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Articles

Extraterrestrial Super Intelligence and Energy-and-Resource Control in the Star, Galaxy, and Universe:

Prospect of Ultimate Astro-Green Criminology

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"Every star is surrounded by its own planetary system." Giordano Bruno (1584).
De l'Infinito, Universo e Mondi.

I. Introduction

Why do we go to space? Why do we search for extraterrestrial life, super intelligence, and advanced civilizations?

While the Earth's supply of non-renewable resources such as coal and oil only dwindle, the global demand for energy only increases. Eventually, the nations of the world will need to seek serious alternatives to traditional primary energy sources, and solar energy is a foremost contender to be the most long-term, stable solution. Paired with the maturation of modern material technologies, a growing environmental drive towards sustainable energy sources has brought the possibilities of large-scale harvesting of solar energy into the spotlight (Wee).

The world should cooperate for a fruitful expenditure of research and goodwill to invest in far-flung futuristic energy solutions: the utopian dream of ultimate space-based solar power. Now research is slowly advancing towards the realization of space-based solar power. It is in space that the secrets of sustainable energy lie, and there exists a glimmer of hope for future of human energy (Wee).

It is supposed that extraterrestrial civilizations have intelligence and technique to effectively use space-based solar power and other sustainable energy, which is not yet known for us. In this article, in order to get suggestions for controlling sustainable energy and resources, concepts and researches concerning extraterrestrial civilizations are examined: Fermi Paradox, Drake Equation, Dyson Sphere, Kardashev Scale, and Energy and Resources Control by Extraterrestrial Intelligence.

II. Fermi Paradox and Drake Equation

1. Fermi Paradox: 'Where is everybody?'

Enrico Fermi, Italian-born later naturalized American physicist, asked why humankind has

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not been contacted by any extraterrestrial civilization yet. The origin of the Fermi Paradox (The Great Silence) was a lunchtime conversation between Fermi and some of his colleagues at Los Alamos. They were discussing the possibility of the existence of alien societies and whether travel at above the speed of light was achievable. This led Fermi to ask the question: "Where is everybody?" What seems like an innocent question at first has major implications for the search for extraterrestrial intelligence (Petrikowski 82, 92).

The idea that there are worlds outside Earth which may be inhabited has existed throughout the history of human beings, Webb, G. explains. However, Fermi was the first to voice the problem posed by the absence of evidence of intelligent aliens on Earth clearly and with some reason. Since he had been a major player in bringing about the nuclear age, the first time in history that human could see how the power necessary for interstellar travel could be generated, it was but a short step for a man of his caliber to spot the vital question 'where is everybody?' However, the term 'Fermi Paradox' was not coined until later when the evidence for absence had begun to build and a convenient way of referring to the problem was needed. The paradox is stated that there should be evidence of intelligent, star-faring, communicative aliens and there is not (Webb, G., 198; Gray 2015; Hart).

Webb, G. continues that the paradox usually provokes 'why' and 'how': Why should there be aliens? How do we know there are no aliens? The first is mainly addressed by pointing to human civilization as a typical development of intelligent star-faring life and the second by the increased amount of astronomical evidence which would seem to indicate that the conditions necessary for the development of civilizations such as our own are common throughout the universe. We cannot say for sure that intelligent technically capable beings do not exist elsewhere in the universe (Webb, G., 198; Webb, S.).

Armstrong and Sandberg explain 'intergalactic spreading of intelligent life and sharpening the Fermi paradox'. The Fermi paradox is the discrepancy between the strong likelihood of alien intelligent life emerging and the absence of any visible evidence for such emergence. Traveling between galaxies, indeed even launching a colonization project for the entire reachable universe, is a relatively simple task for a star-spanning civilization, requiring modest amount of energy and resources. Humanity itself could likely accomplish such a colonization project in the foreseeable future. Given certain technological assumptions, such as improved automation, the task of constructing Dyson spheres, designing replicating probes, and launching them at distant galaxies, become quite feasible. There are millions of galaxies that could have reached us by now. This results in a considerable sharpening of the Fermi paradox (Armstrong and Sandberg; Ćirković 2018; Matloff; Besteiro; Brandt *et al.*; Tegmark).

