

Tatsuya Akiba

Dr. Taner Edis

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Do Aliens Exist?

Once we began to explore the field of astrobiology, the possibility of other intelligent life forms on planets outside of our solar system became a topic of discussion. Furthermore, as we developed technology that allows us to foresee future interstellar travel, we started to also discuss the possibilities of alien visitations. Perhaps Unidentified Flying Objects (UFOs) could be signs of alien encounters and even alien abductions. With my background in physics and mathematics, I tend to give more weight to scientific arguments rather than witness testimonies or philosophical arguments. I believe that although investigations of the existence of aliens often involve a significant amount of extrapolation from scientific knowledge, it is science that gives us the basis for discussion and the ability to logically analyze non-scientific arguments regarding the existence of aliens. With all the evidence in mind, I claim that aliens exist somewhere in the universe, but alien visitations have not been happening and are unlikely to happen in the near future.

Firstly, it is important to put things in perspective before we begin to construct arguments for the existence of aliens. When you look up and gaze into the night sky, almost all of the luminous points you see are stars. Those stars which can be seen by the naked eye and many more that can be observed through a telescope are part of our galaxy, called the Milky Way. A good estimate of the total number of stars in our galaxy is 200 billion (Masetti, 2015), which is already a large number, but that is not even close to the total extent of our universe. The Hubble

Space Telescope, which sets our current limit of the visible universe, gives an estimate that there are around 2 trillion galaxies each containing at least several hundred million stars (Hille, 2016). Simple math gives us the estimate that there are about 10^{23} stars in the visible universe, and we do not know how much farther the universe extends. Additionally, most physicists believe that the universe is about 13 billion years old, and our solar system, the only example of a planetary system that definitively harbors life, is around 4.5 billion years old (Wollack, 2012). Although we have not yet explored any direct evidence for aliens, we can at least say that aliens are a possibility considering the size and age of our universe. Since we know that life emerged in our solar system centered around the Sun, a star, and there are an unimaginable number of other stars which have had a similar amount of time as we required to evolve and emerge, all arguments for aliens should therefore at least be taken seriously and fairly investigated.

Now, let us examine more closely how unique or common our environment is. Focusing our attention on just our neighborhood, a survey study roughly estimates that there are 10 billion exoplanets in the Milky Way alone (NASA, 2015). Given this information, NASA launched the Kepler space observatory in 2009 with the specific mission of discovering exoplanets and the distribution of their size, distance from its star, and other properties. To date, there are around 2500 confirmed exoplanets and an additional 5000 candidates (Johnson, 2015). Of the confirmed exoplanets, 30 are near-Earth-size planets which are in habitable zones where liquid water, a key ingredient for life on Earth, could exist. For instance, Kepler-452b is a super-Earth orbiting in the habitable zone of a sun-like star. Research suggests that this planet is most likely rocky, has a 385-day orbit, and has been in the habitable zone for around 6 billion years (Johnson, 2015). From the standpoint of astrobiology, there is nothing that rules out Kepler-452b from harboring life since all the environmental conditions on Earth seem to hold on this planet as well. Despite

these possibilities, one might say that since the number of exoplanets discovered by Kepler is of much smaller order of magnitude when compared to the total number of stars, it may be the case that exoplanets are relatively uncommon. However, the numbers are limited by the fact that Kepler's field of view is only around 0.25% of the entire sky and that our main method of detection is by observing transits, which limits detection to only nearby planetary systems with orbits parallel to our line of sight. Considering these limitations, we should be excited that there are thousands of exoplanets for which further observational study can be carried out, and that on 30 of such planets, life is a definite possibility given our current understanding of life on Earth. By appropriate induction, we should expect thousands of Earth-like exoplanets in our galaxy alone, giving us countless exoplanets in the entire universe, on the order of quadrillions.

Nonetheless, people may argue that although these exoplanets have the potential to harbor life, they are still merely possibilities and not a definitive proof of the existence of aliens. After all, we must make a radical jump to conclude that life exists on other planets just because we have found several exoplanets where life is a possibility. To give another example of this jump in logic, the fact that there is a possibility for anyone to die within the next hour does not mean that you will die in the next hour. However, this is where the vast extent of the universe comes into play. We know that there is some probability for which life actually emerges on an Earth-like environment, because humans emerged on Earth. Now, unless your estimate for this probability is extremely pessimistic – on the order of 10^{-23} per 10 billion years – you will come to the conclusion that aliens have at least existed at some point, because the 10^{23} stars in the visible universe can overcome the probability. Although we cannot give a complete, quantitative argument for why the probability of life emerging on an Earth-like environment should not be negligibly small, some biologists have pointed out that the abundance of biological building

blocks in Earth-like planets is analogous to having a trillion test tubes where life could be created in any one of them (Lewin, 2016), and we have recently succeeded in creating a new life form in a laboratory setting (Griffin, 2017). On top of this, it is entirely possible for life to emerge in an environment quite distinct from that of Earth. For instance, some astrobiologists believe that methane-based life might be possible on Titan, one of Saturn's moons, and several other celestial bodies in our solar system alone (Cooper, 2011). Considering these qualitative, scientific evidence, it is likely that the probability of life emerging on Earth-like environments is at least greater than 10^{-23} , and further progress in the field of biology will only improve our estimate for this probability. Using our example from earlier, we cannot say with any certainty that a particular person will die within the next hour, but we can say that at least somebody will, since there are 7.5 billion people in this world. Similarly, we cannot say with any certainty that life exists on the particular exoplanets we discover, but we can say that life should exist on some exoplanet, because we have billions and trillions of Earth-like exoplanets out there in the universe.

