DYSON SPHERE RESEARCH PAPER

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ABSTRACT

Dyson sphere is a theorem that will be very difficult to realize. In this article, we will give information about the Dyson sphere. Technology is developing in order to meet the increasing need and a lot of energy is used as a result of this development. As people grow and technology evolves, our energy needs are increasing. This level of development is called the Type 1, Type 2, Type 3 civilization level. Each of these civilization levels has energy needs. Scientists are doing research on this subject. The largest and cleanest source of energy we can get is now the Dyson sphere. The Dyson sphere has a flawless design to meet all your energy needs.

INTRODUCTION

Originally proposed by the legendary physicists, Freeman Dyson, Dyson remains one of the most exciting theoretically proposed ideas in the world of astrophysicists today. The idea came to Dyson after reading the 1937 novel Star Maker. In an article dated 1960, Dyson proposed an article in Science magazine entitled 'Search Artificial Star Sources of Artificial Infrared Radiation'. He described a superstructure built near or near the sun, which could capture the energy of the Sun and return it to Earth. Even if this happened, the Sun would not have to rely heavily on fossil fuels or other existing energy sources, even with only a part of the energy civilization. [1]

Defenders of solar energy know that only a small part of the total energy of the sun strikes the Earth. What if we collect all the solar energy as a civilization? So, sometimes we used a kind of Dyson sphere called the Dyson shell or structure. Freeman J. Dyson, a physicist and astronomer, first discovered this idea as a thought experiment in 1960. Advanced civilizations in our galaxy would inevitably use. Dyson argued that the search for evidence of the existence of such structures could lead to the discovery of advanced civilizations elsewhere in the galaxy.

In recent years, astronomers explored that possibility with a bizarre star, known to astronomers as KIC 8462852 – more popularly called Tabby's Star for its discoverer Tabetha Boyajian. This star's strange light was originally thought to indicate a possible Dyson sphere. That idea has been discarded, but, in 2018, other possibilities emerged, such as that of using the Gaia mission to search for Dyson spheres. [2]

WHO IS FREEMAN J. DYSON?

With this idea, we will give information about the Freeman Dyson who shaped the world of science. Who is Freeman Dyson? What are the achievements?

Freeman Dyson is now retired, having been for most of his life a professor of physics at the Institute for Advanced Study in Princeton. He was born in England and worked as a civilian scientist for the Royal Air Force in World War II. He graduated from Cambridge University in 1945 with a B.A. degree in mathematics. He went on to Cornell University as a graduate student in 1947 and worked with Hans Bethe and Richard Feynman. His most useful contribution to science was the unification of the three versions of quantum electrodynamics invented by Feynman, Schwinger and Tomonaga. Cornell University made him a professor without bothering about his lack of Ph.D. He subsequently worked on nuclear reactors, solid state physics, ferromagnetism, astrophysics and biology, looking for problems where elegant mathematics could be usefully applied.

Freeman Dyson at the Long Now Seminar, San Francisco, October 5, 2005.
Photo by Jacob Appelbaum/Wikimedia Commons.

He has written a number of books about science for the general public. "Disturbing the Universe" (1979) is a portrait-gallery of people he has known during his career as a scientist. "Weapons and Hope" (1984) is a study of ethical problems of war and peace. "Infinite in All Directions" (1988) is a philosophical meditation based on Dyson's Gifford Lectures on Natural

Theology given at the University of Aberdeen in Scotland. “Origins of Life” (1986, second edition 1999) is a study of one of the major unsolved problems of science. “From Eros to Gaia” (1992) is a collection of essays and lectures, starting with a science-fiction story written at the age of nine, and ending with a mugging in Washington at age fifty-four. “Imagined Worlds” (1997) is an edited version of a set of lectures given in 1995 at the Hebrew University in Jerusalem about human destiny, literature and science. “The Sun, the Genome and the Internet” (1999) discusses the question of whether modern technology could be used to narrow the gap between rich and poor rather than widen it. “The Scientist as Rebel” (2006) is a collection of book reviews and essays, mostly published in The New York Review of Books. “A Many-colored Glass: Reflections on the Place of Life in the Universe” (2007) is an edited version of a set of lectures given in 2004 at the University of Virginia. Dyson is a fellow of the American Physical Society, a member of the U.S. National Academy of Sciences, and a fellow of the Royal Society of London. In 2000 he was awarded the Templeton Prize for progress in Religion, and in 2012 he was awarded the Henri Poincaré Prize at the August meeting of the International Mathematical Physics Congress. [3]

What’s Nikolai Kardeshev’s Scale and harmless energy?

