Theoretical research "A new understanding of the nature of dark energy and dark matter"

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The question of the nature of dark energy and dark matter is considered.

Introduction

It is extremely interesting that there is still no clear understanding of the nature of dark energy, as well as the extreme scarcity of information about dark matter. So what is this darkest energy?

What we know about dark energy [8]

In standard cosmology, there are three components of the universe: matter, radiation, and dark energy. Matter is everythingëwhose energy density is measured in the inverse cube of the scale factor, i.e.,ep ∝ -3, while radiation is everything measured in the inverse fourth power of the scale factor (a,, -4,,). This can be understood intuitively: for an ordinary particle in a cubic box, doubling the edge length of the box reduces the density (and thus the energy density) by a factor of eight [9]. For radiation, the decrease in energy density is greater, because an increase in spatial distance also causes a redshift. [10]

The last component is dark energy: it is an integral property of space and has a constant energy density, regardless of the size of the volume under consideration (p ∝ a0). Thus, unlike ordinary matter, it is not diluted by the expansion of space.

Evidence for the existence of dark energy is indirect, but comes from three independent sources:

Distance measurements and their relationship to redshift, which suggest that the universe expanded more in the second half of its life.[11]

In recent years, a new approach to verifying evidence for the existence of dark energy has attracted considerable attention, using observations of the Hubble Constant (OHD), also known as space chronometers.[12][13][14][15]

The Hubble constant, H (z), is measured as a function of the cosmological redshift. OHD directly tracks the expansion history of the universe, using passively developing early-type galaxies as "cosmic chronometers".[16] From this point on,

this approach provides a standard clock in the universe. This idea is based on the measurement of differential age evolution as a function of the redshift of these cosmic chronometers. Thus, it gives a direct estimate of the Hubble parameter.

The existence of dark energy, in whatever form it may be, is necessary to reconcile the measured geometry of space with the total amount of matter in the universe. Anisotropy measurements indicate that the universe is close to flat. For the shape of the universe to be flat, the mass–energy density of the universe must be equal to the critical density. The total amount of matter in the universe (including baryons and dark matter) measured from the cosmic microwave background spectrum is only about 30% of the critical density. This implies the existence of an additional form of energy, which accounts for the remaining 70%. [17]

Measures large-scale wave patterns of mass density in the universe. Accelerated cosmic expansion causes gravitational potential pits and hills to flatten out as photons pass through them, forming cold and hot spots on the cosmic microwave background aligned with huge supervoids and superclusters. This so-called late-time Integrated Sachs-Wolf effect (ISW) is a direct signal of dark energy in a flat universe.[41] Its high significance was reported in 2008 by Ho et al. [18] and Gianantonio et al. [19]

Supernovae. Supernovae are vivid evidence of the existence of dark energy. Supernovae are useful for cosmology because they are excellent standard beacons (candles) at cosmological distances. They allow researchers to measure the expansion history of the universe by looking at the relationship between an object's distance and its redshift, which shows how fast it is moving away from us. The relationship is approximately linear, according to Hubble's law. Measuring redshift is relatively easy, but determining the distance to an object is more difficult. Astronomers usually use standard candlesticks: objects that have a known intrinsic brightness, or absolute value. This allows you to measure the distance to an object based on its actual observed brightness or apparent magnitude. Type Ia supernovae are the best-known standard candles at cosmological distances due to their extreme and constant brightness.

Recent supernova observations agree that the universe consists of 71.3% dark energy and 27.4% a combination of dark matter and baryonic matter.[20]

The main hypotheses about the nature of dark energy.

The simplest explanation for dark energy is that it is the internal, fundamental energy of space. This is a cosmological constant, usually denoted by the Greek letter Λ (Lambda, hence the name lambda-CDM model). Since energy and mass are related according to the equation $E = mc^2$, Einstein's general theory of relativity predicts

that this energy will have a gravitational effect. It is sometimes called the vacuum energy, because it is the energy density of empty space-vacuum.

The main unsolved problem is that the same quantum field theories predict a huge cosmological constant that is about 120 orders of magnitude larger. This would have to be almost, but not quite, reversed by an equally large term with the opposite sign.[21]

The quintessence. In dark energy quintessence models, the observed acceleration of the scale factor is caused by the potential energy of a dynamic field called the quintessence field. The quintessence differs from the cosmological constant in that it can change in space and time. So that it does not accumulate and form a structure similar to matter, the field must be very light, so that it has a large Compton wavelength. In the simplest scenarios, the quintessence field has a canonical kinetic term, is minimally related to gravity, and does not contain higher-order operations in its Lagrangian.

