IV

Aesthetic Pipelines

Rashi Rajguru interrogates the aesthetic, cultural and political influences on modern scientific imagery

Editor's Note

The writer invites a non-linear reading, in line with the subject matter presented. Following with the Prologue, the reader is presented with three options; they can read the text in a traditional linear fashion or alternatively they can read the chapters labelled 1, 2, 3, etc. followed by those labelled A, B, C, etc. or vice-versa, closing with the Epilogue. This layout highlights the challenges that exist in the traditional linear presentation regarding scientific imagery that look to shape chronological events and thinking to support specific narratives.

Prologue

In 2019 the first ever image of a black hole was presented to the world. This single image was heralded as the final representation of both the scientific experiment that created it and the decades of multidisciplinary research that led to its production. A public-facing, newsworthy scientific image like this one is usually transported through well-established communicative pipelines, from the creator(s), through the institution, onto the media, to the viewer. Yet this black hole image, like all images, is not a neat, geometric ideal that slides through these checkpoints unaltered. Rather, it swells, leaking out of the cracks already formed along the structures designed to support and control it.

The base function of the black hole image is its symbol as the endpoint of a scientific exercise, as its creators reach 53 million years into the past to simultaneously generate the future. It gains further value as it moves along those lines of mainstream science communication, which only allow for references that uphold the linear narrative of forward-facing progress. Yet, once made public, the black hole image becomes a departure point for much more than that. Here, an enquiry into its movements and mutations unfolds out to consider the expanding realities of objectivity, aesthetics and progress.

This image – and the idea of this image, and the idea of the subject it represents – is a crystallised sludge of desires, intentions, systems and knowledge pools that fuse together into a photograph that then gets handled, exchanged and even gifted for that which it represents as a singular whole. Its outer skin has its own agency, but so does everything else that swims inside it or that sticks to its underside. If an image has been seen by billions of people, it is apt for a re-encounter, a non-linear, non-definitive slowing down, to sit with the leaks, growths and caveats that can start to re-present and re-evaluate the image in some of its multitude.

1: What is a Black Hole?

Theorised by Einstein (1915), solved by Schwarzchild (1916) and mathematically categorised by Chandrasekhar (1931), black holes are an extreme consequence of nature. The primordial fusion of space and time produces a 4-dimensional fabric that both binds and supports the knowable universe. Objects with a high amount of mass, such as the Sun, warp their surrounding fabric, creating curvatures and divots that will alter the movement of any object or ray of light that travels into its reach – think of a bowling ball on a trampoline and the effect that would have on a nearby marble. Some objects – such as old stars that have gravitationally imploded – develop such extreme amounts of concentrated mass that they end up producing ruptures in spacetime, generating regions where anything that crosses the event horizon must fall irreversibly into a gravity well, known to many as a black hole.

Humans can only detect black holes indirectly, relying mostly on gravitational footprints. One method requires the black hole to be in an active state, emitting huge amounts of bright radiation as it consumes gas, dust and even complete stars that have succumbed to its gravitational pull. This material begins to circle the black hole, its trajectories morphed to bend in towards the gravitational source, creating an accretion disk of plasma that spins around the black hole's equator.[2] Momentum causes the gas molecules to violently rub against each other, producing friction. This builds up heat and sparks radiation, emitting light in various wavelengths that then travels across the vacuous universe, some of which will eventually hit human-made receivers stationed above and below the Earth's atmosphere.[3] Due to limitations in recording and imaging, when we try to view these active black holes we can only see an over-exposed, globular mass, rather than the desired crisp outline of a dark abyss at its centre.

Artist's impression of the Black Hole at the heart of M87
Credit: ESO/M. Kornmesser

A: A Real Reference

How do you produce an image for which there can be no 'real' reference? The modern, Eurocentric history of scientific image-making is animated by shifting definitions of objectivity through the visual representation of things. The advent of photography introduced a mechanical instrument that could take over from the hand of the scientist, helping cement a developing and popular notion that images were more likely to be faithful if the scientist was abnegated from any opportunity to insert falsehoods. The camera became an extension of the scientist's toolkit in a manner akin to the microscope; astronomers could document the Moon or Mars with a device that would not be tempted to alter the image with prior knowledge of the subject. The mechanical image equated to optimum visibility, even though the data was still wrapped in the materiality of the instrument that produced it.

Lorraine Daston and Peter Galison document another transition that occured over the twentieth century and continues to persist now: a move from the mechanical image to the interpreted image, as validity becomes verified by 'expert judgement'.[4] The scientist's personal viewpoint is brought back into the truth equation as scientific culture suggests that only the trained eye of an expert could sift through the increasing mounds of computational images and select that which is most 'correct'.

