A JOURNAL BY SISSA MEDIALAB

PRACTICE INSIGHTS

Imagining exoplanets as destinations: a case study of artist-scientist collaborations on NASA's iconic Exoplanet Travel Bureau posters

Ceridwen Dovey

Abstract

This is the age of exoplanets. Thousands of planets around other suns have been discovered, upending settled science. Unlike spectacular imagery of other phenomena (e.g., nebulae), exoplanets are difficult to 'directly' image, and exoplanet scientific imagery is visually limited. This practice insight is a qualitative case study of how artists and scientists at NASA's Exoplanet Travel Bureau co-imagined exoplanets as destinations of the future, with the artists playing an essential role of clarifying and extending scientific thinking. Using textual/visual analysis of how the Bureau's iconic series of exoplanet posters (launched in 2015) invited the public to visit exoplanet landscapes, this practice insight reflects on a recent historical instance of how exoplanets were visually communicated to the public in innovative ways, using overlapping scientific and artistic practices.

Keywords

Public engagement with science and technology; Science and technology, art and literature; Visual communication

Received: 17th December 2024
Accepted: 22nd July 2025
Published: 1st September 2025

1 ▪ Introduction

Do you sometimes long to plan a trip to somewhere truly exotic; somewhere nobody else on Earth has ever been — a place that will turn all your notions of familiar and strange upside down? The next time you're searching for unusual travel destinations, take a side trip to NASA's Exoplanet Travel Bureau [NASA, n.d.]. There, you will find travel ideas that are — quite literally — out of this world.

Feast your eyes on the vivid, vintage-design travel posters (see Figure 1) filled with views that might be available to you on different exoplanets (planets outside our own solar system). There are now over 5,000 confirmed exoplanets, and many thousands more expected to be discovered in the coming years, so you'll be spoiled for choice — if you don't mind spending tens of thousands of years getting there. You might start with a journey to the first exoplanet discovered orbiting a Sun-like star, 51 Pegasi b (see Figure 2), which won its discoverers the Nobel Prize [Mayor & Queloz, 1995]. Take your sunscreen: this one is jammed right up against its sun, so close that it completes an orbit every 4.2 Earth days.

Or book a ticket to Kepler-186f, "where the grass is always redder on the other side" (see Figure 3). This was the first detected exoplanet existing in the habitable zone: not too close and not too far from its sun for liquid water to potentially exist on its surface [Quintana et al., 2014]. It's 'Earth-sized', but don't let that fool you into thinking it will be anything like Earth.

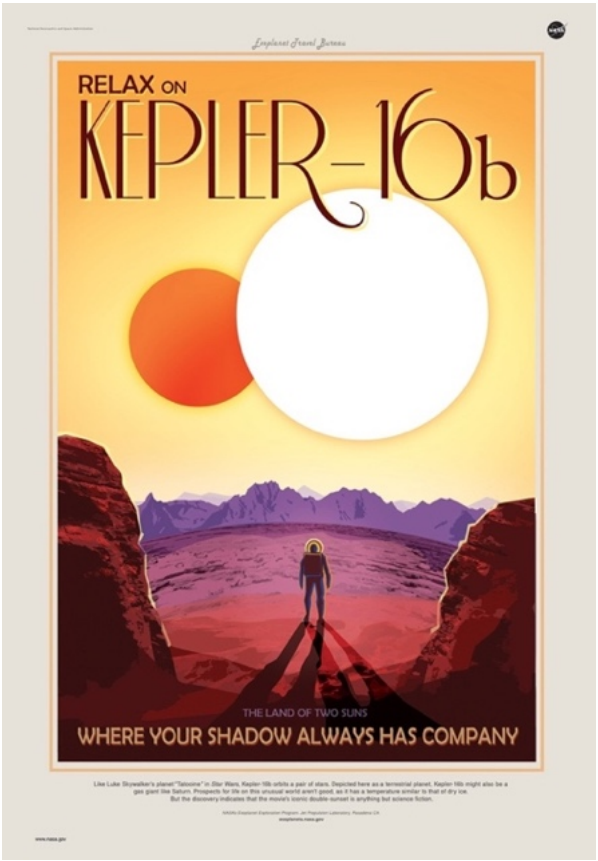

Figure 1. NASA Exoplanet Travel Bureau poster of Kepler-16b. Source: https://exoplanets.nasa.gov/alien-worlds/exoplanet-travel-bureau/?intent=021.