There is no evidence of quintessence yet, and it is not excluded. It usually predicts a slightly slower acceleration of the expansion of the universe than the cosmological constant. Some scientists believe that the best proof of quintessence would be violations of Einstein's equivalence principle and changes in fundamental constants in space or time.[22] Scalar fields are predicted by the Standard Model of Particle Physics and String Theory, but there is a problem similar to the problem of the cosmological constant (or the problem of constructing models of cosmological inflation): renormalization theory predicts that scalar fields should acquire large masses.

The coincidence problem asks why the acceleration of the universe started exactly when it did. If acceleration had started earlier in the universe, structures like galaxies would never have had time to form, and life, at least as we know it, would never have had a chance to exist. Proponents of the anthropic principle see this as a confirmation of their arguments. However, many quintessence models have a so-called "tracker" behavior that solves this problem. In these models, the quintessence field has a density that accurately tracks (but is less than) the radiation density to the point where matter and radiation are equal, which causes the quintessence to start behaving like dark energy, eventually dominating the universe. This naturally sets a low energy scale for dark energy.[23][24]

In 2004, when scientists compared the evolution of dark energy with cosmological data, they found that the equation of state may have crossed the boundary of the cosmological constant (w = -1) from top to bottom. The forbidden theorem was proved that this scenario requires models with at least two types of quintessences. This scenario is the so-called Quinthome scenario.[25]

Some special cases of quintessence are phantom energy, in which the energy density of the quintessence actually increases with time, and k-essence (short for kinetic quintessence), which has a non-standard form of kinetic energy, such as negative kinetic energy.[26] They may have unusual properties: phantom energy, for example, can cause a large gap.

In 2021, a group of researchers argued that Hubble voltage observations may imply that only quintessence models with a non-zero coupling constant are viable. [27]

Interacting dark energy. This class of theories attempts to create a comprehensive theory of both dark matter and dark energy as a single phenomenon that changes the laws of gravity at various scales. This could, for example, treat dark energy and dark matter as different facets of the same unknown substance,[28] or postulate that cold dark matter decays into dark energy.[29] It is assumed that another class of theories combining dark matter and dark energy are covariant theories of altered gravity. These theories alter the dynamics of spacetime in such a way that the altered dynamics are related to what has been attributed to the presence of dark energy and dark matter.[30] In principle, dark energy can interact not only with the rest of the dark sector, but also with ordinary matter. However, cosmology alone is not sufficient to effectively limit the strength of the coupling between dark energy and baryons, so other indirect methods or laboratory searches must be applied.[31] In the early 2020s, it was briefly suggested that the excess observed in the XENON1T detector in Italy could be caused by a chameleon model of dark energy, but further experiments refuted this possibility.[32][33]

Models of variable dark energy. The density of dark energy may have changed over time throughout the history of the universe. Current observational data allow us to estimate the current density of dark energy. Using baryon acoustic vibrations, we can study the influence of dark energy on the history of the universe and limit the parameters of the dark energy equation of state. Several models have been proposed for this purpose. One of the most popular models is the Chevalier–Polarski–Linder (CPL) model.[34] [35] Some other common models are (Barboza & Alcaniz. 2008), [36] (Jassal et al. 2005), [37] (Wetterich. 2004), [38] and (Oztas et al., 2018).[39][40]

Observational skepticism. Some alternatives to dark energy, such as inhomogeneous cosmology, aim to explain observational data through more sophisticated use of established theories. In this scenario, dark energy doesn't really exist and is just a measurement artifact.

A new hypothesis about the nature of dark energy

To understand the structure of a building without having its plan, it is best to look at it from the outside in addition to studying it from the inside, in order to exclude the incompleteness of knowledge set out in Godel's theorems:

Godel's incompleteness theorem and Godel's second theorem are two theorems of mathematical logic about the fundamental limitations of formal arithmetic and, as a consequence, any formal system in which the basic arithmetic concepts can be defined: natural numbers, 0, 1, addition and multiplication.