2: EHT — Making The Image

Black holes were brought back into mainstream media by the achievements of the Event Horizon Telescope Collaboration (EHT) – an international consortium of over 300 scientists and experts from leading institutions. The EHT aims to directly capture the highest resolution images ever seen of black holes. To date, their most famous research focuses on a supermassive black hole that sits in galaxy M87 over 53 million light years away. The black hole, which was officially renamed after the image's release to Pōwehi, a Hawaiian term that can be translated to 'embellished dark source of unending creation'[5] measures at 6.5 billion times the mass of the Sun and its event horizon, the boundary of its fatal effects, would run around the entire solar system.

EHT's method to image black holes has two equally crucial stages: first the astronomical observation and secondly the subsequent computational imaging. The former focuses on connecting various ground-based radio telescopes across distant locations into a temporal network. This network can simulate the capabilities of one massive planetary telescope to synthetically form an Earth-sized radio dish which is needed to produce the level of detail that EHT sets as one of its primary goals. The latter stage entails both the merging of all of the data acquired from each individual telescope and the complex reconstruction undertaken to try and produce an image which is true to its source.

Yet, there are various disruptions at play. It is difficult to acquire the same weather conditions in Spain, Chile and Hawai'i and the difference in atmospheric levels creates a guaranteed blur in the data. The telescope network is also patchy in its coverage; EHT's founding director Sheperd Doeleman compares it to 'taking an optical mirror, smashing it and putting all the shards in different places'',[6] meaning that the telescopes produce very narrow sight-lines. Only five of the eight telescopes in EHT's 2017 observation could directly observe M87's black hole region, so the team had only ten pinholes of data (and the helpful swing of the Earth's rotation) to create an entire image from.

If these were processed without any intervention, their patchiness would remain compatible with not only the expected image of a black hole, but also an infinite number of other images. To solve this, the team used computational tools known as image processing algorithms to fill in the gaps between the data points and iteratively construct a full image.[7]

There was also the inevitable issue of human bias, so to mitigate this they made use of the algorithms to produce hundreds of thousands of possible outcomes. After many blind experiments, independent workshops and group comparisons, the team expanded the role of the expert to fit the 200-strong collective of 2018 and eventually whittled it down to a final image which became the public-facing result for the entire project. The final image is a compression of almost 5 petabytes of raw data down to just a few hundred kilobytes. The European Space Observatory's online image archive offers the black hole image in various sizes, swelling all the way up to 183MB for a 'Fullsize Original'.[8] It even transforms from its square beginnings into a vast landscape of negative space, ready for its highly anticipated release into the public world.

B: The Simulation Black Box

Scientific images seem transient and ephemeral as they swing past one's viewports, but they are nonetheless pedagogical agents. Art historian Ingeborg Reichle highlights an increasing reliance on the use of simulations and data visualisations as forms of knowledge transfer and how it has produced a 'black box' of ambiguous knowledge production. In the twentieth century shift towards the computer-generated, algorithmic digital image, 'computational speed and accuracy were quantitative changes that had a dramatic qualitative effect'. [9]

As these images remain as powerful instruments for decision-making and larger-scale actions in the geo-political world, it is becoming more necessary to pry open such boxes across disciplinary fields. A global iteration of this phenomenon has been playing out since March 2020, as anxiety-inducing charts and graphs continue to be both displayed and analysed on national news broadcasts and then regurgitated through social networks.

3: Announcing the Image

On 10th April 2019 at 2:08pm GMT, EHT members, field experts, government officials and international media gathered on stages in various countries to unveil the black hole image at a synchronised time to the public. This globalised experience mimicked the synthetic orchestration of the telescopes back when they recorded the image's source two years prior. The event was able to direct the image straight towards its

The Unveiling I and II. Courtesy of the writer.

intended audience whilst allowing it to be framed within its singular and linear narrative of success, progress, and futurity.

As well as this media event, there was the concurrent publication of six scientific reports in *The Astrophysical Journal Letters*, an academic journal that caters towards quicker publishing of high-impact research. These were made free to read, which, along with polished press kits, allowed for quick dissemination through online news articles and more viral sharing through social media. The following day, the black hole image was found above-the-fold on the cover of most major newspapers across the planet. Subsequent issues of popular science magazines and journals would include an article on the discovery, as well as increased coverage on other ongoing black hole research.

In September that year, an announcement was made that the EHT had won the 2019 Breakthrough Prize in Fundamental Physics, growing a resurgence of media attention towards the research project and the image itself. By December, it was declared as *Science* magazine's 'Breakthrough of the Year' and was selected as one of *Time*'s annual 'Top 100 Photos'.