Figure 2. NASA Exoplanet Travel Bureau poster for 51 Pegasi b. Source: https://exoplanets.nasa.gov/alien-worlds/exoplanet-travel-bureau/?intent=021.

The star it orbits is a lot colder and redder than our own, so if plants ever grew there, they might look red rather than green to our eyes.

You might decide to embark on one of the NASA Exoplanet Travel Bureau's guided visual tours (available in English or Spanish), where you can travel to your destination via the 360-degree visualization tool, and set foot upon the virtual surface of a few exoplanets — or on a rocky moon of an exoplanet, if that exoplanet is made of lava. Wherever you go, rest assured it will be something you can boast about to your friends on Earth for thousands of years after your return.

2 ▪ Methodology and literature review

The aim of this paper is to consider how the NASA Exoplanet Travel Bureau brought together artists and scientists to co-imagine exoplanet landscapes for the public, launching a series of iconic posters in 2015 that have shaped the visual and scientific cultures of exoplanets using a collaborative arts-science approach. This practice insight uses qualitative study design methods to analyze existing data from between 2015 and 2024 (including website material, online interviews, public talks, and web presentations) generated by or about the NASA Exoplanet Travel Bureau team responsible for creating the exoplanet travel poster series. The resulting historical case study generates insights and reflections about this

Figure 3. NASA Exoplanet Travel Bureau poster for Kepler-186f. Source: https://exoplanets.nasa.gov/alien-worlds/exoplanet-travel-bureau/?intent=021.

innovative science communication project launched in the recent past, and contributes to the growing body of research on science-art collaborations [Parks & White, 2021; Calvert & Schyfter, 2017; Dowell & Weitkamp, 2012; Halpern, 2012; Pinto et al., 2015].

This case study is predominantly informed by desktop textual and visual analysis, but it also draws on wider insights from the social studies of science, particularly in terms of how a team of people works together to form collective practices of representation. Janet Vertesi [2015] has considered the 'team' as an object of sociological study through her research on the scientific teams carrying out robotic Mars exploration by rovers, and anthropologist Lisa Messeri has explored how exoplanet scientists pass on to their colleagues both scientific and "visual practice[s]" that are "worlding practice[s]" [2016, p. 114]. While these researchers focus mainly on how scientists use images to 'do' science, my goal here is to consider how artists and scientists within NASA's Exoplanet Travel Bureau informed and clarified one another's approaches in imagining exoplanets, and thus co-created a visual culture of exoplanets as viable — even habitable — destinations for the public to dream about visiting, thousands of years into the future.

As Vertesi [2015], Messeri [2016] and Elizabeth Kessler [2012] have explored in their work, astronomers and astrophysicists have long worked in partnership with astronomical image processors and visualizers to transform telescope data and observations into images that sit somewhere on a spectrum: from processed but 'true-to-the-science' images that accompany

published research, to scientifically informed artworks, to artist concepts or artist impressions that respond to the data but take some speculative liberties. In so doing, the teams responsible for generating these images have developed particular visual styles and representational modes for bodies of visual imagery generated from data collected by certain telescopes, observatories, or planetary rovers.

Messeri was the first researcher to look at how scientists craft "an exoplanetary imagination" [2016, p. 110], and this practice insight builds on her findings that scientists studying exoplanets are working to "creatively find ways to envision being somewhere humans cannot survive and cannot even reach" with their technologies of seeing [p. 110]. She describes the scientific processes of "visualizing alien worlds" [p. 111] used by leading exoplanet scientists, showing how they have already begun to make exoplanets into "places" [p. 119] and "alien worlds" [p. 111] that can be visualized through mostly indirect scientific means, thus "forging a new visual culture" of these exoplanets [p. 119]. Messeri notes that 'place' and 'world' are not interchangeable terms: "Worlds are large and places more intimate" [2016, p. 118]. Exoplanet scientists do not yet (and may never) have access to the kind of local detail that has already turned Mars into a place, Messeri writes, but this has not stopped them from adopting practices to "produce abstract representations" [p. 118] that allow them to co-create exoplanets *as* places, not just worlds.