The first theorem states that if formal arithmetic is consistent, then there is a non-deducible and irrefutable formula in it. In general terms: any consistent axiomatic theory contains statements that cannot be proved or refuted by means of the theory itself.

The second theorem states that if a formal arithmetic is consistent, then it does not contain a formula that meaningfully asserts the consistency of this arithmetic. Generically: the consistency of any axiomatic theory cannot be proved by means of this theory itself. [1]

Both of these theorems were proved by Kurt Godel in 1930 (published in 1931). [2][3]

For an outside view, let's look at the evidence for the existence of the God of Thomas Aquinas. [4]

Here are five proofs:

1. The Argument from Motion: Our senses can perceive motion by seeing that things act on one another. Whatever moves is moved by something else. Consequently, there must be a First Mover that creates this chain reaction of motions. This is God. God sets all things in motion and gives them their potential.

2. The Argument from Efficient Cause: Because nothing can cause itself, everything must have a cause or something that creates an effect on another thing. Without a first cause, there would be no others. Therefore, the First Cause is God.

3. The Argument from Necessary Being: Because objects in the world come into existence and pass out of it, it is possible for those objects to exist or not exist at any particular time. However, nothing can come from nothing. This means something must exist at all times. This is God.

4. The Argument from Gradation: There are different degrees of goodness in different things. Following the "Great Chain of Being," which states there is a gradual increase in complexity, created objects move from unformed inorganic matter to

biologically complex organisms. Therefore, there must be a being of the highest form of good. This perfect being is God.

5. The Argument from Design: All things have an order or arrangement that leads them to a particular goal. Because the order of the universe cannot be the result of chance, design and purpose must be at work. This implies divine intelligence on the part of the designer. This is God. [4], [43]

Every event finds its mention. Behind any matter, behind any event in the universe, there is energy in one way or another. This is a single measure of the various forms and interactions of matter, a measure of the motion and force of the transition of the motion of matter from one form to another. Everything is somehow atransformed form of energy. All events somehow leave their mark, information about themselves. Information is also a transformed form of energy. Every event, every disturbance of probability, leaves its own energetic trace in space-time. If we consider the universe to be a closed system, then, guided by the law of conservation of energy, we can say that dark energy is a log of the events of the Universe-Acta universi, if you want, then the book of life of the Universe. In the future, for simplicity, we will call the Acta universi – AUfield. In this AUfield, every event is reflected, mentioned, which leads to its expansion and increase.

It is known that the gravitational properties of dark energy are different from other forms of energy. Dark energy is not collected in clumps. Its density is uniform and varies slightly over time. With the negative pressure inherent in dark energy and, as mentioned above, a constant density, dark energy increases in volume, and the volume of the Universe increases along with it. Of course! There are many different events in the Universe that leave their information and energy trace, which we observe in the form of dark energy. Events are moving, energies are raging, matter is interacting everything is flowing, everything is changing, the log of the universe is growing, the universe is expanding - which is what we are seeing.

If dark energy is an AUfield, then following the law of conservation of energy, dark matter can be interpreted as a kind of dump, counterweight, by-product of imprinting in the AUfield, a kind of book of life of the Universe. It is even somewhat unsurprising that dark matter is usually found around event centers – galaxies, clusters of galaxies. Metamorphoses of matter lead to the expansion of the" book of life " of the Universe and the mass of dark matter. Any fluctuation in probability leads to the expansion of the universe. The AUfield expands the universe.

In the AUfield, the concepts of space and time collapse. The AUfield contains any object, any event, anywhere and always. When trajectories collapse, it doesn't make sense to determine the coordinate, time, or trajectory. There is only a phase space of correlations, which consists of ensembles of fluctuations and perturbations. Here, an ensemble is a set of identical systems with different initial conditions.

Types of ensembles.

1. Standard model. The Standard Model of Particle Physics is a theory that describes three of the four known fundamental forces (the electromagnetic, weak, and strong forces excluding gravity) in the universe and classifies all known elementary particles.

