched in solidarity with millions of high school students worldwide on September 20, 2019, in a global "Climate Strike" organized by Swedish teen activist Greta Thunberg. It should not have been any surprise, perhaps, when I noticed that the flyer for the march (created by Oregon students, ostensibly) depicted a collage

[10] Lackoff and Johnson (1980, pp. 25–29) discussed *ontological metaphors*, and Watzlawick (1984) pointed out some examples of "self-fulfilling prophecy," including the interpretation of quantum mechanics: "Similar quotations, referring to the effect of such "unscientific" factors as simple expectations and assumptions in the sciences, could be collated in abundance – the book in hand is itself intended as such a contribution. In this connection, one might recall, for instance, Einstein's remark in a talk with Heisenberg: "It is the theory that determines what we can observe." And in 1959 Heisenberg himself stated, 'We have to remember that what we observe is not nature in itself, but nature exposed to our method of questioning'" (p. 101). Black holes represent a hard problem of reconciling gravity with quantum mechanics.

[11] Indeed, comparisons between Trump's rhetoric as a "self-fulfilling prophecy" and a black hole call for closer scrutiny; this should be the subject of a future research paper.

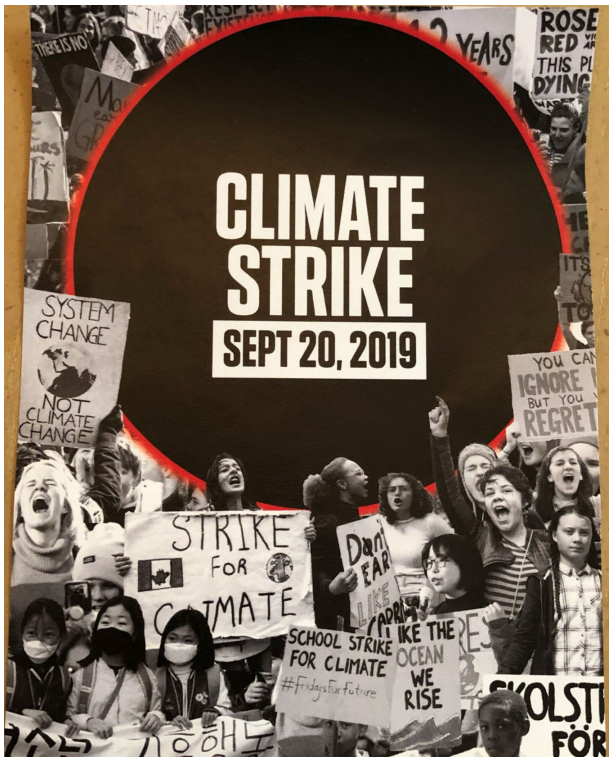
of student protestors around a central black hole. The words “Climate Strike” were depicted as a write-over in white letters, and the black spot itself fringed with a diffuse red boundary (again, reminiscent of “Hawking radiation”) (Figure 7).

According to the non-profit National Resources Defense Council (NRDC, 2019), students had a pro-social mandate to skip school that day. The NRDC noted that by the time high school seniors now are 50, the number of average days in the U.S. with a heat index greater than 100 degrees Fahrenheit will double, storms will have become more devastating worldwide, and year-round wildfire “seasons” and quickly rising sea levels could displace more than 800 million people. One year later, September 2020, saw an unprecedented number of fires on the West Coast of the U.S., particularly in Oregon outside of Portland, where an estimated half a million residents were displaced (“Oregon Wildfires,” 2020); the trend continued with climate fires raging on the West Coast and Oregon earlier than expected in the summer of 2021, and NASA confirmed that the summer of 2023 was the hottest on record (Kuthunur, 2023).

The public has been quick to embrace the reality of the black hole in M87 but slow to embrace the reality of climate change, a comparative case study in science demonstrated (Shepherd, 2019). It is a slow, reluctant embrace that has arguably been held back by oil and corporate interests and the conservative Right, one that has spanned my entire lifetime (Cornwall, 2019).

Figure 8

Climate Strike Flyer, 2019. Note the presence of activist Greta Thunberg, lower right. (Source: Climate Strike Oregon)



Thus, the image of a "black hole" at the heart of the flyer surrounded by a collage of protestors recalled for me the totality of the 2017 eclipse and functioned as a harbinger of the coming ecological catastrophe of West Coast climate fires in 2020 and beyond.