In this practice insight, I am extending the idea of exoplanets as worlds and places to show that the NASA Exoplanet Travel Bureau posters took this one step further, and turned exoplanets into visual, almost viscerally habitable *destinations*. Their exoplanet travel poster series was the outcome of an arts-science initiative informed by the scientific and "cultural work" that Messeri notes is required to "describe and maintain something as a world" [Messeri, 2016, p. 114]. It was a collaboration that asked scientists and artists to imagine together what these planets might be like to visit and set foot upon — not just through the posters but through 360-degree views from the surface of the planet (or the planet's moon) [Matchar, 2018].

During her extensive fieldwork, Messeri observed exoplanet scientists actively speculating "about being on the surface or floating in the atmosphere of these planets" [2016, p. 131]. As soon as an exoplanet has been declared to be a world (through these collective, learned processes of scientific 'seeing'), she writes, astronomers start to "push these limits" of scientific certainty by attempting to model aspects of that world, such as its atmosphere or interior composition, and begin to position the exoplanet as "a place-in-the-making" [p. 131].

The NASA Exoplanet Travel Bureau posters did something similar in that, once created, they existed in this same realm of speculation, but they also gave the scientific imagination active expression through visual art and design, in order to ignite the public's imagination about habitable — or at least survivable — exoplanets; ones that future humans might visit as tourists and live to tell the tale. In a broader discussion of the hunt among exoplanet scientists to find what they would define as an "Earth-like world" — linked to the scientific and public fascination with the possibility of life existing elsewhere in the universe, on habitable exoplanets — Messeri describes the Exoplanet Travel Bureau's poster of Kepler-186f (see Figure 3) [2016, p. 156]. She notes that this poster invites "future explorers to the planet" [p. 157], and that "the fun of speculating about other habitable worlds occurs outside the day-to-day routine work of searching for them" [p. 158].

In this practice insight, however, I will suggest that the posters were not just about scientists and artists having fun speculating together, but became evidence of something more sophisticated and powerful. Since they were launched, the posters have made a significant contribution to the emerging visual cultures of exoplanetary science, and have been understood as a creative response to the ongoing challenge faced by exoplanet scientists: how can they get the public interested in exoplanets as more than tiny specks of dust that are impossibly far away? The answer, the posters suggested, lies in the richness of the imaginative visualizing of these exoplanets as NASA-verified 'destinations' of the future, drawing on very detailed scientific deductions (or speculations) such that even the quality of the light, the perceived color of the plants, or the necessary mode of transport on particular exoplanets (lava world = boats or balloons) was rendered in precise and striking detail.

3 ▪ Background: the age of exoplanets

It might seem like common sense that planets exist around other stars, given that our own Sun is orbited by a family of planets, but until the 1990s there was no way of scientifically proving this for sure. The 1995 discovery of 51 Pegasi b by Michel Mayor and Didier Queloz was heralded as the first exoplanet to be found around a Sun-like star [Mayor & Queloz, 1995], and was subsequently confirmed by other scientific teams as being valid [Messeri, 2016, p. 115].

In the early days of exoplanet fever in the 1990s and 2000s, the discovery of a new exoplanet was breaking news. Joshua Winn notes that when he started out as an astrophysicist two decades ago, he knew the name of each exoplanet "as if they were members of my household" [2023, p. 4]. Now, he admits, there are so many that it is "no longer possible to be on a first-name basis with every exoplanet" [p. 4]. The Kepler Space Telescope (launched in 2009) collected evidence of thousands of exoplanets in our neighborhood of the galaxy. TESS (NASA's Transiting Exoplanet Survey Satellite, launched in 2018) has also discovered thousands of candidate exoplanets, with hundreds of these confirmed through ground-based telescopic observations [Winn, 2023]. The James Webb Space Telescope, launched in 2021, is focusing not only on finding exoplanets but observing the composition of exoplanet atmospheres [Webb Space Telescope, 2024]. Scientific work on exoplanets is a global astronomical research funding priority, and both existing and future telescopes and observatories (on the ground and in space) are devoting significant time and resources to exoplanetary science ['The continued growth of exoplanets', 2024].