2. Drake Equation

1) Definition

Drake Equation is an equation, formulated by Frank D. Drake, American astronomer and astrophysicist, in 1961, used to estimate the number of detectable extraterrestrial civilizations in the Milky Way galaxy (Petrikowski 92). It is used in the fields of exobiology and the search for extraterrestrial intelligence (SETI), King explains. The Drake equation is closely related to the Fermi paradox in that Drake suggested that a large number of extraterrestrial civilizations would form, but that the lack of evidence of such civilizations (the Fermi paradox) suggests that technological civilizations tend to disappear rather quickly. This theory often stimulates an interest in identifying and publicizing ways in which humanity could destroy itself, and then counters with hopes of avoiding such destruction and eventually becoming a space-faring species (King 75).

The Drake equation states that:

$N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$

where:

N = the number of civilizations in our galaxy with which communication might be possible.

and:

R^* = the average rate of star formation per year in our galaxy

f_p = the fraction of those stars that have planets

n_e = the average number of planets that can potentially support life per star that has planets

f_l = the fraction of the above that actually go on to develop life at some point

f_i = the fraction of the above that actually go on to develop intelligent life

f_c = the fraction of civilizations that develop a technology that releases detectable signs of their existence into space

L = the length of time such civilizations release detectable signals into space (King 76).

2) Elaboration and Criticism

The Drake equation is a very simple model that does not include potentially relevant parameters. Because it is the contact cross-section that is of interest to the SETI community, many additional factors and modifications of the Drake equation have been proposed. These include the number of times a civilization might re-appear on the same planet, the number of nearby stars that might be colonized and form sites of their own, and other factors (King 77; Molina).

Criticism of the Drake equation follows mostly from the observation that several terms in the equation are largely or entirely based on conjecture. Another objection is that the very form of the Drake equation assumes that civilizations arise and then die out within their original solar systems. If interstellar colonization is possible, then this assumption is invalid, and the equation of population dynamics would apply instead. One reply to such criticisms is that even though the Drake equation currently involves speculation about unmeasured parameters, it was not meant to be science, but intended as a way to stimulate dialog on these topics. Then the focus becomes how to proceed experimentally. Another reply to such criticism is that the Drake equation is a Fermi problem which involves the multiplication of several estimated factors, and such calculations will probably be more accurate than might be first supposed assuming that there is no consistent bias in the estimated factors. This is because if there is no consistent bias, then there will be probably be some factors that are estimated too high and other factors that are estimated too low, and such errors will partially cancel each other out (King 77, 83; Vakoch *et al.* 2015; Michaud; Hawksett; Loh-Hagan; Al-Khalili).

In short, on the one hand, facing with Fermi's question, many searches for extraterrestrial life have to come up with a different explanation. So one could not come to the conclusion that there are any or there aren't any. On the other hand, although there exist considerable disagreements on the values of most of parameters of Drake equation, they have been pursuing better current estimates for the parameters. This shows the importance and the meaning of Drake equation.

III. Dyson Sphere and Kardashev Scale

1. Installation and Scale of Extraterrestrial Civilization

1) Dyson Sphere and Dyson Swarm

In 1960 Freeman J. Dyson, English-American theoretical physicist and mathematician, proposed Dyson sphere, which describes an immense artificial construct orbiting a star, with the capability to capture its light and convert it to useful forms of energy (Dyson), Wee explains. Originally he envisioned a gargantuan spherical shell that would completely encapsulate the star and soak up all its light. While this idea has been popularized within the scientific community, in the genre of science fiction it is enthusiastically portrayed. However, such an idea was required to be preclude from being efficient by the physics of orbital mechanics and the veritable planet-sized mass of materials (Wee).

The Dyson swarm is the most realistic and feasible variant of the Dyson sphere, Wee continues. Such an installation is depicted as a constellation of man-made satellites in orbit around a star. The basic dynamics of this orbital arrangement are similar to how the Earth and other planets revolve around the Sun, however, at a much closer distance and with many more elements. This conjures up the image of a swarm of honey bees defending their hives. Each of these satellites would have solar panels to collect the Sun's radiation, both visible and invisible, and transmit this energy wirelessly back to Earth, where it would be intercepted and used. This setup would cause the Sun to be slightly eclipsed each time a satellite passes, causing fluctuations in light. This line of justification has led to renewed research media speculation as to the possibility of alien megastructures, built by some advanced civilization in the past, which could be some variation of Dyson's initial postulate (Wee).

2) Kardashev Scale

Although the idea of converting solar rays into energy to power our homes and fuel our industries is by no means novel, but the degree to which an advanced civilization might be able to use a star's energy has been a longstanding thought experiment among astronomers and searchers of extraterrestrial life. In 1964, Nikolai S. Kardashev, Russian astrophysicist, proposed that a civilization's level of technology is inevitably tied to its energy consumption, and civilizations could be classified by the sheer magnitude of energy they generated (Kardashev 1964; Kardashev 1985). According to his metric, while Type I civilization would be able to fully utilize all the resources available on its home planet, a Type III civilization would be capable of harnessing the energy of its host galaxy. The Type II civilization, intermediary stage, is defined as being able to harvest the total energy output of its parent stars, by means of a Dyson sphere of some form (Wee).

