# The Philosophy of Space Exploration and Exoplanet Science

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# INTRODUCTION

> *"It has been said that astronomy is a humbling and character-building experience. […] To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known."*
>
> ~ Carl Sagan, Pale Blue Dot: A Vision of the Human Future in Space

Human's ever present fascination with the night sky has always provoked many fundamental questions about the cosmos and our relation to it: What is out there? Are we alone? What is our place in this vast universe? Thoughts like these date back to antiquity (and probably even much further), with famous philosophers like Aristotle developing their own cosmology and Immanuel Kant speculating about the existence of other galaxies like our own. This was before scientific astronomers, such as Galileo, Kepler and Tycho Brahe, began to make first groundbreaking discoveries about other planets and their motions. When Copernicus eventually put forward a heliocentric model as opposed to an Earth-centered one, he not only revolutionized our understanding of the universe and our place within it, but also laid the foundations for an exciting new era. The sky was no longer the limit.

Today, our curiosity towards those ancient questions constantly grows through fields like astrobiology, combining many disciplines from physics and astronomy, over biology and geology to philosophy and anthropology, whilst one of the fastest-growing and most promising endeavours of our time seems to be the search for planets outside our own Solar System (called *exoplanets* or *extrasolar planets*).

Modern astronomy and exoplanet science provide an unprecedented insight into our solar, galactic and inter-galactic neighbourhood with recent findings offering exciting prospects for potential paradigm-shifting discoveries like the detection of an exoplanet similar to our Earth[1] or even finding life elsewhere. Over the past decades, such eventualities have left the realm of pure science-fiction and have become a real possibility. This not only depends on constant scientific progress and innovation, but also asks for a deeper evaluation of the philosophical implications of how such discoveries might change our self-perception and that of our own planet as only one of many in a seemingly endless cosmos.

In light of this, it is highly important to discuss a most fundamental issue: Should the search for exoplanets, and for Earth-like worlds in particular, be continued and supported at all?

[1] A planet is called *Earth-like* simply if it possesses the characteristics of a rocky, terrestrial planet. Cf. Charles S. Cockell, 'The Ethical Relevance of Earth-like Extrasolar Planets', *Environmental Ethics,* 28 (2006), 303-314 <doi:10.5840/enviroethics200628319> (p. 304).

## OVERVIEW

In the following paper, I will argue that the simple answer to this question is *yes*. This will be justified through an argument coming not from ethics, as it is often done, but from what I will call *cosmological philosophy*. It will be shown that possible exoplanet detections and our growing knowledge about the cosmos make us appreciate and value our home planet rather than causing us to neglect it with the potential to create a feeling of connectedness instead of a sensation of mediocrity. I will come to this conclusion by looking at various scientific data and estimates, creating a rough overview of the astronomical scales we will be working with and thus demonstrating the actual feasibility of finding Earth-like exoplanets. I will then consider a seemingly strong argument from Earth environmentalism against the moral permissibility of space exploration, and it will be demonstrated how its line of reasoning can be reversed in order to support the main thesis of this paper.

## EXOPLANET DATA

Scientists estimate that there are between $10^{11}$ (one hundred billion) and $10^{12}$ (one trillion) galaxies in the observable universe, where our Milky Way Galaxy is believed to contain several hundred billion stars.[2] These numbers suggest that there are at least $10^{22}$ (ten sextillion) stars in the entire observable universe – $10^{22}$ potential planetary systems.

Such unimaginable big scales demonstrate how much there is yet to explore and how little we already know about our cosmic home. The potential number of stars in our universe also hints at the possibility of our planet being not the only one of its kind. Over the past 25 years, there have been 4,512 confirmed exoplanet discoveries in 3,344 different planetary systems[3] in our closer galactic neighbourhood, some of them in "systems thought to be impossible or unlikely."[4]

Current data suggest that one in five Sun-like stars "may have Earth-size planets in their habitable zones"[5] and even that "half of Sun-like stars in the Milky Way may have Earth-like terrestrial planets".[6] Assuming that there could be approximately 250 billion stars in our own galaxy, this

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[2] ESA, *How many stars are there in the Universe?,* (Paris: ESA, n.d.) <https://www.esa.int/Science_Exploration/Space_Science/Herschel/How_many_stars_are_there_in_the_Universe> [accessed 28 June 2021].