As we have seen, we can claim that aliens most likely exist because the universe is vast. But on the flip side, the size of the universe can help construct a compelling argument against alien visitations. The unimaginably long distance aliens must travel in order to visit the Earth makes alien visitations less likely. Indeed, it is difficult to understand why aliens would want to do that in the first place. An intelligent alien civilization capable of interstellar travel would most likely not gain any new knowledge from humans, and it is challenging to find a compelling argument for colonizing a life-harboring planet like Earth if there are no benefits of doing so. Moreover, unlike the biological knowledge we have built based on life on Earth which may or may not apply to aliens elsewhere in the universe, the laws of physics, in particular Einstein's

theory of relativity, have been experimentally verified, thus far, to hold true universally. The problem with long-distance communication and interstellar travel is that relativity forbids anything from travelling faster than the speed of light (Norton, 2013). Imagine an alien civilization on Kepler-452b discussed earlier, capable of communication technology. Kepler-452b is approximately 1400 light-years away (Johnson, 2015), which means that any information transmitted via electromagnetic radiation will take 1400 years to get from Earth to the other planet and another 1400 years for information to be sent back to Earth. Although we have started to send out radio signals containing information about Earth to exoplanets so that aliens with communication technology will be able to receive them (IRE RAS, 2009), we did not have such communication technology 1400 years ago. The information we have been sending has not yet reached systems like Kepler-452b. Thus, even if aliens existed on the specific exoplanets we have sent radio signals to, the aliens are yet to receive the information that there is intelligent life on Earth and do not have any reason to travel a long distance to visit Earth specifically. Even if we had the technology to visit Kepler-452b, we would most likely not do so until we have caught a signal coming from it that proves the existence of intelligent life on the planet. By a similar argument, it is unreasonable to expect alien visitations when we have not had communication technology long enough for aliens to be aware of that fact.

Furthermore, as far as we know there are two significant problems with interstellar travel. One is the long time associated with long-distance travelling. Even if we come up with a spacecraft capable of travelling at 1% of the speed of light, a speed we are not even close to achieving, it would take us 140,000 years to get to Kepler-452b, a much longer timescale than one human lifespan. Thus, if we want to send humans to these systems, we would need to create a completely self-sustained environment in this spacecraft including an agricultural system, a

manufacturing sector, education, healthcare, and so on, or develop the technology to preserve humans alive for that long period of time. Even with our high-level technology and continuous development, this is an unthinkable level of sophistication. Now, with our recent development in artificial intelligence (AI) technology, we could possibly send robotic AIs instead of human beings to avoid these challenges associated with sustaining life. However, these space-travelling robots must be intelligent enough to gather their resources at their new planet, select their new destination, and successfully continue their journey through the galaxy independently, and we are not certain whether this type of high-level general AI can be developed. Another problem is the energy cost associated with interstellar travel. With our current energy production technology, we cannot possibly complete even a single trip over such a long distance. We would need some new, much more efficient technology for producing energy, and although methods like nuclear fusion (World Nuclear Association, 2017) or antimatter technology (Dunbar, 2006) have been proposed as theoretical ideas, we are far from achieving them in reality.

The challenges of interstellar travel notwithstanding, some people claim that alien visitations have been happening, based solely on witness testimony. Indeed, there are certain unexplained cases of UFO sightings that may make UFOs seemingly believable. However, UFO sightings have emerged only in the twentieth century when people began to consider the topic of extraterrestrial life and interstellar travel. Furthermore, sightings have increased dramatically over the last three decades as media expanded our UFO culture around the world (FOX News, 2017). This correlation is strong evidence that UFO sightings are not due to real aliens, but rather a mixture of mistaking various flying objects such as government aircraft, simply displaying how unreliable the human perception is. Additionally, the technology of photo or video-editing has become much more common and convenient over the last decade or so, making it extremely easy

for people to create fake images or videos of UFOs. Therefore, witness testimony and even evidence like photographs or videos are not reliable sources that support the existence of alien visitations. Also, believing in UFO sightings and believing in alien visitations are distinct from one another, since a mysterious object flying in the air does not necessarily imply that aliens are responsible for it. Unless there is significant evidence to support that the UFO was not the work of human beings, the “alien visitation” is most likely just the work of the government or other human activities that the public are not made aware of. Thus, even if we accept the fact that certain UFO cases are unexplainable by science, there is still no direct connection that relates those events to alien visitations.

All in all, I believe that we are not alone, but we are isolated from each other in space and time. Even with its small field and limitations in detecting exoplanets, Kepler has confirmed 30 Earth-like planets in habitable zones which shows that there are many planetary systems out there with environmental conditions similar to those of Earth. Considering the size of the universe and some recent progress in biology that shows that the probability of life emerging is non-negligible, there should be alien life out there in the universe. At the same time, the vastness of the universe significantly limits effective communication between distant civilizations and interstellar travel. It is a challenging task to try and justify why aliens would want to visit Earth in the first place, and it is implausible that an alien civilization is capable of doing so according to our current understanding of physics and technology. However, I do not think that it is meaningless to explore the subject further since the discussion is far from being conclusive. We should continue our efforts to find life elsewhere so that one day, we may witness our movie fantasies turn into reality by interacting with an alien civilization.

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