Humanity barely qualifies as a Type I civilization by the most lenient of criteria, Wee continues. As the solar activity of our Sun is estimated to remain stable for the next five billion years, compared to the finite and rapidly diminishing resources on Earth, the Sun would appear to be a limitless supply of energy that we have just begun to tap into. Currently, most of solar radiation is blasted uselessly into space; less than a billionth of the total energy output by the Sun reaches the face of the Earth. If we could harness but one part of a millionth of that energy, we would have the energy equivalent of the total energy consumption of the modern world for an entire year (Wee).

2. Not Energy Consumption But Energy Transformations

1) Criticism against Kardashev Scale

Frank, A. criticized Kardashev Scale that we should change the standards of civilizations from 'energy consumption' to 'energy transformation'.

Kardashev was raised on the techno-utopian vision of the future. Technology was imagined in terms of sleek, gleaming machines that were destined to be humanity's salvation. Technology's growth and power would be unconstrained. That was why the Kaldashev scale focused only on energy. Civilizations were expected to rise up the ladder of energy harvesting to ever-greater heights until the entire galaxy would become a resource to be mined. At each stage, the feedback from all this energy use on the physical systems from which the energy was drawn could be ignored (Frank 212).

From the work of Lovelock, Margulis, and others, a new scientific understanding of planets and life emerged. Even when they lack life, planets are complex systems. If a vibrant biosphere is present, it becomes part of that complex whole. The living and non-living parts of the system coevolve across time. In this way, the coupled systems that make up a planet have their own internal dynamics. Those dynamics must be fully embraced when mapping out the trajectories of civilizations (Frank 213).

It is not simply energy consumption but also energy transformation that must be considered. We need to look at those physical laws that constrain energy as it flows through a planetary system. Recognizing the limits on energy transformation is the fundamental lesson of the Anthropocene. We can't use energy to build a civilization without expecting feedback. Instead, we must understand biospheres and civilizations as part of the coupled planetary systems. The development of long-term, sustainable versions of an energy-intensive civilization must be seen on a continuum of interactions between life and its host planet. Sustainable civilization must enter into a long, cooperative relationship with their coupled planetary systems (Frank 213–214).

2) Hybrid Planet

The evolution of a planet across billions of years depends on which processes it can harness to absorb starlight and transform that energy into something else, Frank continues. The story of planetary evolution across cosmic time is the story of these energy transformations (Frank 214).

The relationship between complexity, work, and energy flows make us understand what a sustainable civilization might look like. A planet with a sustainable civilization might be even more adept at wringing work and change out of sunlight. The civilization not only harvests more energy but also figures out how to put this energy to work in ways that do not push the planet into dangerous territory. Now the civilization is deliberately working with the rest of the natural systems to increase the flourishing and productivity of both itself and the biosphere as a whole (Frank 219).

Our activity and choices are strongly modifying the state of the biosphere and other planetary systems. However, we are making these changes without a long-term plan. We are evolving the planet toward something new, but we can't say if that novel state will include us in the long term. Now it is a hybrid world. It's evolving toward something other than it was, and it's doing so in a way that's dangerous for our project of civilization (Frank 220).

In short, we must understand not only extraterrestrial civilizations but also planets, celestial bodies, and galaxies as complex systems which consist of lots of complicated factors. It is important to clear the relationship between these factors and make a new realistic classification of extraterrestrial civilizations which includes their dynamic reality.

IV. Energy and Resource Control by Extraterrestrial Super Intelligence

1. Review of Kardashev Classification

Ćirković reviews the history and status of the classification of extraterrestrial civilizations given by Kardashev, roughly half a century it has been proposed. While Kardashev's classification (Kardashev scale) has often been seen as oversimplified, and multiple improvements, refinements, and alternatives to it have been suggested, it is still one of the major tools for serious theoretical investigation of SETI issues. During over last fifty years, several attempts at modifying or reforming the classification have been made. Recent studies in both theoretical and observational SETI studies, especially Ĝ infrared survey, have persuasively shown that the emphasis on detectability inherent in Kardashev's classification obtains new significance and freshness. Several new movements and conceptual frameworks, such as the Dysonian SETI, tally extremely well with these developments. Although the apparent simplicity of the classification is highly deceptive, Kardashev's work offers a wealth of still insufficiently studied methodological and epistemological ramifications and it remains the worthiest legacy of the SETI 'founding fathers' (Ćirković 2015; Wright *et al.*).