[3] NASA, *Exoplanet Exploration: Planets Beyond our Solar System,* (Washington D.C.: NASA, n.d.) <https://exoplanets.nasa.gov/> [accesses 31 August 2021].

[4] Steve B. Howell, 'The Grand Challenges of Exoplanets', *Frontiers in Astronomy and Space Sciences,* 7:10 (2020), 1-5 <doi: 10.3389/fspas.2020.00010> (p. 3).

[5] The *habitable zone* (also called *Goldilocks Zone*) is the region around a star that allows liquid water to remain in a stable state. Cf. Cockell, p. 304.

[6] *2015 NASA Astrobiology Strategy,* ed. by Lindsay Hays (Washington D.C.: NASA, 2015) <https://astrobiology.nasa.gov/nai/media/medialibrary/2015/10/NASA_Astrobiology_Strategy_2015_151008.pdf> (p. 92).

would mean that in the Milky Way alone, there might be about 125 billion Earth-like planets.[7] Regarding our home galaxy as a regular sample could thus make us "conclude that not only our galaxy but also many others are great producers of enormous numbers of planets"[8], hinting at a great planetary abundance.[9]

So far, we can of course only speculate about finding a so-called *Earth-twin*[10] or maybe even life-bearing planets, but those philosophical thoughts can help us prepare for the final frontier of such possible discoveries, which some even consider likely to happen within "the life span of some that are alive today."[11]

## A GREAT FUTURE FOR EXOPLANET ASTRONOMY

> *"We shall not cease from exploration*
> *And the end of all our exploring*
> *Will be to arrive where we started*
> *And know the place for the first time."*
> - T. S. Elliott

Space telescopes and observatories like *TESS, CHEOPS, Gaia* or *Kepler* are highly important when it comes to searching for exoplanets, and many Mars missions like NASA's *Viking Program* or the *2020 Perseverance Rover* attempt to look for past or present signs of life on another planet. However, as of today, the vast majority of philosophical speculations concerning space exploration have been made within SETI, the search for extraterrestrial intelligence. Puzzles like the *Fermi Paradox*[12] or attempts to calculate the numbers of intelligent civilisations in our universe[13] are undeniably fascinating mysteries, but there exists surprisingly little philosophical

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[7] Howell, p. 3.

[8] Ludwig Kostro, 'Are Life, Consciousness, and Intelligence Cosmic Phenomena?' in *The Physics of Reality: Space, Time, Matter, Cosmos,* ed. by Richard L. Amoroso, Louis H. Kauffman and Peter Rowlands, (Singapore: World Scientific Publishing, 2013), pp. 484-489 (p. 484).

[9] Lucas John Mix, 'Philosophy and data in astrobiology", *International Journal of Astrobiology,* 17:2 (2018), 189-200 <doi: 10.1017/S1473550417000192> (p. 190).

[10] An Earth-twin is an Earth-like planet with the special conditions of having a mass, radius, temperature and atmosphere like our planet. Cf. Kostro, p. 485.

[11] Dan McArthur and Idil Boran, 'Agent-Centered restrictions and the Ethics or Space Exploration', *Jorunal of Social Philosophy*, 35, no.1 (2004), 148-163 (p. 149).

[12] This is a popular problem first posed by physicist Enrico Fermi, often abbreviated through the simple question *Where is everybody?* The essence of this striking paradox is that, under the assumption that there must be many other intelligent civilizations, some probably more advanced than us, there seems to be no explanation as to why we have not been contacted and have not found anything (or anyone) yet.

[13] The *Drake Equation*, for example, is a famous argument used to calculate the estimated number of intelligent civilizations in our galaxy through many variables like the fraction of planetary systems or the presumable average number of planets that could support life.

research when it comes to the probably much likelier event of finding non-intelligent (microbial) life[14] and the realistic prospect of finding an Earth-like exoplanet.