4: High Expectations

There are a couple of immediate details regarding the black hole image that are necessary to mention:

1. The black hole image is not an image of a black hole, but is an image of its shadow.

2. The surrounding glow (the plasma) is not really orange. The image was captured in black and white and when the colour was added in later, orange was chosen to better convey heat, intensity and movement.

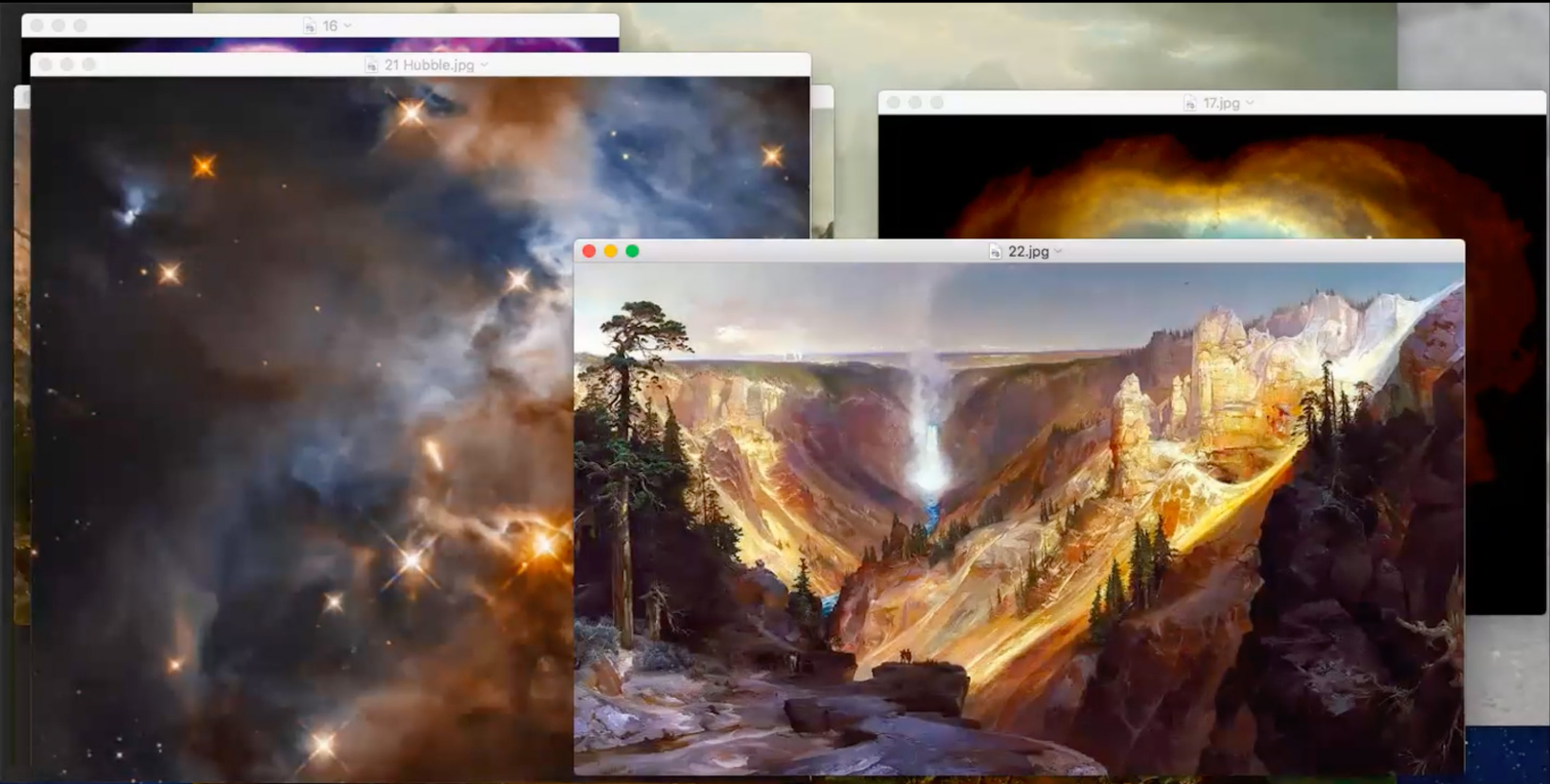
3. The image depicts 230 Ghz radio-wave energy that would otherwise be totally invisible to the human eye.

These points are not a critique of the process of imaging within radio astronomy, but rather highlight the lack of discussion around how the black hole image utilises various visual currencies that reside in the agency of the public. It is therefore imperative to unfold the wider environment of astronomical image-making, particularly when the product becomes handled like a 'classic' photograph by visual and social cultures.

