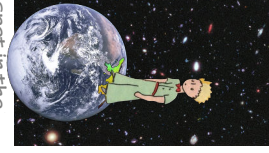


The Scream, painted by E. Munch in 1893, has become an icon of the anxiety and loneliness of our age.

12



This is a picture of a tiny dark spot in the sky, much smaller than the moon, where the Hubble Space Telescope, after an exposure of more than 20 days, could detect thousands of galaxies. There are billions of galaxies in the observable Universe, and each galaxy contains billions of stars and planets. Are we alone in the middle of this sea of possibilities?

Why is the sky dark at night? Imagine an infinite Universe full of stars. The further you look, the more stars you see, with the increase in their numbers compensating the decrease of their brightness. All the sky should be as bright as the surface of the Sun. This is known as Olbers' paradox, and led J. Kepler to conclude in 1610 that the Universe is finite.

An Infinite Universe?

Today we know that the darkness of the sky is mainly due to the finite age of the Universe: the light of the stars that are outside the observable Universe has not been able to reach us yet. This solution was first proposed by the writer E. A. Poe!

We still don't know whether the Universe is finite or infinite...

5

Are we alone in the Universe?

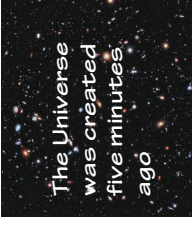
The absence of evidence of alien life leads us to consider the possibility that we are the only conscious beings with technological capabilities, at least in our corner of the Universe.

N. Bostrom, here on more solid ground than when considering that we live in a simulation, reasons that this might be good news. His argument goes like this: We haven't found life elsewhere in the Universe because (choose at least one explanation):

- ★ Life is extremely improbable.
- ★ Evolution rarely leads to technological civilizations.
- ★ Technological civilizations destroy themselves in a very short time.

As long as we find the Universe a barren place, we can hope to avoid the doom implied by the third explanation.

13



The Universe was created five minutes ago

Quiz



The Universe is a simulation



There are infinite universes

Answers on overleaf



We are alone in the Universe

Which of these ideas are impossible to disprove?

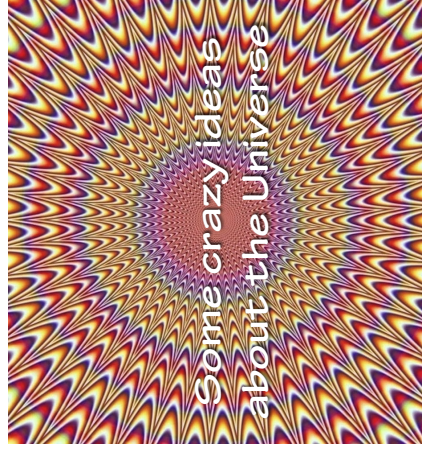
Is the Universe a Simulation?

Let's assume that humanity survives long enough to achieve a technological development consistent with known limitations. Wouldn't it be interesting to run many computer simulations that explore alternative histories for civilizations similar to ours?

In fact, the philosopher N. Bostrom proposes that at least one of the following statements must be true:

- ★ It is likely that our species will be extinct before we reach an advanced stage of development.
- ★ It is extremely unlikely that advanced civilizations will run computer simulations of their ancestors.
- ★ We live in a computer simulation.

9



Some crazy ideas about the Universe

The Universe in my pocket



Mónica Rodríguez
Instituto Nacional de Astrofísica, Óptica y Electrónica México

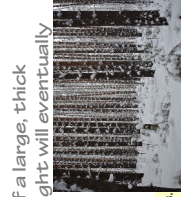


Left: an image of the Hubble Space Telescope (Extreme Deep Field). Right: simulated image from the Illustris cosmological simulation, illustrating the behavior of nearly 20 billion 'particles' from the beginning of time. Impressive, but a single grain of sand contains many more atoms!

If there are civilizations in the Universe with very advanced technical capabilities, they might be able to simulate universes that develop life and consciousness. The number of simulated beings might be much larger than the number of real ones!

Many people think that this is not a good scientific theory. It is neither productive nor disproveable, and it is not clear that our Universe or consciousness can be simulated in a computer.

8

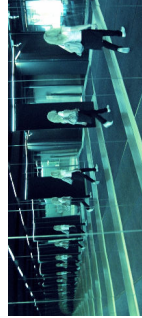


If you are in the middle of a large, thick forest, all your lines of sight will eventually reach a tree trunk.

Change 'trees' for 'stars', and you get Olbers' paradox.

Image taken by Сергей Копанюк

In an infinite Universe, everything that can possibly happen will happen, an infinite number of times. We can imagine infinite versions of ourselves living infinite variations of our lives. If you are having a bad day, will it cheer you up to think of some version of yourself having a wonderful day somewhere else in the Universe?



A finite Universe is also a crazy idea. Does it have edges? If so, what lies beyond it? Or does the Universe wrap around itself in some mind-bending shape?

4

Other tentative theories that predict a multiverse are: string theory, eternal inflation, and the mathematical universes of Tegmark.

different outcome for the interaction.