Astronomers have learned "to extract gigabytes of data from the trickles of light that reach us from distant stars and planets" [Winn, 2023, p. 8–9]. The techniques used by astronomers and astrophysicists to find exoplanets are complex, and it is beyond the scope of this practice insight to describe these techniques in detail (for more on how exoplanet scientists learn to 'see' exoplanets using these techniques, please see Chapter 3 [pp. 111–148] of Messeri [2016]). In brief, each technique involves using "knowledge of the laws of physics" [Winn, 2023, p. 9] combined with telescope measurements, data and observations (usually related to the effects of exoplanets on the particular sun they're orbiting) to prove the existence of exoplanets. Most often, they are 'sensed' or 'deduced' to be there as "unseen companions" [p. 62] to their stars, and visualized not as planets that can be observed but as "patterns of data points on a plot" [p. 79].

4 ▪ Findings — Destination: exoplanet. A case study

When the NASA Exoplanet Travel Bureau (an initiative of NASA's Exoplanet Exploration Program Office) first released its series of seven exoplanet travel posters in 2015, they immediately went viral [Harris, 2021a, 2021b]. Downloaded in the millions when they were launched, they have become prized backdrops hung on the walls of homes and offices and used as computer backgrounds, as well as making appearances in many TV shows and films [Harris, 2021b]. Fans of the posters from around the world responded enthusiastically to the Bureau's stated aim of "not just advertising these exotic exoplanet travel destinations, but giving … people a way to visit" [quoted in Matchar, 2018, para. 5].

According to Joby Harris, a NASA/Jet Propulsion Lab (JPL) visual strategist and a key illustrator on many of the posters, "We'd been talking about exoplanets since the 90s, but a lot of the public had never heard of them until these posters came out" [Harris, 2021b, playback loc. 3:00:08]. Harris works within what is referred to as The Studio, which is itself based within NASA/JPL's Designlab. The team who created the posters consisted of nine artists, designers and illustrators, and the final posters were "the result of many brainstorming sessions with JPL scientists, engineers, and expert communicators", with each poster going through many rounds of concepts and revisions based on "feedback from the JPL experts" [NASA Jet Propulsion Laboratory, 2020, para. 2].

The posters are still free for anyone to download and use, as are other linked art products, including applications where a visitor can go on a guided tour of an exoplanet (with text and audio in English or Spanish), or use a VR visualization tool to take a simulated look at the landscape. Since there are "endless possibilities for the composition of planets", and it is impossible to really say for sure at the moment what any exoplanet is *really* like on its surface [Winn, 2023, pp. 108–109], the Bureau team had a lot of freedom — both artistically and scientifically — to imagine exoplanets using a combination of informed scientific guesses, speculative imagery and evocative travel taglines. The goal of the overall project was to stimulate public interest in the science of exoplanets by encouraging people to visit different exo-worlds using their imaginations [Soares, 2021].

The exoplanet travel posters now sit within a larger series of posters created by the Bureau called "Visions of the Future" [NASA Jet Propulsion Laboratory, 2020]. This series connects the planets and moons of our own solar system — which are also imagined as tourist destinations — to distant exoplanets. The visual design of all of these posters is inspired by the well-known posters advertising U.S. National Parks, created by the Works Progress Administration (WPA) in the 1930s (for instance, of Yellowstone National Park; see Figure 4) [NASA Jet Propulsion Laboratory, 2020].

Harris has described the style of the exoplanet posters as "retro-future fantasy", and says that they consciously echoed the vintage nostalgic feel of the WPA posters, which "did a really great job delivering a feeling about a far-off destination" because "[t]hey were created at a time when color photography was not very advanced, in order to capture the beauty of the national parks from a human perspective" [quoted in NASA Jet Propulsion Laboratory, 2020, para. 6]. The Bureau's poster series showed places in our own solar system, and in far distant solar systems, "that likewise haven't been photographed on a human scale yet — or in the case of the exoplanets might never be, at least not for a long time". For Harris and the team, this "seemed a perfect way to help people imagine these strange, new worlds" [para. 6].

Figure 4. U.S. Works Progress Administration poster for Yellowstone National Park. Source: https://www.loc.gov/item/2007676133/.

