

Institution: Queen Mary University of London		
Unit of Assessment: 9		
Title of case study: Influencing international science policy, space exploration and culture through the discovery of our nearest exoplanet		
Period when the underpinning research was undertaken: 2012–present		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr. Guillem Anglada-Escudé	Reader in Astronomy	Sep 2013–Jul 2019
Prof. Richard Nelson	Professor in Astronomy	Sep 2000–present
Period when the claimed impact occurred: 2015–present		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words)		
<p>In 2016, researchers at Queen Mary discovered an “exoplanet” (Proxima b) orbiting our nearest star. This is the nearest such planet ever to be discovered. It is in the habitable zone where liquid water can exist, making it possible that the planet could harbour life. The discovery informed international science policy, causing the European Southern Observatory to reassess its approaches to allocating telescope time and distributing news to the public. It also directly inspired and defined the course of private space exploration, resulting in the launch of an observational programme and spacecraft-based initiative focused on the Proxima Centauri system. Proxima b inspired the creation of numerous valuable cultural artefacts, including documentary films, literature, music and video games. It strongly engaged large, diverse audiences with astronomy, as evidenced by activity on news media websites, social media, and online learning resources.</p>		
2. Underpinning research (indicative maximum 500 words)		
<p>“Are we alone in the Universe?” This question has fascinated researchers for thousands of years, and continues to do so as scientists scour the cosmos for planets around other stars (‘exoplanets’) that may be able to sustain life. Each star has its own ‘habitable zone’, a band of space in which an orbiting body can sustain liquid water, widely thought to be a necessary condition for life. Hunting for planets that orbit within this zone around other stars is, therefore, a crucial step in our search for life in the Universe.</p> <p>Dr. Anglada-Escudé has long-standing expertise in exoplanet hunting. One of the methods typically used to detect exoplanets is the radial velocity, or Doppler method, by which the presence of a planet can be detected by hunting for shifts in the light of the host star. This method is more difficult than alternatives, but can be applied to many more stars, making it hugely promising. Prior to joining Queen Mary, Anglada-Escudé worked to increase the precision of this technique by developing new algorithms, thus creating a new method, named Template-Enhanced Radial velocity Re-analysis Application (TERRA). This method has been used to analyse data from the world’s most precise radial velocity instrument, the European Southern Observatory’s High Accuracy Radial velocity Planet Searcher, or HARPS, via the ‘HARPS-TERRA’ software tool. Anglada-Escudé’s research at Queen Mary focused on combining archival data with new observations made using his TERRA technique, and resulted in discoveries such as that of two small planets around an M-dwarf star (with one in the habitable zone) [3.1].</p> <p>The success of the HARPS-TERRA framework led Anglada-Escudé to search for exoplanets around the nearest star to our own: Proxima Centauri. Anglada-Escudé used several smaller</p>		

telescopes around the globe in conjunction with HARPS to monitor the star system continuously for two months, logging results at the same time each evening, which is typically not possible given the way in which telescope time is usually allocated. Anglada-Escudé named the project 'Pale Red Dot' and maintained a popular science blog describing the search methods and results as they happened. The project culminated in August 2016 with the discovery of a planet in the habitable zone of Proxima Centauri [3.2-3.3], Proxima b, the closest exoplanet ever discovered (Figure 1).



Figure 1: Artist's visualisation of Proxima Centauri from the surface of Proxima b. Reprinted from <https://www.eso.org/public/images/eso1629a/>. Kornmesser. 2016. ESO. Copyright [2016] by ESO.

3. References to the research (indicative maximum of six references)

[3.1] Anglada-Escudé *et al.* (2014). Two planets around Kapteyn's star: a cold and temperate super-Earth orbiting the nearest halo red dwarf. *Monthly Notices of the Royal Astronomical Society: Letters*, 443(1), 89-93. <https://doi.org/10.1093/mnrasl/slu076>

[3.2] Anglada-Escudé *et al.* (2016). A terrestrial planet candidate in a temperate orbit around Proxima Centauri. *Nature*, 536, 437-440. <https://doi.org/10.1038/nature19106>

[3.3] Anglada-Escudé *et al.* (2016). The habitability of Proxima Centauri b. I. Irradiation, rotation and volatile inventory from formation to the present. *Astronomy and Astrophysics*, 596. <https://doi.org/10.1051/0004-6361/201629576>

Evidence of the quality of the research

[EQR.1] Nelson, R. P. [Principal Investigator]. Anglada-Escudé, Guillem. [Co-Investigator]. (2017-21). Astronomy Research at Queen Mary [ST/P000592/1]. STFC. Research Grant. GBP1,246,942.

4. Details of the impact (indicative maximum 750 words)

Queen Mary's Dr. Anglada-Escudé used his previously developed framework, HARPS-TERRA, to discover Proxima b, an exoplanet within the habitable zone of the nearest star to our own Sun, Proxima Centauri. This has driven numerous wide-ranging impacts: it has informed international policy on telescope time allocation and public engagement; inspired and shaped the course of private space exploration; created valuable cultural artefacts; and led to increased levels of public engagement and awareness of astronomy.