Predictions of "other planetary systems revolving about even the closest stars"[15] made five years before the first exoplanet discovery in 1995 demonstrate the fast pace at which exoplanet astronomy is moving forward and support the credibility of claims about a "revolution"[16] and "golden age"[17] of "one of the most fruitful research fields in astronomy in the 21st century."[18] When criticising the search for Earth-like planets and extraterrestrial life as purely speculative or simply too ambitious, one should therefore keep in mind that "as has shown the history of science human mind reaches often truths earlier than human senses."[19]

We have now seen that the detection of planets similar to our own is nowadays within technological reach, leaving us with the important question of whether such endeavours should be continued and supported at all, based on the philosophical implications they might bring.

Media, books and movies play a vital role in the public's image of exoplanet astronomy and influence our perception of space exploration. Fortunately, philosophy allows us to discuss those topics from a different perspective in order to speculate about the big 'what ifs': What if we actually detected a planet capable of housing life as we know it? Would this mean that our Earth is not so special after all? (*Principle of Mediocrity*) And what if we were unsuccessful with all our efforts and only found dead planets and empty space? What if our really planet is special in its capability to host life? (*Unique Earth Hypothesis*)

Both these options can seem daunting and raise the question of whether it would be better not to know the answer in the first place – and why should we even care at all?

## EARTH ENVIRONMENTALISM AND SPACE EXPLORATION

> *"Man must rise above the Earth—to the top of the atmosphere and beyond—for only thus will he fully understand the world in which he lives."*
>
> ~ Socrates

[14] Benjamin Sachs, *Eight ethical questions about exploring outer space that need answers*, (The Conversation, 2018) <https://theconversation.com/eight-ethical-questions-about-exploring-outer-space-that-need-answers-98878> [accessed 29.06.2021].
[15] Robert W. Graham, 'Extraterrestrial Life in the Universe', *NASA Technical Memorandum,* 102363 (1990), 1-8 (p. 1).
[16] Howell, p. 1.
[17] Carl Sagan, 'The Abundance of Life-Bearing Planets', *The Bioastronomy News,* 7, no.4 (1995).
[18] Wu Guang-jie and Chen Dao-han, 'Searching for Extra-terrestrial Intelligence and the Discovering of Extrasolar Planets', *Chinese Astronomy and Astrophysics,* 26 (2002), 125-140 (p.125).
[19] Kostro, p. 484.

Space exploration raises many complex questions about the moral permissibility of endeavours like the terraforming of other planets[20], ISRU[21], asteroid mining and interplanetary contamination[22].

Whilst all of these topics are undeniably important, one of the loudest voices against modern space exploration stems from Earth environmentalism. The discipline of exoplanet science is "often criticised as being disconnected from earthly activities."[23] In an era of a rapidly changing climate and the imminent shortage of resources, it seems reasonable to argue that we should not waste our time and energy on searching the sky for an idealized "Eden Earth"[24], but rather focus on sustaining the environment and repairing our own planet.

The fear of a "disposable planet mentality"[25] provokes the thought that exoplanet astronomy's promise to search for another potential home for humanity would not leave many reasons to protect and save planet Earth.[2627] Given these potential destructive consequences of astronomy's holy grail of finding a planet just like ours, the prospects of exoplanet science seem not so promising after all, if not even dangerous for the fate of our Earth and human survival.

Despite popular responses to this argument within the ethics of space exploration – like arguing that availing resources from other astronomical bodies of the Solar System might one day be the only option to solve our very problems here on Earth[28] – it is important to note that we are by far not ready to actually visit and colonise extrasolar planets. It should be kept in mind that it is still "likely that the Earth will be the only home we ever have."[29] For now, exoplanet science is merely reduced to searching for and exploring other planets from afar in order to learn more about other star systems and our cosmic home. Environmental movements and space exploration are thus no conflicting enterprises – just the opposite: "We should […] make decisions based on the most comprehensive picture of the Earth's environment we can obtain.

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[20] This is the process of altering a planet's atmosphere and environmental conditions in order to make it habitable.

[21] In-Situ Resource Utilisation means using and working with materials extracted from other astronomical objects in the Solar System.

[22] This consists of two parts: Forward contamination describes the process of contaminating other astronomical objects, whereas backward contamination entails the threat to Earth through return samples and potential microorganisms that would interfere with our environment.

[23] Lisa Messeri, 'Gestures of Cosmic Relation and the Search for Another Earth', *Environmental Humanities,* 9:2 (2017), 325-340) <doi:10.1215/22011919-4215325> (p. 331).