Much of the framework for these spaces of exchange is determined by the size and reach of the scientific institutions that both fund and manage the operations of the most well-known scientific instruments, such as the Hubble Space Telescope (HST). Its longstanding fame was generated and maintained by a technocultural web that saw HST's launch, the release of Adobe Photoshop and the first publicly available website all take place within 10 months of each other in 1990. This amalgamation of developments helped set the ground for forms of digital image-making which could then ride the new waves of both public communication and online dissemination that were surfacing at the time.

HST's accurate and equally spectacular depictions of supernova and spiral galaxies naturally contributed to the setting of a high aesthetic bar for future large-scale astronomical image production.

To further complicate matters, researchers have found that the high levels of sharpness in HST's images can lead viewers to doubt that what they are looking at is even 'real', highlighting further complexities in assumptions regarding the validity of astronomical images.[10]



From *The last time I looked at the stars, I felt the colors radiating inside me*. (2020) Nadim Choufi.
Courtesy of the artist.

C: From Bierstadt to Hubble

In 1998, some of HST's image developers began the Hubble Heritage Program, an initiative where unseen data from the archive was revisited under the mandate of producing a beautiful and definitive historical record of the telescope's capabilities. Elizabeth Kessler makes a connection between the aesthetic quality of these images and key elements in nineteenth century American landscape painting.[11] For Kessler, the tones and composition applied to Hubble's Heritage images hold a striking similarity to the use of transcendentalism by painters such as Albert Bierstadt and Thomas Moran. Both painters, amongst others, were commissioned to depict the lesser known American West in images that would be toured and heavily promoted throughout the rest of America and Europe. Their application of the sublime helped to generate interest in Western territories as necessary areas of American expansion, such as the development of Yellowstone National Park.

Zoltan Levay, previously a leading image developer for HST, has expressed his support for Kessler's analysis, noting that while the visual similarities were never intentional her claims did resonate with him.[12] Levay has discussed his personal affinity to Ansel Adams' method of using the relevant tools to achieve the right final image, which for the Heritage program meant marrying awe-inspiring aesthetics with scientific integrity. Artist Nadim Choufi applies a little extra pressure, suggesting that, regardless of intent, the overt aesthetic similarities can generate an ideological springboard for what is considered to be the next American frontier.[13]

5: New Faces

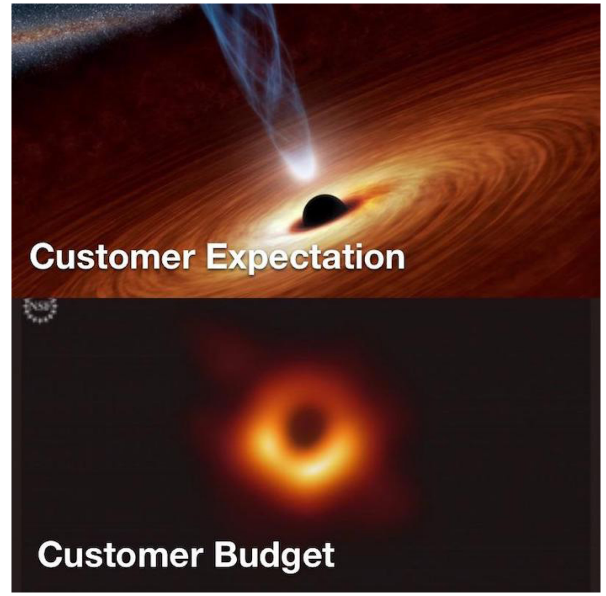
The expectation for authenticity is certainly a fair one, given the mix of science communication's romanticism, the blurred boundaries between direct images, visualisations and simulations, and the compounding feedback loop of everything else by visual culture. This is emblematised in the promotion of the upcoming James Webb Space Telescope which has been tagged by the media as 'the next Hubble' even though it will be producing images with infrared light, not optical, highlighting a long-developed miscommunication on how different telescopes are built to search across the electromagnetic spectrum, not just the visible.

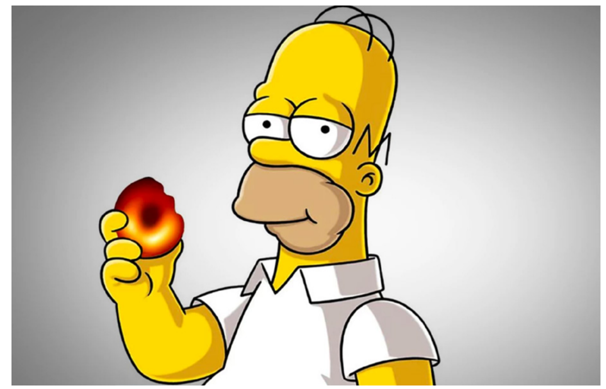
While optical telescopes like HST can directly focus visible light onto a plane or sensor, radio astronomy is a field that relies on heavy computation: weak, invisible radio photons must first be collected, amplified, and processed into usable data before there is any possibility of then producing an image (which many radio astronomers may not need for their research). Since imaging in radio astronomy requires taking individual, sparse point sources and connecting them through equations, image processing algorithms naturally grew alongside the development of radio interferometry (the practice of linking multiple radio antennas to observe together); the first significant imaging algorithm, CLEAN, was created in 1974[14] and is still used by EHT to process the findings of their 'computational telescope'.[15]