2. Time. Time types:
   - Ontological time (transcendental, eschatological, teleological): The time of Scripture, the time of Sartre, Heidegger. Spiritual, non-linear, discontinuous (discrete), finite time, is given by Revelation. (The Quantum Observer). [5], [42]
   - Thermodynamic time (biological, geological, evolutionary): Boltzmann, Clausius, Prigogine [6], Bertalanffy. Live, non-linear, directed, inhomogeneous, finite, observable / computable time. (Ontological observer) [5], [42]
   - Metrological time (physical, mechanical, and geometric): Newton, Einstein, and Wheeler time. Dead, linear, directed, uniform, infinite, measurable time. (Live observer) [5], [42].

3. Operators of being, non-being, and otherness.
   B (Being), N (Non-being), O (Otherness)
   NNN (non-existence of non-existence is non-existence) – Red Road. Absolute nothingness
   NNB (non-existence of non-existence is being) is a classic Black Road.
   NNO (non-existence of non-existence is otherness) - Beige Road, quantum fluctuations are NOTHING, generating Something Else.
   NBN (non-existence of being is non-existence) - Yellow Road, anti-creation.
   NBB (non-existence of being is being) - Purple Road, determinism, wheel of Samsara
   NBO (non-existence of being is otherness) - the Emerald Road, the region of the miraculous.
   NON (non-existence of otherness is non-existence) - Raven-colored Road – the fall of Satan.
   NOB (non-existence of otherness is being) - Mother-of-Pearl Road – the Fall
   NOO (non-existence of otherness is otherness) - Silver Road (all paths lead to God)
   BNN (the being of non – being is non-being) - A Gray Road, an endless wandering, an ontological exorcism, an interweaving that does not form a whole.

BNB (the being of non-being is being) - A Green Road, a creation from nothing.
BNO (being of non-being is otherness) - Bleached Road, Lovecraftianism, Cthulhu's lair.
BBN (being of being is non-being) – Blue Road, Black hole (of Being), Abyss, Ungrund.
BBB (being of being is being) - Golden Road, Being
BBO (being of being is other-being) - White Road-synergy, my will and the will of God are united in a single action, in a single will. To some extent, techno/scientifical magic, the creation of foreign worlds.
BON (the existence of otherness is non-existence) – Absolutely Black Road, Hell.
BOB (the being of otherness is being) is an Apple-green Road, materialism in its complacency.
BOO (the being of otherness is otherness) - Purple Road, ascent to otherness, monasticism.
ONN (otherness of non-existence is non-existence) - Amethyst Road, High Paganism, ancient Gods, pagan Olympus
ONB (the otherness of non-being is being) - The Linen Road," The Little Prince " by A. de Saint-Exupery.
ONO (otherness of non-being is otherness) - Crimson Road (???)
OBN (the otherness of being is non-being) - The Silver Road (germination, pecking, emergence with the death of the previous one-a butterfly from a chrysalis...)
OBB (the otherness of being is being) - Amber Road, cyclical modes of Being.
OBO (the otherness of being is otherness) - Azure Road, deification.
OON (otherness otherness is non-being) - Wuthering Road, the Last Judgment
OOB (Otherness of otherness is being) - Dark Blue Road, Salvation through the Sacrifice of the Cross
OOO (otherness otherness is otherness) - Cobalt Road, the ultimate Otherness. [5]

4. Locality and non-locality.

Local and non-local correlations. Local-these are all correlations that science operates with outside of quantum physics, can be explained by the influence of one phenomenon on another. Interaction and information transfer are carried out by a chain of events. Effect follows cause. The reason is transmitted from point to point, without jumps or breaks. Cause and effect are inextricably linked. There is no cause without effect, and there is no effect without cause. The cause propagates continuously in space from the original local point. In this

sense, we will call correlations local-they all have a local starting point in time and space.

Non-local correlations are correlations where no information is exchanged. For example, as a result of quantum entanglement, a non-local whole is formed. Imagine that you have two cars. You hand them over to the service for repair. They are disassembled there in some way for repairs. Perform repairs, collect them after repairs and give them to you. And as a result of repairs, cars acquire unusual properties. You get behind the wheel of one of the cars and go on a trip. If necessary, you can manipulate the controls, turn on and off the high and low beam, turn signals, and car radio. And at the same time, your second car in the garage begins to turn on and off turn signals, turn the wheels, play the radio, so to speak, synchronously with the devices of your first car. In fact, in theory, any object can be entangled. But so far, entanglement has been demonstrated for photons, atoms, and elementary particles. The largest objects that were connected were crystals. [7] An interesting question may be the entanglement of all elementary particles in the universe to some extent, which could arise as a result of the evolution of the universe.