The scale developed by Nikolai Kardashev in 1964 categorizes the level of development of a civilization according to the amount of energy produced and the method of production

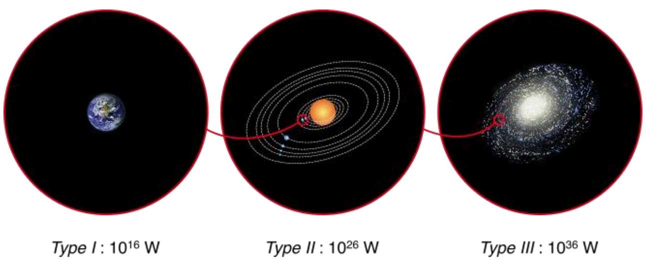


Fig1. Nikolai Kardashev Scale

According to this scale, the level of civilization in the universe is divided into three. These are Type 1, Type 2 and Type 3. These levels of civilization are developing in direct proportion to energy use and energy needs. In the Type 1 civilization, which we are in, but we do not fulfill the requirements, we must use all clean energy sources on the planet in a way that will not harm the human and nature. To be at type 1 civilization level, we must be able to use all the clean energy sources in the world and to be able to convert the energy from the stars to the electric energy. But at present, we provide more than half of the energy required by our planet from fossil fuels. Serious predictions of fossil fuels will be exhausted in 2050. After the fossil fuels are exhausted, the use of clean energy sources will increase and then these clean energy sources will not be enough for us due to the results of developing technology. Most people say that if clean energy sources are insufficient, they can close this gap with nuclear power plants. But they are connected to the elements in the world in nuclear power plants. These elements are uranium, thorium. If one day will end in these elements, we can see the world expecting troublesome days about energy.

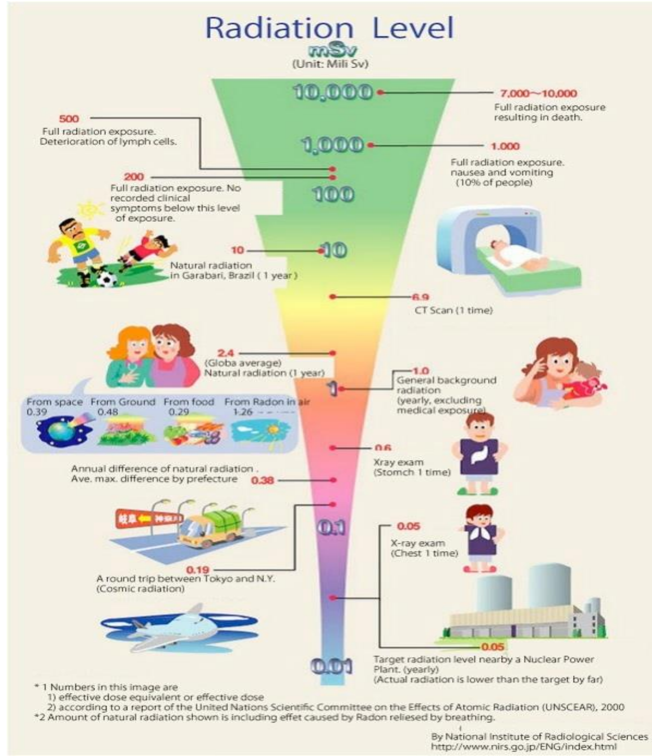


Fig2. Radiation Level in Daily Life

In addition, we must take into consideration that we must not harm nature and human beings while producing our energy to achieve Type 1 civilization level. Figure 2 below shows the amount of radiation in daily life. Nuclear power plant accidents until the time we have shown in Figure 3.