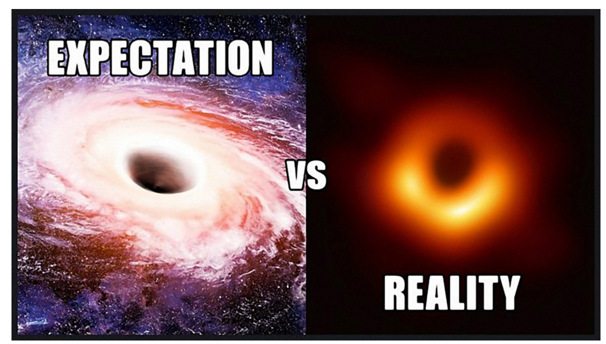
Image processing comes with the inherent possibility of multiple outputs, baking the notion of multitude into both the EHT's background and its approach. In their 2019 reports, the public-facing image is only shown alongside other variations, labelled as being 'a representative example of the images collected'.[16] And yet, the way that scientific communication is structured means that the moment of bridging between 'the science' and 'the public' only readily caters for an emphasis on the singular and the iconic. As if those communicative pipelines are only wide enough to squeeze through one image at a time, viewers continue to be given the implication that a single, summarising representation is the only one with value. Moreover, the immensely positive response and high level of immediate engagement by viewers thrusts this notion forward, upholding a relationship that assumes some perpetual need for expert judgement to draw a definitive line around one's visual understanding of the world.

As the desire for multiplicity is not catered for by these linear pipelines, the image re-engages in its multitude as it disseminates, moving away from those decided frameworks and towards the mercy of the internet user. Cue donuts, empty wallets and the Eye of Sauron. Memes are anticipatory; they are made for an open network with the hope or assumption that the image will move further than its initial community.

They jump into new clusters, growing along common cultural threads and spawning variations along the way. The 'original' image







M87 Meme Culture includes *fair use* of Twentieth Century Fox Film Corporation and Middle-earth Enterprises copyrighted materials amongs others. Courtesy of the writer.

collapses as it shifts into the realm of Hito Steyerl's poor image, acquiring new value as it utilises its compression to gain cultural currencies.

Towards the end of 2019, EHT advisory member and historian of science Peter Galison, on behalf of the science team, gifted a 40.6cm x 40.6cm physical print of the black hole image to the Museum of Modern Art in New York.[17] Upon closer inspection, it is clear this image is a new iteration altogether: the asymmetrical ring has levelled out to a more radiant, almost painterly glow, as if produced through a memory that only recalls the subject's most basic features. The fidelity of this iteration becomes less important than its successful referral to the event behind it.

D: Black-Holes-On-Earth

'MS. TOWN CALLED 911, FRANTICALLY TELLING A DISPATCHER THAT HER HUSBAND HAD FALLEN INTO A "BLACK HOLE" ACCORDING TO A RECORDING RELEASED BY THE FIRE DEPARTMENT'[18]

In 2007, a group of cave divers discovered the oldest and most complete human skeleton 'in the New World' in an underwater chamber within the Yucatàn Peninsula, Mexico. The skeleton's remains were found in the Hoyo Negro cave, named by the divers in reference to how the light of their torches would become sucked into the cavern.

MoD accused of overspending as budget 'black hole' hits £17bn

Watchdog censures department over fourth successive unaffordable equipment programme

The NAO warned the MoD's plans did not take into account the full cost of flagship projects such as the Tempest fighter jet programme © BAE Systems

'MoD ACCUSED OF OVERSPENDING AS BUDGET "BLACK HOLE" HITS £17BN'[19]

Meanwhile, a quick online search for the use of 'black hole' in news articles shows a seemingly endless application of the term in financial journalism to describe unstable economies. These black-holes-on-Earth point to an inherent nature of human storytelling: the repurposing of understood notions and motifs to help visualise new ones, pushing sticky narrative pulses through cultural spacetime.