5. Special theory of relativity.
6. General theory of relativity.
7. An ensemble of fluctuations. [6]
8. Combined ensemble. An ensemble based on connections and intersections of elementary event spaces of other ensembles.

In summary

1. We know about the existence of dark energy.
2. There is evidence for the existence of dark energy. Mostly indirect ones.
3. There are observations that confirm the existence of dark energy.
4. Existing theories and models do not reveal the essence and properties of dark energy.
5. A new model of dark energy is proposed. According to this model, dark energy is a log of the events of the universe – Acta universi, if you will, the book of life of the universe. In the future, for simplicity, we will call the Acta universi – AU field. In this AU-field, every event is reflected, mentioned, which leads to its expansion and increase. In the AUfield, the concepts of space and time collapse. The AUfield contains any object, any event, anywhere and always. When trajectories collapse, it doesn't make sense to determine the coordinate, time, or trajectory. There is only a phase space of correlations, which consists of ensembles of fluctuations and perturbations.

6. The AU field is described by the following types of correlation ensembles:
    - Standard Model of Elementary Particle Physics.
    - Time.
    - Operators of being, non-being, and, otherness.
    - Locality a in Russian nd non-locality.
    - Special theory of relativity.
    - General theory of relativity.
    - An ensemble of fluctuations.
    - Combined ensemble. An ensemble based on connections and intersections of elementary event spaces of other ensembles.
7. Dark matter is the product of AU-field metamorphoses ("dark energy"). Any processes and events in the Universe lead to the expansion of the" book of life " of the Universe and the growth of massesы in dark matter. Any probability fluctuation in compliance with the law of conservation of energy leads to an increase in energy reserves through an increase in the mass of dark matter and an increase in the AU-field ("dark energy") as anti-energy.
8. Any fluctuation in probability leads to an expansion of the universe. The AUfield expands the universe.

Conclusion

The proposed theory needs to be verified by practical research. At the same time, it opens the way to understanding and understanding the interrelation of the fundamental laws of nature. In the future, it will lead to the emergence of new branches of knowledge, new areas of fundamental and applied science, give an impetus to the development of technology (for example, in the field of deep space exploration), and also allow Humanity to embark on the path of transformation from a species chained to one planet of one star system to an interstellar species.

References

1. The shortest explanation of Godel's Theorem https://habr.com/ru/articles/79715/
2. Wikipedia article "Godel's Incompleteness Theorems" https://clck.ru/3LNjie in Russian.
3. Wikipedia article «Gödel's incompleteness theorems» https://en.wikipedia.org/wiki/G%C3%B6del%27s_incompleteness_theorems
4. Thomas von Aquin Die Gottesbeweise in der "Summe gegen die Heiden" und der "Summe der Theologie" Text mit Übersetzung, Einleitung und Kommentar, herausgegeben von Horst Seidl-Thomas Aquinas Proofs of the

Existence of God in theSumma against the Gentiles» and theSumma of Theology» Compilation, introduction and commentary by Horst Seidl Translation from Latin and German German K..V.. Bandurovsky Moscow 2000 / Thomas von Aquin Die Gottesbeweise in der «Summe gegen die Heiden» und der «Summe der Theologie» Text mit Übersetzung, Einleitung und Kommentar, herausgegeben von Horst Seidl - Фома Аквинский Доказательства бытия Бога в «Сумме против язычников» и «Сумме теологии» Составление, введение и комментарии Хорста Зайдля Перевод с латинского и немецкого К.В. Бандуровского Москва 2000