Informing international policy at ESO

Anglada-Escudé's discovery of Proxima b caused the European Southern Observatory (ESO), a 16-nation intergovernmental research organisation for ground-based astronomy, to adjust its policies for a) allocation of telescope time and b) public engagement.

Allocation of telescope time: ESO now allows researchers to obtain short time slots at similar times each night, a crucial factor in the discovery of Proxima b. This strategy, under which observation runs typically last for at least three nights, "really deviated from the norm", according to Ferdinando Patat, Head of Observing Programmes Office at ESO, and was first approved on the 3.6m HARPS telescope at Anglada-Escudé's request. As a result of the high-profile success of this approach, ESO now offers it in their updated 'call for proposals' documentation and has implemented the technique regularly since 2016 [5.2].

Public engagement: As a result of the success of the Proxima b campaign, the ESO now also does Reddit 'ask me anything' (AMA) sessions for new campaigns, in addition to their press conferences. This is because they found the sessions "an excellent opportunity to have a more in-depth science conversation with members of the public," according to Anna-Lynn Wegener, Head of Communication Department at ESO. "The scientists also enjoy the opportunity to explain their results and engage directly with the public." Wegener's team has given more attention to training their press conference speakers. The training now includes a simulated Q&A session to help speakers to deliver "clearer, more coordinated and easier to understand [messages]" [5.3].

Inspiring and changing the course of private space exploration: Targeting Proxima b

The 'Breakthrough Starshot' programme (part of Breakthrough Initiatives) was founded by Yuri Milner, Mark Zuckerberg and Stephen Hawking in 2016. Breakthrough Starshot aims to develop a proof-of-concept fleet of tiny nanocraft ('StarChips') capable of travelling to the Alpha Centauri system to seek evidence of life. The programme's CEO attended the Proxima b press conference and described the discovery as "truly inspirational", explaining that they "hope to build a privately-funded prototype system costing between USD500,000,000 and USD1,000,000,000. We are really excited and, to use the US term, 'pumped', about this discovery. We are on our way!" [5.4]. Breakthrough Starshot co-founder Stephen Hawking later confirmed that the StarChips should take 20 years to reach Proxima b (at 20% of the speed of light) and said that "Once there, the nanocraft could image any planets discovered in the system, test for magnetic fields and organic molecules, and send the data back to Earth in another laser beam" [5.5]. Milner further estimated the total future cost of the Breakthrough Starshot programme at USD5-10,000,000,000, with first probes sent in 2036 [5.6].

In January 2017, Breakthrough Initiatives signed an agreement with ESO to collaborate on a multi-million-dollar astronomical programme ('Breakthrough Watch') to hunt for other planets that may be present in the Alpha Centauri system. Informed and guided by the discovery of Proxima b, observations began in May 2019, with press releases emphasising the motivation provided by Proxima b as "an Earth-like planet in our own cosmic back yard" [5.7]. Breakthrough Watch will enhance the design of space-based and extra-large ground-based telescopes to optimise planet detection – aims that would lead to huge advances in astronomical discovery, and have been strongly influenced by Anglada-Escudé's work [5.7].

Creation of new cultural artefacts: Influential and wide-ranging output

In 2017, Anglada-Escudé was listed as one of Time magazine's (print readership: 26,000,000; circulation: 2,300,000; monthly browsers: 27,100,000) '100 most influential people of the year', and received both The Guardian's Higher Education award for Research Impact and The Times'

Higher Education award for ‘Research Project of the Year’. The discovery was front page news around the world. It was included as one of the *BBC*’s (monthly browsers: 38,600,000) top six ‘Amazing Science Stories’ of 2016, chosen as one of *The Guardian*’s (print readership: 3,600,000; circulation: 111,953; monthly browsers: 25,100,000) ‘12 Key Science Moments of 2016’ and was [mentioned in over 4,200 news articles](#) in the week following the paper’s publication in *Nature*. The intense media interest focused on (i) Proxima b being the closest exoplanet to Earth ever discovered and (ii) the planet’s location in the habitable zone around Proxima Centauri, making it a promising candidate for extra-terrestrial life.