Since the exoplanet poster series was created, the Exoplanet Travel Bureau team has used them in many kinds of public engagement and communication in support of NASA's exoplanetary scientific missions, and to tell the "thematic story" of exoplanet science to the general public [Khan, 2021]. They have presented on the posters not only at science and astronomy conferences, but at major popular culture events like SXSW and Comicon [Soares, 2021]. "In practical terms, I think for many people the posters are an entryway", Exoplanet Exploration Program manager Gary Blackwood has said. "They make exoplanet science cool, and that opens a door for many members of the public — especially students — to learn more about the science behind the posters" [quoted in Wall, 2019, para. 10].

In public presentations about the team's work, Harris is open about how, when he first joined NASA as an artist with a background in film and music, he was initially unsure about how art might be used to communicate science [Harris, 2021b]. Now, however, after more than a decade in the role, he has become passionate about exploring how art has always been embedded with science, and that this conversation about art-science partnerships is not new [Harris, 2021b]. He is keen to overturn the stereotype that "if you attach art to NASA, it's a random person in a smock in the corner throwing paint around, talking to themselves, on the taxpayer dollar" [Harris, 2021a].

Harris often starts off his public presentations about the exoplanet posters with a short history of evidence of this intertwining of art and science at NASA based on his own research in the NASA archives [2021b]. He traces a trajectory of arts-science collaborations over time,

from the appointment in 1952 of JPL's first Art Director, Arthur Beeman; to the establishment of the post-war Graphics Group (made up of 14 women and 7 men, all cartoonists or illustrators); to NASA's Art Program in the 1960s, which invited leading artists like Andy Warhol and Norman Rockwell to send art into space; to the NASA Ames Research Center's artist commissions in the 1970s, which led to the production of artist concepts for future space colonies. The NASA JPL Computer Graphics Laboratory continued this work, and in the 1980s NASA focused increasingly on pop culture crossover and outreach (for instance, the space art commissioned from Robert McCall). What Harris emphasizes about the exoplanet travel posters is that they fit into this history of pioneering science visualization strategies, where the goal was never just to make pretty pictures for the general public, but a means of asking scientists and engineers to communicate their ideas more clearly through a process of working closely with internal science visualizers and artists [2021b]. The process of developing these posters was one of intensive collaboration between scientists, engineers, artists and science communicators, which Harris describes as "like a dance, dancing with the scientists" [Harris, 2021b, playback loc. 3:09:01].

In public workshops, he has used the creation of the 55 Cancri e exoplanet poster (see Figure 5) as a detailed case study of how the team worked in practice [Harris, 2021b]. When the design team first met with the relevant scientists to begin to create this poster, they were excited by the scientific theories that 55 Cancri e might be a lava world — an extremely hot

Figure 5. NASA Exoplanet Travel Bureau's poster of 55 Cancri e. Source: https://exoplanets.nasa.gov/alien-worlds/exoplanet-travel-bureau/?intent=021.

exoplanet orbiting very close to its sun, with a surface consisting largely of a magma ocean [Harris, 2021b]. This characterization has subsequently been confirmed for 55 Cancri e [Mercier et al., 2022].

Harris's early concept sketches for the poster showed a space-train taking people to see a waterfall of lava. After the scientists clarified that there would most likely be no solid ground on the exoplanet, the mode of travel shifted to a space-boat, but Harris didn't find this idea aesthetically pleasing. The team was also struggling to come up with a good reason why people would want to visit a lava planet until, as Harris recalls, one of the scientists mentioned that the atmosphere of this exoplanet might consist of silicate, creating a dreamscape of sparkling light. This gave Harris the idea that the best way to experience this exoplanet would be from up in the air, which led to his next design iteration, with people using hot air balloons to glide above the exoplanet, looking down at the bubbling lava surface.

After considering this new design, someone in the meeting wondered what would happen to the people gliding above the lava when they landed, and worried that the image implied that people who visited this exoplanet made of lava would struggle to avoid a fiery death [Harris, 2021b]. Harris's solution was to create a bubble-like protective capsule around the people in the image, and to show a boat on the lava far below, notionally gesturing to the fact that a visitor to this planet would survive the experience. The science feedback informed the art design of the poster, but he also believes that the artwork itself could pull someone imaginatively — and scientifically — into the future, to start to think about what kind of coolant might one day be able to make a protective bubble for a visitor to an exoplanet [Harris, 2021b]. The final poster was given the title *lava life* and the tourism tagline of "Skies sparkle above a never-ending ocean of lava".