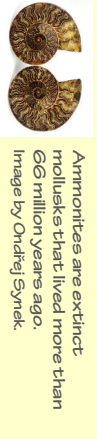
Quantum mechanics, one of our more successful theories, has counterintuitive implications, like particles that seem to exist in several places at the same time and that can communicate with other particles instantaneously. The many-worlds interpretation of this theory proposes that every time a particle interacts, the Universe splits into different universes, each with a different outcome for the interaction.

An Infinity of Universes?

An infinite number of universes, a multiverse, is predicted to occur by several crazy theories.

The idea that the Universe was created five minutes ago was discussed by the philosopher and mathematician B. Russell. It can be considered an extrapolation of the omphalos hypothesis.

The omphalos hypothesis (P. H. Gosse, 1857) reconciles the age of the Earth implied by the Bible with the much longer age deduced from geological evidence and fossils by proposing that the Earth was created with all that evidence in place.



The omphalos hypothesis has never been very popular, either because it makes the creator of the Universe a deceiver or because it is not a scientific idea.

We also tend to believe in interesting things. Wouldn't it be nice if aliens were already here and willing to help us fix our problems?

All the claims of contact with aliens that provide enough information to be investigated have resulted in explanations involving natural phenomena or hoaxes.

require extraordinary evidence.

C. Sagan applies: 'Extraordinary claims require extraordinary evidence.'

As depicted in many movies and books, our first contact with an extraterrestrial civilization would be momentous. Hence, the aphorism made popular by the astronomer

many sightings of UFOs (Unidentified Flying Objects), the crop circles that have been found in several parts of the world, or the reports of persons claiming they have been abducted by aliens.

Some people think that there is no paradox, that the aliens are already here. As evidence, they might point out the many sightings of UFOs (Unidentified Flying Objects), the crop circles that have been found in several parts of the world, or the reports of persons claiming they have been abducted by aliens.



This idea is impossible to disprove.

This idea can be disproved by finding any clear evidence of life outside the Earth. However, it can never be proved to be right.

We cannot disprove this idea now (but we could prove it right by finding a message from the programmers)

Our current knowledge does not allow us to disprove this idea.

explanation that will work for all possible civilizations.

known as the Great Silence, have been proposed, but it is difficult to find an explanation that will work for all possible civilizations.

explanations of the paradox, also known as the Great Silence, have been proposed, but it is difficult to find an explanation that will work for all possible civilizations.

popular name for this problem (previously discussed in 1933 by K. Tsiolkovsky): the Fermi paradox. Many explanations of the paradox, also known as the Great Silence, have been proposed, but it is difficult to find an explanation that will work for all possible civilizations.

This was the question posed by E. Fermi in 1950, and it led to the most popular name for this problem (previously discussed in 1933 by K. Tsiolkovsky): the Fermi paradox. Many explanations of the paradox, also known as the Great Silence, have been proposed, but it is difficult to find an explanation that will work for all possible civilizations.

teaming with extraterrestrial civilizations. So, where is everybody?

There might be billions of planets just in our Galaxy. And some of them were probably born a few billion years before the formation of the Earth. Even if just a tiny fraction of these planets develop life and civilizations with technological capabilities, the Galaxy should be teeming with extraterrestrial civilizations. So, where is everybody?

Is the Universe full of aliens?

In the last three decades, we have discovered thousands of planets orbiting nearby stars (see TUMIP 8).

The Universe in my pocket No. 16

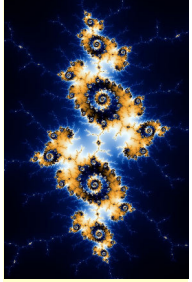
This booklet was written in 2019 by Mónica Rodríguez from Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE), and revised by Stan Kurtz, from UNAM, Mexico. For current scientific theories of the Universe, see TUMIPs 12 and 13.

Cover image: optical illusion from Thomson. Image in page 8. Illustris Collaboration. Page 12: portion of the Hubble Extreme Deep Field (NASA, ESA, G. Illingworth, D. Magee, and P. Oesch, R. Bouwens, and the HUDF09 Team). The image of the Earth in page 12 was taken by the Apollo 17 crew (NASA); the little prince is based on drawings of A. de Saint-Exupéry. Other images taken from Wikipedia, Flickr and Pixabay.



To learn more about this series and about the topics presented in this booklet, please visit: <http://www.tumip.org>

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Close-up of a region in the Mandelbrot set, a mathematical structure created with the function $f(z) = z^2 + c$ (Brettre222).

mathematics and that all possible mathematical structures exist somewhere in the multiverse.

The Souls of Millions of Light Years Away: the work of Y. Kusema illustrates beautifully the concept of infinity. Image taken by Adam Fagen.

A Five-Minute Universe?

You probably remember getting out of bed this morning and what you had for breakfast. You might also remember your first kiss or the joy of your first ride on a bike.

According to this idea, these things never happened. You were created five minutes ago, along with all your memories and, for that matter, along with the rest of the Universe.

There is absolutely no way in which this idea can be disproved. And there is no way at all to prove that it is true. Moreover, the idea does not provide any useful knowledge about the Universe.

Therefore, this idea is not a scientific theory. Scientific theories must be fruitful, and it must be possible to disprove them.