The discovery inspired the widespread creation of new cultural artefacts, including:

- *Documentary films*: the BBC’s ‘The Search for a New Earth’, Amazon Prime’s ‘Journey to the Pale Red Dot’;
- *Music*: the music streaming service ‘Spotify’ currently lists over 100 distinct tracks named after Proxima b;
- *Science fiction literature*: the ‘Proxima Rising’ trilogy by Brandon Q. Morris, which discusses how aliens on the planet cope with solar flares from the Sun, a key current research topic concerning the potential habitability of the planet. The first book in the series has sold 81,000 copies in German and English in at least 8 countries;
- *Science non-fiction literature*: the Lonely Planet travel guide to ‘The Universe’ features a significant discussion of Proxima b and its potential for habitability;
- *Video games*: ‘Proxima Royale’, a competitive science fiction multiplayer shooter set on Proxima b; the educational game ‘Space Odyssey’ which allows players to “embark on exploration missions ... starting ... with the exoplanet named Proxima B”, crowd-funded by Neil De Grasse Tyson ([7207 backers pledged a total of \\$357,866](#)); and a Proxima b update for the popular ‘Universe Sandbox’;
- *Popular comedy*: the satirical website *The Daily Mash* carried the article ‘Closest Earth-like planet best hope of getting on property ladder’, whose related Facebook post was shared over 2,500 times and gained over 375 comments and over 10,000 ‘likes’).

Increased public awareness of and engagement with astronomy

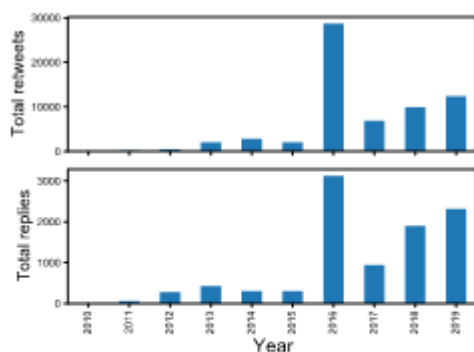


Figure 2: Engagement with tweets relating to Proxima Centauri: retweets (top) and replies (bottom). Adapted from [5.1].

By engaging a large, diverse audience with astronomy, Anglada-Escudé’s discovery has advanced public debate about extra-terrestrial life. Since the finding, topics related to astronomy, exoplanets, and Proxima Centauri have seen a marked increase in engagement. On Twitter, the number of global retweets per year containing the keywords “Proxima Centauri” was over 23 times higher during the discovery year, indicating active engagement, with a sustained increase (nearly 8 times higher on average) post-discovery compared to pre-discovery (Figure 2) [5.1]. Tweets containing “Proxima Centauri” received three times more retweets if they also contained the word “habitable” and, in the same dataset, tweets containing “habitable”, “water”, “alien”, or “life” dramatically increased after the 2016

discovery, an increase that has continued through to early 2020.

Roughly 30% more people read about Proxima Centauri per month on Wikipedia post-discovery than pre-discovery, amounting to 20,000 extra views per month. The Pale Red Dot project website also saw a significant increase in unique visitors per month, rising from 1,200 in the month pre-discovery to 15,200 in the discovery month.

An analysis of nearly 5000 comments from BBC, *Daily Mail* (print readership: 2,200,000; circulation: 990,106; monthly browsers: 37,100,000) and *The Guardian* news articles (2016-2020) showed that “likes” (or similar reactions) are associated with the terms “habitable”, “alien”, “religion” and “travel”. Comments on online news reports show that audiences are developing new knowledge as a result of engagement. Specific comments include “It’s great that we are getting better at detecting exoplanets” (BBC) and “This is stunning news. A habitable world around the closest star to us” (*Daily Mail*). Posts related to Proxima b on Reddit, a community discussion site with 330,000,000 users, peaked along with the discovery in 2016. Following this peak, activity continued at a sustained level of approximately 4.7 posts per week in 2017–19. The Reddit communities with the highest proportion of Proxima b posts include one focused on creative writing and another dedicated to “exhibiting the awesome potential of humanity”, indicating that Proxima b has uniquely captured public imagination beyond typical astronomy-interested audiences.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[5.1] Phillips, A. E., Sajonia-Coburgo-Gotha, B., & White, C. (2021). What happened, and who cared? Evidencing research engagement retrospectively (QMUL-PH-21-14). <https://arxiv.org/abs/2103.06778>

[5.2] F Patat. Head of Observing Programmes Office. *European Southern Observatory* (testimonial letter, 16 July 2020) [Corroborator 1]

[5.3] A Wegener. Head of Communication Department. *European Southern Observatory* (testimonial letter, 23 September, 2020). [Corroborator 2]

[5.4] European Southern Observatory. (24 August 2016). *Press Conference at ESO HQ*. [Video]. <https://www.youtube.com/watch?v=n5QkN05xodA>

[5.5] Johnston I. (2017, 21 July). *Stephen Hawking working on spacecraft that could reach ‘Second Earth’ in 20 years*. Independent. <https://www.independent.co.uk/news/science/stephen-hawking-second-earth-spacecraft-travel-20-years-star-chip-breakthrough-star-shot-a7800991.html>. 19 October 2020

[5.6] Overbye D (2016, 12 April). *Reaching for the Stars, Across 4.37 Light-Years*. NY Times. <https://www.nytimes.com/2016/04/13/science/alpha-centauri-breakthrough-starshot-yuri-milner-stephen-hawking.html>. 19 October 2020

[5.7] Breakthrough Initiatives. *Watch*. Breakthrough Initiatives. <https://breakthroughinitiatives.org/initiative/4>. 19 October 2020