6: Black Hole Build-up in Visual Culture

The presence of a public image is not only powered by the series of actors who directly facilitate it but also by the cultural and linguistic complexities that humans accumulate and carry with them when they encounter the image itself. Both limbs of production are intrinsically fused together: the way in which pop culture influences the 'standard' idea of a black hole affects how the dissemination of an image of a black hole is navigated, and vice versa. As a concept, black holes have been maintained within public consciousness through the second half of the twentieth century by major cultural vehicles such as popular science and science fiction. Many commercial movies attempt to reflect back to their audience the black hole knowledge pool of their time, cashing in on their anthropomorphisation as merciless enemies of deep space that may one day lurk in range of 'our' solar system. They tend to animate and frame the natural conditions – time dilation, space distortion – as modes of attack, characterising black holes as having an active and violent agenda.

This desire makes sense; much of historical cosmology has focused on discovering fundamental harmony in the universe. As a subject, black holes cater to the more tragic elements of humanity, with an added seduction in their narrative arc of transforming theory into reality. They become an embodiment of the absolute – pass the event horizon and one is locked into its temporal death-drive. But it is the idea of the black hole that permeates. For Timothy Morton, the supermassive black hole is an example of a hyperobject: those things that feel abstract and elsewhere, like global warming, but are very much right here, right now.[20] Their presence creeps in and plays out through one's very existence.

E: Black Hole of Calcutta

The biggest black-hole-on-Earth arguably lives in the mouth. The etymology of the term 'black hole'is anchored by a conflict that took place in Calcutta in 1756 between the British East India Trading Company and Nawab Siraj ud-Daulah, the regional prince of Bengal. After their defeat, a large group of British captives were forced into a small 4m x 4m prison cell within their own headquarters known as 'the Black Hole'. The captives were left in the room, which was previously used to sober drunken sailors, overnight, leading to a large number of deaths associated with suffocation and heat exhaustion – a count that is rejected by most historians. The highest ranking survivor, John Holwell, returned to the British Crown and presented his personal account of imprisonment in what he referred to as the 'Black Hole of Calcutta'. This was then used as the rationale for the British forces to retaliate and ultimately defeat ud-Daulah, capturing Bengal and using this as the concrete starting point to consolidate power and control over most of the Indian subcontinent, Myanmar, and Afghanistan.

Holwell's hyperbolic account was taken as an official record, being printed, bound and widely distributed; the book includes a foreword which requests the reader to forgive the author for being 'in some places, a little passionate, in others, somewhat diffuse'. The 'Black Hole of Calcutta' narrative grew from a desire for emotional British propaganda which could bleed into future culture — as a motif, it appears in literature and journalism throughout the Victorian era and runs alongside Britain's rule over India like an ideological support system for maintaining imperialistic momentum. It occured at a crossroads for the British Empire, as they looked, post-Napoleonic wars, to expand not just their territorial control but also their financial dominance.

In Notes on Indian History, Karl Marx refers to the 'Black Hole of Calcutta' event as one which 'the English hypocrites have been making so much sham scandal to this day'. We can see a painful parallel between the consumption of the Indian economy, which accounted for a larger share than the entirety of Europe in the 1700s but less than 4% in the years directly after independence,[21] and the consumption of energy by the 'Black Hole' narrative.

7: Science Collaboration

Scientific collaboration has both been at the mercy of and benefited from geo-political shifts over the last century. International conflicts brought with them increased state funding for the astrophysical application of war-based technologies, such as radar and sounding rockets. And whilst many of the burdens of war were shared amongst active and non-participants, many of these developments would be kept exclusive to the individual nations that developed them. During the postwar era, financial and technological avenues grew for astronomers, physicists, and engineers to crossover their respective research areas and produce 'trading zones'[22] which laid the logistical and diplomatic groundwork for international Big Science (such as EHT) to eventually take form. Transnational cooperation produced new instruments and devices that encouraged an even newer realm of data collection, pushing demand for higher computing power to both process it and contribute to more successful experiments. This resulted in a further increase in the empirical evidence these activities generated which supported the argument for more funding, creating the perfect causal feedback loop.

F: Dark Star

In 1960, the bicentenary of John Holwell being appointed Governor of Bengal, the 'Black Hole of Calcutta' re-entered mainstream discourse. American physicist Robert Dicke transposed the term into the field of astronomy when he began to publicly note a similarity between the fatal effects of the notorious Black Hole prison cell and the 'gravitationally completely collapsed stars' that came out of Einstein's theory of General Relativity. At the time, physicists were searching for a better name for the phenomenon, as other large astronomical bodies were being given names such as 'pulsar', 'quasar', 'blazar' and 'collapsar'. Some still preferred the term 'dark star' for this new theorised object, initially used by John Michell back in 1784.

However, in 1967 the more famous physicist John Wheeler, who worked on both the Manhattan Project and the hydrogen bomb program, was giving a talk on gravitationally collapsed stars when someone eventually shouted from the audience that he should just refer to them as 'black holes'. Wheeler's subsequent use of the term was transcribed and disseminated, definitively embedding 'black hole' into the vocabularies of astrophysics, science fiction and wider culture.