In a different public presentation, Harris and exoplanet scientist Morgan Cable (an Ocean World Astrochemist at NASA/JPL) did a joint live demonstration of the kind of conversation they might have if they were working together on a visual poster to support an invented NASA mission to a super Earth exoplanet, which is defined as a planet with a mass greater than Earth, but less than Neptune [Cable & Harris, 2021]. During their negotiations on how to create a poster of a super Earth that was science-inflected but also visually engaging, Cable said:

> Every time I meet with someone like Joby, I end up thinking about things in a different way, looking at things from a different perspective. He and the other artists have a very diverse set of experiences, and any time you can bring that into a team, interleave all backgrounds and ideas, you end up with something much stronger.
>
> [Cable & Harris, 2021]

Cable also described how working with Harris and the Designlab team at NASA/JPL has helped her understand that "to integrate art at an early stage into a concept makes us better as scientists, even in terms of framing our basic questions in our science" [Cable & Harris, 2021]. In an audience question at the end of the panel with Harris and Cable, someone asked Cable for more detail about how working with an artist helps her as a scientist to see a concept afresh. She responded:

> We'll realize we were so deeply entrained in the concept we didn't stop to think — this instrument isn't going to fit the way we expected, or that whole spacecraft looks really boxy, and it needs to be more aerodynamic because this planet has an atmosphere. Or tweaks to footpad designs, how they interact with the surface — artists weigh in on that too. It's important at every stage of mission development, not just the proposal at the end, but through the entire process.
>
> [Cable & Harris, 2021]

5 · Implications — Helping the public see a destination in a grain of sand

Using current rocket technology, it would still take tens of thousands of years to get to the exoplanets orbiting the Sun's closest neighboring star, Proxima Centauri, which is 4.2 light years from Earth [Winn, 2023]. As Winn has noted, "[F]or now, it is a sobering fact that up-close inspection of exoplanets is out of the question. We cannot collect rocks from the Kochab system, breathe the air of Arcturan worlds, or plunder the planet of Pollux" [2023, p. 8]. This scientific longing to *be there*, to set foot on these distant exoplanets, is a longing that will most likely never be fulfilled. The extent of this scientific frustration that exoplanets are not only almost impossible to 'see' directly, but are impossible to visit (perhaps forever), means that the exoplanet scientific community has been thrown back onto their collective imaginations, and is extremely open to working collaboratively with artists and visualizers to make their scientific findings and speculations come to visual life.

Winn notes that the planets in our own solar system went from being "wandering points of light in the night sky" to becoming "worlds unto themselves" [2023, p. 25] precisely as telescope technology improved — leading to actual visits from probes and spacecraft. Yet the scale of the distances between Earth and the exoplanets is so vast that this expectation is necessarily frustrated, over and over. The best image exoplanet scientists can hope to produce is a teeny-tiny, grainy dot (an exoplanet) orbiting a slightly bigger dot of light (a sun) in a highly processed, sometimes quasi-simulated, and extremely rare 'direct' image [Messeri, 2016]. As poet William Blake once acknowledged, it is an enormous yet enlightening challenge "To see a World in a Grain of Sand" [Blake, 2024].

In a contemporary astronomical culture that is visually saturated with wondrous scientific images, the reality is that exoplanet imagery is — and will remain for a long time — dry, limited, and technical. Compare the grainy dot of the possible exoplanet DH Tauri b (see Figure 6) to what the Hubble Telescope gave the starstruck general public: beautiful, dramatic imagery processed in a visual style that echoed the romantic style of 18th-century paintings of the American west [Kessler, 2012]. Or compare it to the place-specific recordings that the many rovers sent to Mars have already sent back: tantalizingly vivid details of the actual landscape of a planet that is our close neighbor, showing blue sunsets, clouds drifting across the sky, close-up selfies with boulders, sand dunes and tracks, and even audio of the sound of Martian wind [Vertesi, 2015].