5. "Cognitive codes and descriptors of Civilizations" S. B. Pereslegin St. Petersburg August 8, 2024 / «Когнитивные коды и дескрипторы цивилизаций» С.Б Переслегин Санкт-Петербург 8 августа 2024 года https://disk.yandex.ru/i/b1xX-u9xe9a9EA
6. Prigozhin I., Stengers I. Time. Chaos. Quantum. K reshenii paradoksa vremya [To the solution of the time paradox]. Moscow, 2003. / Пригожин И., Стенгерс И. Время. Хаос. Квант. К решению парадокса времени. М.: Едиториал УРСС. Москва 2003.
7. Nicolas Gisin, "Quantum Randomness: Nonlocality, Teleportation, and other quantum wondersNicolas Gisin." Quantum Chance: Nonlocality, Teleportation and Other Quantum Marvels) Alpina Non-fiction Publishing House, 2016 Pages: 202, hardcover, 145×215 ISBN: 978-5-91671-489-0 Circulation: 3000 Translated from English by Ksenia Efimova
8. Wikipedia article "Dark energy" https://en.wikipedia.org/wiki/Dark_energy
9. Wanjek, C. (2015). The Drake Equation. Cambridge University Press. ISBN 9781107073654. Retrieved 9 September 2016.
10. Kennicutt, Robert C.; Evans, Neal J. (22 September 2012). "Star Formation in the Milky Way and Nearby Galaxies". Annual Review of Astronomy and Astrophysics. 50 (1): 531–608. arXiv:1204.3552. Bibcode:2012ARA&A..50..531K. doi:10.1146/annurev-astro-081811-125610. S2CID 118667387.
11. Palmer, J. (11 January 2012). "Exoplanets are around every star, study suggests". BBC. Retrieved 12 January 2012.
12. Westby, Tom; Conselice, Christopher J. (15 June 2020). "The Astrobiological Copernican Weak and Strong Limits for Intelligent Life". The Astrophysical Journal. 896 (1): 58. arXiv:2004.03968. Bibcode:2020ApJ...896...58W. doi:10.3847/1538-4357/ab8225. S2CID 215415788.
13. Davis, Nicola (15 June 2020). "Scientists say most likely number of contactable alien civilisations is 36". The Guardian. Retrieved 19 June 2020.
14. "Ernst Mayr on SETI". The Planetary Society. Archived from the original on 6 December 2010.
15. Rare Earth, p. xviii.: "We believe that life in the form of microbes or their equivalents is very common in the universe, perhaps more common than even

Drake or Sagan envisioned. However, complex life—animals and higher plants—is likely to be far more rare than commonly assumed."
16. Campbell, A. (13 March 2005). "Review of Life's Solution by Simon Conway Morris". Archived from the original on 16 July 2011.
17. Khan, Amina (4 November 2013). "Milky Way may host billions of Earth-size planets". Los Angeles Times. Retrieved 5 November 2013.
18. Davies, P. (2007). "Are Aliens Among Us?". Scientific American. 297 (6): 62–69. Bibcode:2007SciAm.297f..62D. doi:10.1038/scientificamerican1207-62.
19. Crick, F. H. C.; Orgel, L. E. (1973). "Directed Panspermia" (PDF). Icarus. 19 (3): 341–346. Bibcode:1973Icar...19..341C. doi:10.1016/0019-1035(73)90110-3. Archived (PDF) from the original on 29 October 2011.
20. Trimble, V. (1997). "Origin of the biologically important elements". Origins of Life and Evolution of the Biosphere. 27 (1–3): 3–21. Bibcode:1997OLEB...27....3T. doi:10.1023/A:1006561811750. PMID 9150565. S2CID 7612499.
21. newspaper, staff (8 November 1959). "Life On Other Planets?". Sydney Morning Herald. Retrieved 2 October 2015.
22. Forgan, D.; Elvis, M. (2011). "Extrasolar Asteroid Mining as Forensic Evidence for Extraterrestrial Intelligence". International Journal of Astrobiology. 10 (4): 307–313. arXiv:1103.5369. Bibcode:2011IJAsB..10..307F. doi:10.1017/S1473550411000127. S2CID 119111392.
23. Tarter, Jill C. (September 2001). "The Search for Extraterrestrial Intelligence (SETI)". Annual Review of Astronomy and Astrophysics. 39: 511–548. Bibcode:2001ARA&A..39..511T. doi:10.1146/annurev.astro.39.1.511. S2CID 261531924.
24. Shermer, M. (August 2002). "Why ET Hasn't Called". Scientific American. 287 (2): 21. Bibcode:2002SciAm.287b..33S. doi:10.1038/scientificamerican0802-33.
25. Grinspoon, D. (2004). Lonely Planets.
26. Goldsmith, D.; Owen, T. (1992). The Search for Life in the Universe (2nd ed.). Addison-Wesley. p. 415. ISBN 1-891389-16-5.
27. Vinn, O. (2024). "Potential incompatibility of inherited behavior patterns with civilization: Implications for Fermi paradox". Science Progress. 107 (3): 1–6. doi:10.1177/00368504241272491. PMC 11307330. PMID 39105260.
28. Sulleyman, Aatif (2 November 2017). "Stephen Hawking warns artificial intelligence 'may replace humans altogether'". independent.co.uk.
29. "The value of N remains highly uncertain. Even if we had a perfect knowledge of the first two terms in the equation, there are still five remaining terms, each of which could be uncertain by factors of 1,000." from Wilson, TL (2001). "The search for extraterrestrial intelligence". Nature. 409 (6823).