Dicke's proposal speaks volumes: to suggest the repurposing of a colonial event which was and still is widely contested is a prime example of how the way in which one describes objects can unknowingly extend loaded narratives, sitting not-so-deep in the socio-linguistic undercurrents until they resurface once again with a new topology.

8: A Soft Power

Much of modern day astronomical science now sits in a hybrid funding position, with many research programs incorporating increased levels of private-only or private-public funding, while still receiving enough governmental support to be utilised as positive PR. In 2019, The American Security Project, a national non-profit, non-partisan think tank, released a report titled, A New American Message. It highlights an unsurprising steady decline in the country's external image, recommending that it reignites its 'soft powers', such as science and technology, by engaging in more international collaborations. It references the wide coverage received by Katie Bouman when the EHT's black hole image was released, suggesting that 'this type of praise should be routine'.[23]

H: Monetisation of Academic Knowledge

Science and technology academic publishing represents a $10 billion per annum industry, while the wider academic publishing market has been valued at $25.2 billion per annum.[24] The biggest players, such as Elsevier, Springer, and Taylor & Francis, generate profit margins at a rate which is considered unpalatable at best by those that believe scientific knowledge to be a public good. Part of the problem is that their economic cycles are further re-enforced by public funding. State taxes pay towards the government funding of institutional research programs, which then forward some of those funds through applications to academic journals to publish their papers. Other public funds go to university libraries that are then used on purchasing exorbitant annual subscriptions from the same publishers to provide access for their students.

The compounding issue of exclusivity, elitism and perceived quality of more popular journals (based on problematic metrics) forces a given library to pay whatever price is being set by the publisher, which is, of course, unregulated. In a conversation with Dr. Elizabeth Wayne, Dr. Elaine Westbrooks, Vice Provost of Chapel-Hill Libraries at the University of North Carolina, notes that since 2020 her university stopped signing a non-disclosure agreement with Elsevier, allowing them to inform other universities that they are being charged, for example, $40,000 per annum for a single journal subscription.[25]

For potential readers, there are alternative routes. Aside from simply emailing an author of a given paper and requesting a digital copy, users can approach free websites like Sci-Hub or Library Genesis which offer access to papers that are otherwise behind paywalls by using donated login details to gain access to databases. Every time a new paper is acquired, Sci-Hub also downloads a copy into its own archive, producing a shadow library that is then used for any future requests. As of October 2020, the library contained 84,185,608 papers. Naturally, Elsevier has been attempting to force national blockades against Sci-Hub, such as the ongoing court case in India. Although, even if they succeed, communities against the commodification of knowledge are finding ways to disrupt. An independent internet service provider in Sweden followed a national injunction to block access to Sci-Hub, yet retaliated by also blocking direct access to Elsevier's own website.

9: EHT As International

The EHT routinely stress the importance of international collaboration in their work, including disclaimers in their press releases and announcements that their on-going achievements are dependent on open cooperation that transcends notions of borders or national agenda. When individuals are interviewed they frequently credit the contributions of other EHT members and Doeleman highlights that international social and human-oriented liaising is as central to the project's success as the technological developments.

When so much discussion centers on who is included, it begs the question: who is being excluded and what communities are left without the opportunity to both engage and contribute? A map showing the locations of all the affiliated institutions that are credited by EHT in Part 1 of their April 2019 reports will show an unsurprising wave of pins across the Northern hemisphere: out of 139, only four are located below the Earth's equator. This distribution mirrors many other positions of dominance by the Global North, such as access to privatised knowledge distribution.

The ongoing issue of access existed long before the EHT and continues to permeate through most institutional programs, yet that has not stopped individuals from injecting change. Upon joining EHT in March 2020, member Richard Anantua noticed that he and another colleague seemed to be the only Black-identifying members in the entire collaboration. His immediate response was to set up a feeder program, enlisting young students connected to the National Society of Black Physicists and other organisations that represent marginalised communities to gain direct access to work on EHT research. Anantua notes that his initial suggestion of the program was met with extreme support by the collaboration, particularly Doeleman. His focus is more on the stale channels of recruitment for these kinds of large-scale projects, which can be extremely difficult to enter if one is not naturally invited.

I: Scalability/Progress

The dominating modern ideas of progress continue to be wrapped in certain frameworks that allow only those projects that can actively demonstrate their own future success, usually in the form of exponential growth which can escape the death valley curve and produce a return. As a result, they exclude the notion and potential to be just as generative through looser ways of exchange, such as unpredictable encounters or social interruptions.