[24] *Ibid.*, p. 333.

[25] James S. J. Schwartz, 'Our Moral Obligation to Support Space Exploration', *Environmental Ethics,* 33:1 (2011), 67-88 <doi: 10.5840/enviroethics20113317> (p. 80).

[26] Cf. Sachs, Gonzalo Munévar, 'Space exploration and human survival', *Space Policy,* 30 (2014), 197-201 <doi: 10.1016/j.spacepol.2014.10.002> (p. 200).

[27] One could draw a parallel here to societal consumerism and our tending towards throwing away and rebuying things, rather than making an effort and trying to fix them.

[28] Munévar, p.200*,* Marco C. Bernasconi and Cristina Bernasconi, 'Why implementing the space option is necessary for society', *Acta Astronautica,* 54 (2004), 371-384 <doi: 10.1016/S0094-5765(03)00060-2>.

[29] Howell, p. 5.

And to do so we need to understand what a planet is by engaging in comparative planetology, and then to observe the Earth from space in the context of that understanding."[30]

Exoplanet astronomy therefore not only requires a deep understanding of our planet itself, but also has the potential to expand our knowledge about habitable environments and how to live in harmony within them. "The issue is not, then, one of disrupting balance and interfering with the environment. […] The issue is rather one of interfering wisely."[31] If one day we really become able to master interstellar travel and visit other planetary systems, we will of course have to be careful before taking yet another giant leap for mankind and have to prepare ourselves, both scientifically and ethically, as to how such endeavours should be undertaken with respect to all potential consequences. However, instead of letting opportunities go to waste out of pure fear of eventualities that might never occur we should take the chance to widen our knowledge of the cosmos and leave all options open. "There is no long future in ignorance"[32], and without the kind of cosmic experience and insight from exploring outer space we might not learn some important lessons that could help us save some problems we are facing here on Earth. "Even if we cannot visit extrasolar planets, it would be intellectually poor not to expand the boundary of moral discourse to consider them."[33]

Contrary to popular belief, exoplanet astronomy therefore poses no direct threat to our environment. Our cosmic view has grown over centuries without ever "abandoning terrestrial groundings"[34], and there is no reason to assume that any exoplanet detection will cause us to turn away from Earth in the near future. From this ethical perspective, we thus *should* continue to support space exploration and exoplanet science and even have a moral obligation to do so – not only to satisfy our scientific curiosity, but also to be able to protect and nurture our home planet.[35]

## RETURNING TO THE ROOTS OF COSMOLOGICAL PHILOSOPHY

> *"For me, it is far better to grasp the Universe as it really is than to persist in delusion, however satisfying and reassuring."*
>
> ~ Carl Sagan, The Demon-Haunted World: Science as a Candle in the Dark

When it comes to understanding our cosmic home and our duties towards it, it is important to draw attention to the distinction between the *(cosmological) philosophy* and *ethics* of space exploration

[30] Munévar, p. 201.
[31] *Ibid.,* p. 201.
[32] *Ibid.*, p. 201.
[33] Cockell, p. 305.
[34] Messeri, p. 332.
[35] Schwartz, p. 67.

and exoplanet science in particular. There is of course a "powerful link between our exploration of space, […] the fate of our home planet, and the development of environmental ethics"[36], but "environmental ethics itself has been limited by its focus on *ethics* rather than philosophy."[37]

The fear of neglecting our Earth in the context of potential groundbreaking astronomical discoveries is a topic that is situated on a fine line between ethical and philosophical considerations. However, nowadays the discourse about space policy and ethics seems to have overshadowed the roots of our initial fascination with the cosmos, making it all the more important to return to the most fundamental mysteries of ancient philosophy about our place in the universe and how exoplanet astronomy might change this perspective.[38]

> *"I could put my thumb up and hide the Earth completely. Then it dawned on me how completely insignificant we are. Everything I had ever known – my family, my country, my world – was behind my thumb."*
>
> ~ Jim Lovell, A Conversation with Jim Lovell, Part 2

It could be argued that the "most significant legacy of the Apollo missions was […] a view of Earth from space"[39], rather than the venture to the moon. Images like *Earthrise* and *Pale Blue Dot* have the power to agitate a deep awe and a feeling of smallness, maybe even insignificance, in all of us. Could it be that our explorations of space and other planets decenter Earth and maybe even humanity itself in a manner that would be "nothing less than the completion of the Copernican revolution […], deliver[ing] the final blow to Earth exceptionalism"[40]?