Yet exoplanets are difficult to romanticize based on the scientific evidence of their existence alone. A grainy dot does not make a world. The exoplanet community is well aware of this, and it is an acknowledged challenge for the Baltimore-based Space Telescope Science

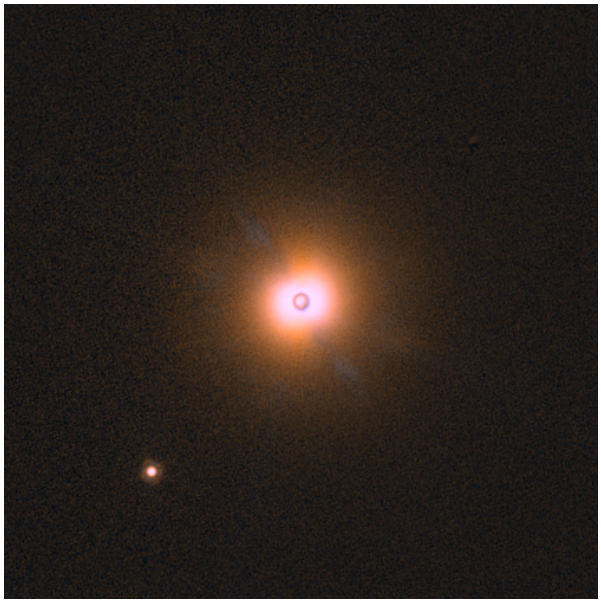

Figure 6. A rare 'direct' image of a possible exoplanet (DH Tauri b) orbiting its sun. Source: Meli Thev — own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=139397703, generated from https://archive.eso.org/dataset/ADP.2022-12-14T08:59:35.531 from ESO VLT SPHERE; Van Holstein et al.

Institute (STScI), which is responsible for leading the science and mission operations of the James Webb Space Telescope (among other telescopes). As Marshall Perrin, a lead astronomer within STScI's Extrasolar Planetary Systems Imaging Group, has noted:

> The challenge with exoplanets is how to get the science out of the spectroscopy. These are wiggly lines splitting light into the spectrum, not swirling gas, like Hubble. There's only this smudge — it's an exoplanet! Our team is looking at how to make this more interesting to the public.
>
> [M. Perrin, personal communication, November 30, 2023]

This challenge is, however, also an opportunity for science communication of the contributions of exoplanetary science to become ever more creative, to keep the public engaged in this important branch of astronomical research. The difficulty in seeing a world in a grain of exoplanetary sand has, in the Exoplanet Travel Bureau poster series, been embraced as creative freedom both on the part of artists *and* scientists. The posters are powerfully evocative because they tapped into the artistic and scientific imagination, and were the product of a close, willing collaboration between exoplanet scientists and visualizers/artists. Created to be a conscious blend of art and science, these posters invited the public to step onto (or float above) actual exoplanets with features that were based on artistic representations of scientific facts, or scientifically-informed conjecture, about what that planet might be like on its surface.

In this way, the posters initiated a new era where exoplanet science became vivid, relatable and visually fascinating — and, in so doing, kept the public emotionally and imaginatively invested in the outcomes of scientific investigations of exoplanets in our galaxy. This was

important not only to inspire the next generation of exoplanetary scientists, but to sustain public support (and public funding) for this branch of science — even if the visual scientific outcomes of this line of astronomical research were not nearly as spectacular as other types of space imagery [Kessler, 2012].

6 ▪ Conclusion. Lessons learned

As the Exoplanet Travel Bureau posters have circulated and generated interest in the years since their launch, the team responsible for their creation has very consciously pulled back the curtain on this nuts-and-bolts, back-and-forth process behind their arts-science partnership. Harris, in particular, has used any discussion of the creation of these posters as an opportunity to speak more deeply and meaningfully about how artists and scientists have always collaborated closely at NASA, in mutually enlightening and beneficial ways. This active demystifying of how art-science projects work in practice has been one of the major accomplishments of the initiative, and has implications for any future projects: the 'art' aspect is not simply a fun 'add-on' but an essential part of the method of asking artists and scientists to think — and imagine — together.