Anna Tsing argues that the rigid structure of scientific research inherently excludes this alternative path due to a wider requirement, in part thanks to tangled economics and industrial interest, for 'scalability'. The core concept of scalability is a project's capacity to easily change its scale without adjusting the process, allowing for high financial investment and time-based commitment to fuel a project that is pre-approved by its scalable quality.[26] Interferometric radio astronomy follows a natural law that the greater the distance between two radio telescopes, the higher resolution it can achieve. The simplicity of this framework, blended with the inherent seduction of the possibility to see black holes, becomes a major advantage for all parties involved – pure geometry is perhaps the ultimate scalable function.

But, as Tsing suggests, the scale can only grow so far before the interconnectedness of things takes a lead. A reality for astronomy-based practices is that they cannot be removed from the anthropocentric geo-political boundaries drawn across the planet that they wish to use as a technological appendage. Efforts of international collaboration gain momentum while moving the spotlight away from very real conflicts, such as the land ownership rights held by indigenous communities in colonised lands. Hawai'i is a known example: the Maunakea volcano hosts 13 telescopes, installed by 11 countries. A long-proposed addition, the Thirty Meter Telescope, has received ongoing backlash from both native communities such as the kia'i and environmentalists – its future remains unclear.[27]

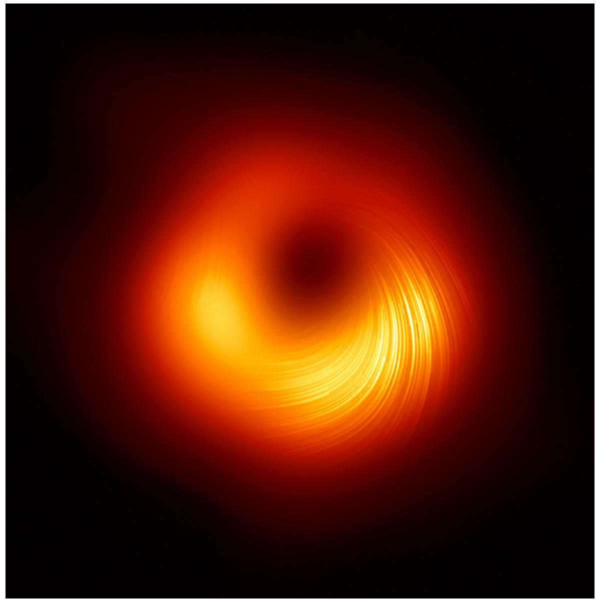
10: Next Gen EHT

Since the black hole image was revealed, EHT has been growing. The next-generation program, fuelled by a $12.7 million grant from the U.S. National Science Foundation alone, plans to add up to eight new ground-based telescopes to its array. This increased network will produce faster snapshots of activity around the black hole's event horizon, allowing the collaboration to create 'the first black hole cinema'.[28] Beyond that, EHT members have argued that this method of synchronising ground-based telescopes is close to reaching its fundamental limit, suggesting that a Low-Earth Orbit satellite could become the first step for a whole new scale of coverage.[29]

The team is also mining their existing datasets to look for fresh knowledge, a process that those working with HST's data have also previously undertaken. EHT recently released a brand new image which was produced from the same data recorded back in 2017. This new image is based on evidence of radio wave polarisation which shows the effects of the black hole's magnetic field – an equally groundbreaking result which re-purposes the scientific image as more of a gateway to the data at its core, which can be re-interpreted for entirely new visibilities.

Epilogue

It is possible to be in awe of the work of a community and still engage in a critical conversation on the entanglements that knot around its bi-products. What becomes evident here is that scientific images, like this black hole image, have the same prismatic complexities that any other images do; their seemingly sterile incubation within laboratories and simulation softwares does not exclude them from any of the stickiness, particularly when their production is so focussed on the planetary as scientific means. And so, when the pipelines of image-based scientific communication are so geared towards the easily transmittable singular, and when an overarching aim for much large-scale scientific research is to present itself as a scalable investment, then the next question is, ultimately, who is it all for?



New M87 Image - Magnetic Fields.
Event Horizon Telescope collaboration.

Galaxy M87 inkjet print in MOMA's collection, credited to the Event Horizon Telescope Collaboration in MOMA's website.

Rashi Rajguru is a London-based artist working predominantly with image, sound and text, holding a BA in Fine Art Photography from Camberwell College of Arts. Her work stems from continuous research into the understanding of objects and how they are defined, how this behaviour further extends to the human narration of situations and events. This text materialises from research for her upcoming publication, Never Before - a project supported by the Camberwell Book Prize.

FOOTNOTES

[1] While the contemporary 'black hole' is bracketed by this timeframe, core notions on the relationships between distance, gravity and speed were theorised centuries beforehand by others such as Ismaël Bullialdus (1645) and John Michell (1784).

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