This seems like a rather drastic view, especially regarding the eventuality of ending up never finding a planet like our own. One must note that determining Earth's (in)significance in any way would always depend on its relation to other planets. However, when viewed from such a perspective of "extraterrestrial non-anthropocentric relativism"[41], exoplanet discoveries appear more likely to be able to teach us about our cosmic neighbourhood and make us extend our idea of environment, habitability and planetary characteristics over a cosmic scale, rather than taking away the image of our world being special. Even if we found an Earth-twin somewhere around some distant star, this would still indicate that the number of such planets is very small in the context of our exploration of space. It is therefore unlikely that such an event will instantly reduce Earth to insignificance – after all, we cannot lose a centrality we never had.

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[36] Erin Moore Daly and Robert Frodeman, 'Separated at Birth, Signs of Rapprochement', *Environmental Ethics and Space Exploration,* 13, no.1 (2008), 135-151 (p. 136).
[37] *Ibid.,* p. 137.
[38] On this note, "the lack of interest […] among contemporary philosophers is surprising […] given that they greatly preoccupied the thought of many philosophers from antiquity into the nineteenth century." Cf. McArthur, p. 148.
[39] Messeri, p. 327.
[40] *Ibid.,* p. 329.
[41] *Ibid.*, p. 331.

Thinking about the effect modern astronomy has on our understanding of Earth and ourselves, it even seems like the detection and exploration of other planets makes us feel more connected to the cosmos, soothing our ancient quest for our place in the universe. It is thus reasonable to assume that exoplanet discoveries and the search for other habitable worlds provide a feeling of cosmic connectedness, rather than one of cosmic loneliness, highlighting Earth's fragility instead of its insignificance, making it all the more significant to us. Because "if Earth is connected, then how we understand the cosmos is inseparable from how we understand Earth."[42]

Concerning the question whether exoplanet astronomy might suffocate our perception of 'Earth exceptionalism', it seems that space exploration is having a wholly different effect on our understanding of the cosmos. Detecting an Earth-twin would be some sort of Copernican revolution, yes, but it would not decenter our planet or humanity itself in any way.[43] In the end, it could even be capable of provoking a deep sense of *connectedness* in us. Instead of creating an ever growing distance to our home, it might "direct […] our attention back down towards Earth […] to the ground upon which the astronomer stands"[44], making us realize how special our environmental conditions are and how precious our planet really is.

## CONCLUDING REMARKS

> *"The question of "our place in the universe" […] will finally be answered, and this answer will come in the form of the detection of a habitable planet."*
>
> ~ Lisa Messeri, Gestures of Cosmic Relation and the Search for Another Earth

Having considered current scientific data and estimated numbers within the fast-developing discipline of exoplanet astronomy, I have demonstrated the possibilities of finding Earth-like planets and maybe even an Earth-twin, which asked for a deeper philosophical evaluation of the potential implications and the question of whether space exploration should be continued at all.

I have then presented an argument against the moral permissibility of space science in the form of Earth environmentalism, which argues that the search for exoplanets might cause us to neglect our own home planet. This concern about a *disposable planet mentality* was shown to be unjustified, as our venturing space is more likely to have the reversed effect of pulling us back to Earth by teaching us more about our cosmic neighbourhood. Having defeated this argument from ethics, I then considered a more philosophical perspective of the possible effects of exoplanet science, coming to the conclusion that potential findings (whether that might be the detection of another

[42] *Ibid.*, p.338.
[43] Mix, p. 190.
[44] *Ibid.,* p. 327, p. 332.

habitable world or finding 'nothing') will create a strong bond and feeling of connectedness between our understanding of ourselves, the Earth and the vastness of the cosmos.

In light of these philosophical speculations, it can thus be concluded that the answer to the question whether space exploration and the search for extrasolar planets should be continued must be *yes*. Rather than depicting us as isolated and alone, exoplanet astronomy has the potential of making us feel more connected, not only in the wider cosmic scheme, but, more importantly, in our relation to Earth.

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