Rethinking Kardashev's classification should have a salutary effect in this area, Ćirković insists. The truly important issue, following the null result of the Ĝ search for Type III civilizations, is whether Type II.x civilizations are detectable from a range of realistic distances, intragalactic as well as intergalactic. This challenge for innovative, imaginative, creative, and bold SETI will remain open for at least a couple of decades to come. Among other things, it will help understanding the prospects and pitfalls of the future of humanity itself, hopefully contributing to a new ecological and ethical consensus necessary for the long-term survival and prosperity of our species (Ćirković 2015, 13; Wright *et al.*; Vidal; Gray 2020; Smith *et al.*; Lupisella; Inglezakis; Tabas; Anker; Takemura 2019; Takemura 2012; Takemura forthcoming).

2. Further Development of Kardashev Scale

1) Qualitative Classification

Ivanov, Beamín, Cáceres, and Minniti propose a classification based on the abilities of ETCs to modify their environment and to integrate with it: Class 0 uses the environment as it is, Class 1 modifies the environment to fit its needs, Class 2 modifies itself to fit the environment, and Class 3 ETC is fully integrated with the environment. Combined with the classical Kardashev's scale their scheme forms a 2-dimensional scheme for interpreting the ETC properties (Ivanov *et al.*).

The most obvious advantage of their proposition is the novel way of thinking about the ETC: the question of how the available energy is used and what is its impact on the interaction with the matter in the Universe. First, the realization that the footprint of an ETC and its detectability – both dominated mainly by the energy – may not scale up with the available energy. Second, the available amount of energy does not necessarily mean a more sophisticated interaction with matter and closer integration with the environment. Furthermore, it is uncertain whether we can expect that more available energy would only scale up our ability to modify the environment. In other words, we still lack the understanding whether the building of a Dyson sphere is just a matter of having more powerful mining equipment and heavier rockets or of some speculative technologies like nano-machines, selfreplicators, etc. In the former case the total amount of available energy may play a role, but in the latter – less so, hereby removing any correlation between the two ETC scales described here. The complexity is not directly related to the available energy (Ivanov *et al.* 4–5).

The new framework leads to questioning the common assumption that progress is equivalent to ascending the ladder of energy consumption from Class I to III, as suggested by Dyson (1960) even before Kardashev came up with his classification. Indeed, an ETC can progress from purely mechanical modification of its environment to more complex manipulation on chemical, atomic, nuclear, etc. levels that allow it to achieve larger impacts and more importantly, impacts that were not possible earlier with the simpler levels of interaction. However, this is not necessarily accomplished by an ever increasing energy consumption (Ivanov *et al.* 5).

To sum up, the new framework makes it obvious that the available energy is not a unique measure of ETCs' progress, it may not even correlate with how well that energy is used. The possibility for progress without increased energy consumption implies a lower detectability, so in principle the existence of a Kardashev Type III ETC in the Milky Way cannot be ruled out. This reasoning weakens the Fermi paradox, allowing for the existence of advanced, yet not energy hungry, low detectability ETCs. The integration of ETCs with environment will make it impossible to tell apart technosignatures from natural phenomena. Therefore, the most likely opportunity for SETI searches to find advanced ETCs is to look for beacons, specifically set up by them for young civilizations like ours (Ivanov *et al*.; Vakoch ***et al.*** 2013; Vakoch 2011).

2) Long Future and Type IV Civilization

Galántai simply criticizes Kardashev Scale as follows: Kardashev's typology is based on a belief that we can categorize super civilization by their energy consumption. On the one hand we can imagine an advanced civilization which conquers either its own solar system or its galaxy without reaching the second or third level of the Kardashev Scale. On the other hand it will be impossible to build a civilization which can harness the energy of an entire galaxy, unless we discover new physical laws. So it is reasonable to create a new typology which is based on the possible special extents of an advanced civilization (Galántai 2006).

Moreover, Galántani offers important questions concerning Type IV civilizations. Neither Kardashev nor his followers (nor Carl Sagan) introduced a fourth category for those who can manage the energy of a whole universe, although it would be theoretically the ultimate possibility at all. They did not envision a civilization manipulating their environment on the highest possible scale. Although it is possible to imagine a universe where a Type IV civilization can use all power sources to convert matter into radiation to create an open universe instead of a closed one, it is hard to believe that a superior civilization can coordinate all the needed tasks. Nobody demonstrated the possibility of an all-embracing realm up to the present day, so it is possible that Kardashev was right to eliminate the opportunity of the creation of a Type IV civilization (Galántai 2004, 85, 87).