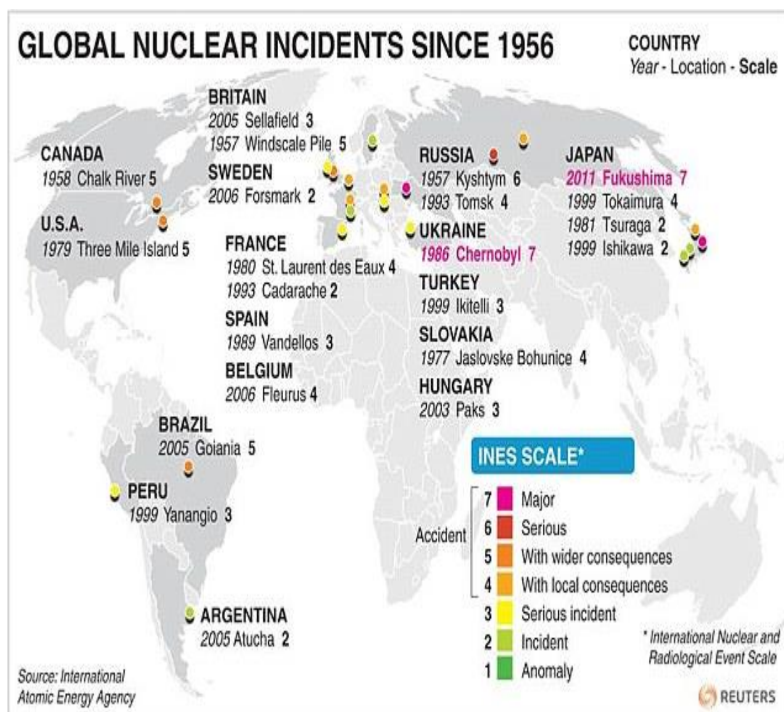


Fig3. Nuclear Power Plant Accidents

Even if the energy obtained from nuclear energy is too much, it cannot meet the requirements of Type 1 civilization level.

What will happen after completing the Type 1 civilization level?

Type 2 level of civilization is a level where the energy resources on the planet are not enough and now a different energy source works. Different types of resources are needed in Type 2 civilization and these are the other planets close to our planet and the sun and stars in the center of our planet's system.
A fictional Dyson Sphere. Such a structure surrounds the entire star and can make use of all the energy it produces. Type 2 civilizations will most likely find ways to use all the energy of their stars with the help of a Dyson Sphere (or similar) technology. They are civilizations that can collect all the energy emitted by their star, for example, a civilization that can build a Dyson sphere. They can collect up to 4 x 1033 erg / sec (4 x 1026 watts) of energy, which is all the energy we can get from the Sun. Alternatively, the fusion power of the star can be used as a large-scale reactor to meet the needs of this civilization [4].
In type 3 civilizations, biological vitality will be intertwined with technology. In such civilizations, it can be very difficult to define the vitality.
Using all of the energy produced by the galaxy in which they exist, these civilizations dominate such energy as 4 × 1044 gig / sec (4 x 1037 watts). They can colonize the galaxy, extract energy from hundreds of millions of stars, hover in interstellar space and capture countless planets.

For people, access to such a species means hundreds of thousands of years of evolution, both biological and mechanical. People who are purely biological are likely to be seen as defective, inferior or non-inverted by their cybernetic companions [4].

How will the Dyson sphere will be possible?

The suggested example of using these energy sources is the Dyson sphere. The Dyson sphere is first shown as a subject in the series and films, but later scientists realize that there is something that can be done by working on it. In order to make the Dyson sphere a perfect engineering, we need to discover new materials for our perfect spacecraft to be able to make our production base on another planet, the materials in the world, not enough materials. First, the dyson sphere is designed to turn around the sun, but the gravitational law will not allow it. The Dyson sphere has the same importance as our ancestors by exploring the fire and making the technological leap. So how do we design the Dyson Sphere? For the Dyson sphere, we can do it perfectly with satellites and a series of optical panels that we will send into the orbit of the sun.

The aim of the hypothesis is building huge structure to harness 100% of its energy and also living on it. The structure's building block is special block, which can transform one star's whole power to useable energy for us. The mass required for the construction of the Dyson Sphere is

$$M = \rho 4\pi r^2 t$$

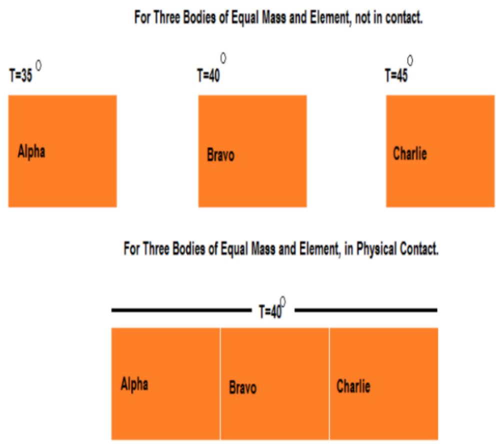
where ρ is the density of the material of the Sphere and t its thickness. For Earth-like density, radius of 3 × 106 km and thickness of 1 meter, we find a mass of ∼ 6 × 1023 kg, slightly less than the mass of the Moon! Obviously, this is a small fraction of the usable mass in the solar system, and the mass of one terrestrial planet will easily give a 10 m-thick shell, so that the inhabitants will not worry very much about accidentally puncturing it. "d" with natural infra-red sources in the same part of the sky.