Conclusion

It is partly this *totality* why I'm still thinking of Mackenzie Wark's essay from September 2017 (a response to Amitav Ghosh's book about climate change, apparently) in which he points out how consumer culture has hollowed out the contemporary novel, robbing it of the possibility for transformative change in favor of a focus on the minutia of everyday life (which might explain my soft-spot for Murakami's writings), while praising genre fiction, weird fiction and in particular climate fiction, or "cli-fi" (note the reference to Ballard's novel in which an imagined 45th President takes on "a role in a climate change story) and including historical anecdotes like how one mid-19th century sea captain correctly predicted the vulnerability of Port Canning in West Bengal three years before a cyclone destroyed it. Wark writes: "[L]et's have a thousand names for the Anthropocene. Ghosh offers catastrophozoic and the penumbral period. Anything of this scale and complexity, not least emotional complexity, needs a whole poetics of its own."

I fancy the latter: Welcome to the Penumbral. This was my reading as I attended the 2017 Oregon eclipse and, given the political climate of the nation at the time and since, it is not difficult to see how the eclipse that crossed the continental United States in 2017 might be interpreted as a warning, or a "spell" resulting from a reductive, positivist worldview (Horkheimer & Adorno, 2002, p. 134). It was also my reading on the morning in April 2019 when I woke up to an image of a black hole on the cover of *The New York Times* and almost spilled my Starbucks coffee. This dazzling spectacle was the sum of the work of a whole team of experts. It gave rise to a new star, a woman graduate student from MIT who became the face of the project, its interpreter for popular science and, also, sadly, the target of unfounded hate emails suggesting that she was unworthy of being a representative for the team of scientists. Arguably, it also holds up the mirror to the unspeakable turn toward authoritarian-style rhetoric and politics that we are witnessing worldwide, which constitutes a self-fulfilling prophecy of the worst sort, and its twin specter, that of environmental degradation, should it also prove to be nothing short of a self-fulfilling prophecy.

In conclusion, the surprising success of Christopher Nolan's 2023 blockbuster *Oppenheimer* (Figure 9) demonstrates the continued audience appeal of science and black holes. But it also goes further to situate research into black holes in the context of what Collins (2013) called "revealing science," and to present black holes in a film that requires audiences to critically reflect on nuclear war. Against the odds, *Oppenheimer* became the highest-grossing biopic in September 2023, earning $900 million at the box office alongside summer competitor *Barbie* (Bramesco, 2023). Indeed, the film briefly depicts Oppenheimer's contribution to black hole research when Cillian Murphy as the titular character explains the concept of an imploding star to a rapt classroom (complete with an accompanying experimental montage). He then encourages a motivated student, Hartland Snyder (portrayed by actor Rory Keane), to puzzle out the limit on

density, telling him with a smirk (and to his surprise), "See where the math takes us. I guarantee it's somewhere no one's been before." Indeed, many famous scientists who contributed to the development of modern physics appear in the film, including two pioneers of black hole research, Oppenheimer and Einstein.

Figure 9
Poster for *Oppenheimer*

The poster art copyright is believed to belong to the distributor of the film, Universal Pictures, the publisher of the film or the graphic artist. (Wikipedia Commons) https://en.wikipedia.org/wiki/File:Oppenheimer_(film).jpg

The mention of black holes in the context of *Oppenheimer* perhaps signals more than just audiences' continued fascination with them, however. Collins, for example, described the value of "revealing science" (Collins, 2013) that makes new discoveries. He claimed that today's science is not "pioneering science" at all and that furthermore, sciences that do probe the boundaries of what is known and what is possible (such as gravity waves science, Collins' chosen subject for sociological inquiry and one that relies on the physics of black holes for observation and data collection) hold themselves up to an incredibly high standard:

> The triumphal accounts are either retrospective, or refer to sciences that are so well established that they have made all their mistakes and become technologically secure—not reaching, but perhaps reaching toward, the reliability of your fridge or your car. The revealing science—the science which more readily shows us how humans wrest their understanding from a recalcitrant nature—is pioneering science, where things are being done for the first time and mistake after mistake is being made. Gravitational-wave detection physics is a true science in this respect. Here things are being done for the first time.
>
> (Collins 2013, p.4)