Nature Publishing Group: 1110–1114. Bibcode:2001Natur.409.1110W. doi:10.1038/35059235. PMID 11234025. S2CID 205014501., or more informally, "The Drake Equation can have any value from "billions and billions" to zero", Michael Crichton, as quoted in Douglas A. Vakoch; et al. (2015). The Drake Equation: Estimating the prevalence of extraterrestrial life through the ages. Cambridge University Press. ISBN 978-1-10-707365-4., p. 13

30. "The Drake Equation". psu.edu.
31. Devin Powell, Astrobiology Magazine (4 September 2013). "The Drake Equation Revisited: Interview with Planet Hunter Sara Seager". Space.com.
32. Govert Schilling; Alan M. MacRobert (3 June 2009). "The Chance of Finding Aliens". Sky & Telescope.
33. [better source needed] Dean, T. (10 August 2009). "A review of the Drake Equation". Cosmos Magazine. Archived from the original on 3 June 2013. Retrieved 16 April 2013.
34. Rare Earth, page 270: "When we take into account factors such as the abundance of planets and the location and lifetime of the habitable zone, the Drake Equation suggests that only between 1% and 0.001% of all stars might have planets with habitats similar to Earth. [...] If microbial life forms readily, then millions to hundreds of millions of planets in the galaxy have the potential for developing advanced life. (We expect that a much higher number will have microbial life.)"
35. von Bloh, W.; Bounama, C.; Cuntz, M.; Franck, S. (2007). "The habitability of super-Earths in Gliese 581". Astronomy & Astrophysics. 476 (3): 1365–1371. arXiv:0705.3758. Bibcode:2007A&A...476.1365V. doi:10.1051/0004-6361:20077939. S2CID 14475537.
36. Selsis, Franck; Kasting, James F.; Levrard, Benjamin; Paillet, Jimmy; ibas, Ignasi; Delfosse, Xavier (2007). "Habitable planets around the star Gl 581?". Astronomy and Astrophysics. 476 (3): 1373–1387. arXiv:0710.5294. Bibcode:2007A&A...476.1373S. doi:10.1051/0004-6361:20078091. S2CID 11492499.
37. Lineweaver, C. H.; Davis, T. M. (2002). "Does the rapid appearance of life on Earth suggest that life is common in the universe?". Astrobiology. 2 (3): 293–304. arXiv:astro-ph/0205014. Bibcode:2002AsBio...2..293L. doi:10.1089/153110702762027871. PMID 12530239. S2CID 431699.
38. Forgan, D. (2009). "A numerical testbed for hypotheses of extraterrestrial life and intelligence". International Journal of Astrobiology. 8 (2): 121–131. arXiv:0810.2222. Bibcode:2009IJAsB...8..121F. doi:10.1017/S1473550408004321. S2CID 17469638.
39. "Are we alone? Setting some limits to our uniqueness". phys.org. 28 April 2016.

40. "Are We Alone? Galactic Civilization Challenge". PBS Space Time. 5 October 2016. PBS Digital Studios.
41. Ward, Peter D.; Brownlee, Donald (2000). Rare Earth: Why Complex Life is Uncommon in the Universe. Copernicus Books (Springer Verlag). ISBN 0-387-98701-0.
42. «Лекции по психоистории» 2019-2020 / "Lectures on psychohistory" 2019-2020 SOCIOSOFT.TB https://www.youtube.com/playlist?list=PLVJKvxv2YVRLvdQROifkNSi8VC710UBUI https://sociosoft.ru/
43. “Aquinas’s Five Proofs for the Existence of God.” In The Catholic Faith Handbook for Youth, Teacher Guide. © 2011 by Saint Mary’s Press. https://www.smp.org/resourcecenter/resource/7061/

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