What is the Temperature of Space?

Regarding the fact that space is part of space/time and they are inseparable, such a question asked as per this chapters titular is as useful as asking:
So, I refer to "space" in the following further examples as a term for outer space in vacuo and extra-planetary events unless stated otherwise. To investigate the thermal energy transfer possibilities of a Dyson Sphere, one must first ask:
Following the zeroth law of thermodynamics, for a systems temperature to be measured, a thermometer works by being in physical contact with the matter being observed and then taking the temperature of the connected matter with either mercury in the system, thermal sensors or thermistors should electronic readings wish to be taken. Essentially when using a thermometer or temperature sensor, the reading you obtain is the temperature of the thermometer/sensor itself when it has reached thermal equilibrium within an enclosed system, so to measure the temperature of "space" is quite nonsensical in its question (disregarding the occasional radiating particle collision).

As the zeroth law of thermodynamics states, heat can be transferred via a system of bodies that are within physical contact. I shall describe The Zeroth Law here in a basic model.
If you have a system of three bodies of mass, for this example we will call them "Object Alpha", "Object Bravo" and "Object Charlie" for references sake, the following scenario shall describe the zeroth law in effect. If "Object Alpha" is in physical contact with "Object Bravo", but not in physical contact with "Object Charlie", if "Object Charlie" is also in physical contact with "Object as the thermal energy (heat) transverses via the atomic structure and molecules of each object and thermally excites the connecting molecules and thus transfers energy in the system, this zeroth law of thermodynamics is very easily observed on Earth but in the imperfect vacuum of open space, there is less solid matter combined in contact than here on Earth (in regard to the vastness of the known universe).

This diagram represents heat transfer via the zeroth law of thermodynamics to help visualise the zeroth law in motion:



The Dyson Sphere
A Dyson Sphere is a hypothesised extra-terrestrial megastructure that was used to solve the question of "What if alien civilisations do not wish to communicate?".
Two curious Professors Cocconi and Morrison at Cornell pondered this question and came to the conclusion that radio signals in space should be searched for (Morrison and Cocconi, 1959), and ultimately this lead to the creation of SETI (Search for Extra-terrestrial Intelligence) when Frank Drake at The Green Bank Observation began his search in a project he named Project Ozma, in Drakes words he wrote, "It is named for the queen of the imaginary land of Oz, a place very far away, difficult to reach, and populated by exotic beings" (Drake, 1959).

The Howard Tatel telescope

Fig4. National Radio Astronomy Observatory,1959

In 1960 Professor Freeman Dyson proposed that it was indeed possible, and if such a civilisation were to exist it would be one of extraordinary capability when it came to the use and harnessing of energy for work, also to contain radio emissions it must be an enclosed system for total isolation, but due to the laws of thermodynamics, the civilisation that created the hypothesised Dyson Sphere and using such large flows of energy, whether or not it wished to communicate with other species it would have no choice via the laws of thermodynamics but to dispose of waste heat, this heat must then be radiated into space in the form of infra-red radiation. Dyson then proposed that uncommunicative civilizations could possibly be detected from sources of infra-red radiation emitted from the gravitational wells surrounding the mass of a star if they used a flow of energy large enough when compared with natural infra-red sources in the same part of the sky.

Per Kardashev's Scale, a civilisation that can create a Dyson Sphere and harnessing all of a star's energy would be categorised as a Type 2 civilisation.