Indeed, Park, Leahy and Funk (2023) recently provided evidence of a lack of truly "disruptive finds" in contemporary science. They concluded that despite "exponential growth" in the quantity of scientific and technological knowledge, the pace of major breakthroughs has diminished noticeably from 1945 to 2010. The authors base this conclusion on an analysis of

45 million papers and 3.9 million patents, and they note the pattern holds "universally" across fields. Thus, according to the *New York Times*, there is a drop in "disruptive finds" and, "investments in science are caught in a spiral of diminishing returns and that quantity in some respects is outpacing quality" (Broad, 2023). In a parallel with *Oppenheimer*'s surprising success, the public fascination with the 2019 EHT photograph of the black hole in Messier 87 could be interpreted as public fascination with and longing for a time nearly a century ago when there was arguably a greater ferment in science.

The success of *Oppenheimer* was also a surprise because it required audiences to reflect on the consequences of atomic science. Recall how in January the *Bulletin of Atomic Scientists* (2023) moved the hand of their Doomsday Clock to ninety seconds – closer to "midnight" and nuclear Armageddon than it had ever been since its inception in 1947. The reference to black holes in *Oppenheimer* creates a further association beyond climate crisis: a link between the origins of black hole research and nuclear war. In this sense, the black hole by way of association – to the climate crisis, to nuclear war – perhaps symbolizes and reinforces a call to ethically reflect on technoscience in the 21st century. Is contemporary science, as Ferris argued in Hawking's anthology, a "white hole"? Or is it a black hole?

A black hole is now *confirmed* – as *real* as the "brute fact" of *climate crisis*.[12] In conclusion, more scholars of communication and culture should endeavor to understand how concepts such as "black holes" fire the popular imagination by studying audience interpretations of scientific discoveries like the 2019 EHT photograph of a black hole in Messier 87. With reference to the work of Collins, a sociologist of science who studies gravity waves (2017, 2013), researchers should get embedded with the scientific community, to understand how influential networks of experts refine their ideas and decide how to talk about compelling scientific discoveries in ways that eventually communicate their findings to the public. Scholars should also focus more on stories of successful women scientists.[13]

Finally, and emphatically, researchers should focus on how scientists use language. Krippendorff (1996) noted that "social theories can be said to reenter the very practices they claim to describe." By way of analogy, sociological and linguistic studies of "revealing science" may in turn reveal the ways in which scientific discoveries, even of the pioneering sort, get caught up in language games and lead to a "self-fulfilling prophecy," in terms of how

[12] Like a menacing sign that reads DO NOT ENTER, the horizon of the black hole demarcates the aspects of the physical universe which, depending on perspective, we have yet to unveil, or that, by the rational epistemological system of Western science and relentless technological advance, *went under* a long time ago. The epistemological assumptions of Western science are deep-seated. Erik Davis (1998) suggested that Judeo-Christian myth has even been re-encoded into modern information technology and genetics. On the other hand, Coles (2001) suggested that modern cosmology, with its emphasis on order that emerged from chaos, is a reinterpretation of the god Marduk in Sumerian creation myth. Therefore, we could say that an ethnocentric, Eurocentric, and Judeo-Christian worldview privileged by contemporary Western science produces the paradox of black holes; Certainly, climate crisis has been driven by the relentless advancement of Western technoscience and industrialization—all encoded in the "social fact" of black holes. And yet, that might still be an oversimplification, historically and philosophically speaking.

[13] This is not just true for Western societies. Where I currently teach in the Emirates, the government has placed new emphasis on encouraging the youth to participate in science, women in particular (ITP Staff, 2021).

those breakthroughs are communicated to the public – again, the public quickly embraced the reality of the black hole in M87 and yet not so much climate change – but perhaps also in terms of where science focuses its resources.

Dedication

This paper is dedicated to the memory of Klaus Krippendorff, the Gregory Bateson Emeritus Professor of Communication at the Annenberg School for Communication at the University of Pennsylvania, one of my teachers who, despite his many obligations, took the time to guide me in the paper's development over the years, and who encouraged me to challenge the limits of my own perceptions of language and reality.

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