Australian poet Alicia Sometimes (who has worked closely with astrophysicists) has pointedly asked, "Science has fuelled inspiration for artists for millennia. But what about the other way?" [2023, p. 33]. The Exoplanet Travel Bureau posters (and wider work done by The Studio) provide one kind of illuminating answer. Science communication is sometimes misunderstood as being a one-way stream of expert information from scientists to artists, a form of genial 'science-splaining'. Yet Harris is clear that from the beginning, this project was just as much about artists helping scientists and engineers to think through their science — to clarify their own thinking via conversation and collaboration, and strengthen their own mission objectives and outcomes — as it was about explaining exoplanetary science to the public in visual terms [Harris, 2021b]. As he said in a public presentation:

> We've…found a niche or a place at JPL and NASA to help with mission formulation in the proposal phases, helping scientists and engineers think through their thinking, almost like therapists. We help them communicate through the art, through visual communication.
>
> [Harris, 2021b, playback loc. 3:00:08]

A final lesson to be learned from this innovative project is how it has creatively exploited the scientific challenge of exoplanets being so far away — and so difficult to image directly for the public, who have become used to gorgeous Hubble telescope imagery of celestial phenomena. The art historian James Elkins has been critical of the highly processed Hubble imagery for being "hopped-up versions of legitimate photographs, with the colors intensified or falsified" [Elkins, 2008, p. 87]. The sensuality of the Hubble imagery evoked "anxieties" on the part of astronomers linked to "the fear that the senses will overtake reason" [Kessler, 2012, p. 74]. Messeri likewise found that scientists working on making 3-D maps of Mars often expressed "discomfort" and "hesitancy" about the "technical artifice required to produce [a] sense of what standing on the surface would be like" [2016, p. 102], and actively "concealed the challenges of producing 3-D models" [p. 89].

The Exoplanet Travel Bureau posters neatly stepped outside of this tension because they were not images designed to be understood by the public as objectively 'real' or 'scientific', yet they were still scientifically informed. The posters were creative documents that visualized scientific speculations at a particular recent moment in exoplanetary science, when so little about exoplanets could be concretely known. They expressed a sense of scientific permission to imagine outside the strict parameters of evidence, and a scientific longing — expressed visually — for these exoplanets to one day reveal more about themselves, not just as places and worlds, but as habitable destinations.

Future research might more deeply explore the reasons for this relaxed and welcoming response (from scientists as well as artists) in relation to other instances of heightened scientific anxiety about the processing and mediation of astronomical imagery used to accompany research findings when communicated to the public in different forms and formats. The warm response to these posters from both the exoplanetary science community and the public showed little of the documented "ambivalence toward images" that "characterizes all branches of science", and less vexatious handwringing over the complicated relationship astronomy has to "seeing and picturing" [Kessler, 2012, p. 71]. This might be because NASA's Exoplanet Travel Bureau had embraced its identity not only as a serious source of scientific knowledge but as an informal science education institution [Harnett et al., 2019], with the goal not of intimidating the public with expertise but sparking deep and abiding curiosity about the universe. The posters were, as such, the outcome of a productive process of co-imagining by artists and scientists, one that was not mired in accounting for the exact proportions of truth and speculation in the images. As tourism posters proposing travel to extremely distant exoplanets, they were not pretending to be direct images of astronomical objects, yet they were also not pure speculation or fantasy. They sat very comfortably — and alluringly — somewhere in between.

Acknowledgments

The author gratefully acknowledges that this research has been made possible thanks to a Macquarie University Research Fellowship.

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About the author

Dr. Ceridwen Dovey is a fiction writer, filmmaker, and science journalist. She is currently an Artistic Associate at the Powerhouse Museum (Sydney, Australia) and a Research Fellow at Macquarie University in the School of Communication, Society and Culture. Her work focuses on emotions, ethics and activism linked to activities in outer space (both past and present), and she is interested in expanding the modes and forms used in science communication to foster genuine science-arts collaborations.

ceridwen.dovey@mq.edu.au

How to cite

Dovey, C. (2025). 'Imagining exoplanets as destinations: a case study of artist-scientist collaborations on NASA's iconic Exoplanet Travel Bureau posters'. *JCOM* 24(04), N03. https://doi.org/10.22323/1460202507220900112.

ISSN 1824-2049. Published by SISSA Medialab. jcom.sissa.it