The hypothetical appearance of a Type IV civilization could result the change of the nature of natural science and especially the nature of cosmology, Galántai continues. As soon as an intelligence can affect the fate of the Cosmos, this new parameter have to be taken into consideration. The expansion of a technical civilization leads to a change of its environment. Kardashev created his taxonomy to identify the possible targets of the search for extraterrestrial civilizations, but it is indifferent from a cosmic point of view, whether we are on a level of a Type I or of a Type III civilization. The only important question is whether we have the power to influence the future of the entire Universe. Our ultimate possible aim is to become a Type IV civilization (Galántai 2004, 87–88; Bostrom).

Kardashev categorized the civilizations on their accessible energy sources, regarding them as their most important and most characteristic features. But Dyson pointed out that an open universe need not evolve into a state of permanent quiescence. Life and communication can continue forever, utilizing a finite store of energy. That is to say, not only the available power has a vital role in an intelligence's survival in the long run. So why not to prefer classifying civilizations on their ability to manage short or long projects? But it would take a long time. Therefore it's time to start thinking about a long time scale interpretation of our human future (Galántai 2004, 88–89).

According to Baker, a crucial question for practitioners of Big History is whether we should expect a continuation of increasing complexity or a deceleration or collapse of complexity in the Near Future. The 'future sections' of the majority of high-profile Big History narratives predominantly paint a binary between catastrophe and a green sustainable future. A minority of big historians have explored what technology and society could look like if complexity does continue to rise. Yet for greater specificity about what that Near Future may look like, we must go beyond disorganised speculation based on technological trends, fads, and rhetoric. Not to mention our own wishful inclinations. Complexity is understood in very broad and general terms, but a more detailed understanding of what complexity is, what its variables are, how it can be measured, and how it changes, will give us a more detailed view of complexity in the future. In essence, with more data on the pattern comes a greater ability to make stronger projections. This is where a more structured approach involving strategic foresight and complexity studies will allow us to profile the Near and Deep Future with a great deal more clarity (Baker).

In short, although more than 50 years have passed since the Kardashev scale was proposed, influential discussions for theoretical fineness have been continuing. The Kardashev's scale will continue to be important for searching for the existence of extraterrestrial civilizations, the reality of their complex systems, and their control mode of energy and resources.

V. Conclusions

Extraterrestrial life is defined as life that does not originate from Earth. It is unknown whether any such life exists or ever existed in the past. Various claims have been made for evidence of extraterrestrial life. A less direct argument for the existence of extraterrestrial life relies on the vast size of the observable Universe. According to this argument, endorsed by Carl Sagan and Stephan Hawking, it would be improbable for life not to exist somewhere other than Earth (King 1).

There are many different reasons why a technical civilization should not be expected to last forever. Assuming that extraterrestrial civilizations have indeed been formed in our Galaxy, the number of them that currently exist must depend on their various lifetimes. If lifetimes are generally short, technical civilizations will flare briefly into existence, only to wink out before encountering any others or advancing beyond the Kardashev Type I level. If civilization can avoid the many pitfalls that await them and last as long as their suns remain stable, there could be aliens scattered all over the Galaxy just waiting to be discovered (Pierce 186; NASA History Office *et al.*; Ashkenazi; Boss; Bruno).

Selecting a value for the lifetime of an average technical civilization (L) to use in the Drake equation is not an easy task. We can only guess which of the many fates will be most likely to limit our reign over this planet, assess the degree to which these fates will be lethal, and estimate a time frame in which they might occur. As for alien civilizations, we cannot know exactly what dangers they might face, but if they have evolved around a star similar to ours, on a planet similar to ours, by processes similar to ours, using atoms and molecules similar to ours, they should be subject to many of the same limitations as we have listed for ourselves (Pierce 187).

Theoretical physicist Stephen Hawking warned that humans should not try to contact alien life forms. He warned that aliens might pillage Earth for resources. "If aliens visit us, the outcome would be much as when Columbus landed in America, which didn't turn out well for the Native Americans," he said (King 15; Vakoch 2014).

However, if we can get suggestions to control sustainable resources and energies from considering concepts and researches concerning extraterrestrial civilizations, the reality of their complex systems, and their control mode of resource and energy, we will be clever and fortunate and may survive for another million years.

[Notes]

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