Sun to Earth Scale

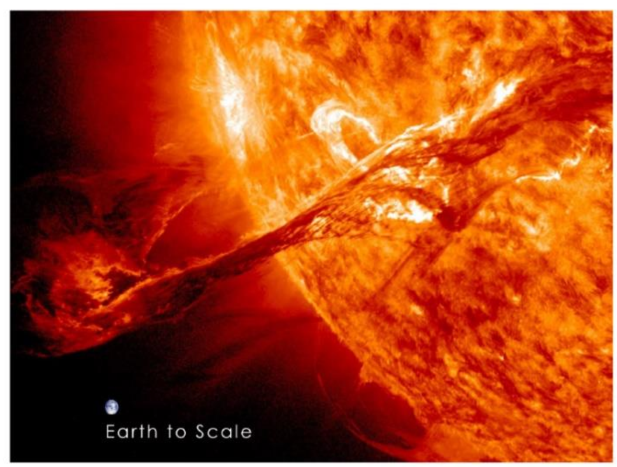


Fig5. Earth to Scale,NASA,2013

Due to the tremendous scale of a living stars size and the energy output in its various states of nuclear fusion, the civilisation that created such a megastructure to encompass an entire star would need to use a dense material that is capable of supporting itself under the massive gravitational pull of the host star, as the amount of photons striking the inner surface of the sphere would also be contained, this will almost certainly require an outlet for such pressures and energy in order for the structure to maintain its integrity without collapsing.

There is also the factor of volumetric expansion per the material used in the spheres construction material, the formula:

$$\Delta V = \beta \Delta T$$

explains that per the materials coefficient of linear expansion (multiplied by 3 for volumetric

expansion), when used in combination with the zeroth law of thermodynamics that there will be waste heat that leaves the structure itself, as it will eventually reach thermal equilibrium as this is what the universe strives for.
I will hypothetically speculate on the possibilities of heat transfer via the sphere, and apply the laws of thermodynamics to the hypotheses of Kardashev and propose that there may be other viable methods of detection, should such an object exist. If there is a sealed Dyson Sphere with an area exact of our stars (taking the exact measurement and not leaving space in-between for a more direct measurement), the area of the star would be 6,078,747,774,547 km^2 and by using Dennis L. Mammana's pre-stated measurement that there is one atom per cm^3 in "empty" space, if we convert that to metres we reach:

$1\ m^3 = 1{,}000{,}000\ cm^3$

Now taking the area of an atom, using the model used mainly in particle and quantum physics of 1×10^{-12} m, or one trillionth of a metre (Mark Winter, 2014), and multiplying it by 1,000,000 cm^3. We have an area of space filled with $1x10^{-6}$ m of atoms per cubic metre, when this is multiplied by the area of the outside wall of the hypothetical Dyson Sphere it would mean that there are potentiall of the individual atoms combined area colliding with the outside sphere at any stage.
As heat flows from hot to cold, a cold reservoir must be maintained, if this were to be within a 100% sealed Dyson Sphere, eventually the gaseous content and energy within the sphere will reach thermal equilibrium, everything will be at the same temperature and no useful.

If you think of a heat engine (or even electrical as there will be frictional heat) like water flowing down the side of a hill, energy flows from a higher temperature to the lower temperature. It is this flow that an engine converts into useable work.

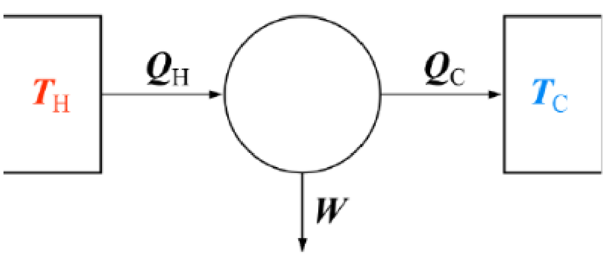


Fig6. Carnot Engine,2014

It does not matter how high the top of the hill is (using the hill height as an analogy to the temperature of the high temperature reservoir), you will only get the amount of work from the elevation of the reservoir (temperature of the sink reservoir (cold)) that the heat flows into.

As per the heat exchange of radiated energy via rays in space, if the star is completely covered by the structure, the radiated energy transferred within the sphere itself would be completely contained, the photosphere is the shell of a star in from which light is radiated, assuming that the Dyson Sphere itself may be just outside the perimeter of a star's photosphere (the deepest region of a luminous object).

The physicist and natural philosopher Ludwig Boltzmann along with the theoretical physicist Max Planck theorised that every physical body of mass will spontaneously and continuously emit electromagnetic radiation, this is known as Black Body Radiation, and as such Boltzmann theorised that the sun emits in the region of 5700 K at the photosphere (Ces.fau.edu, 2016), this is a very high temperature and as such, should a Dyson Sphere contain said energy, supporting life without a vent once it reached thermal equilibrium seems unfitting when the models for life are based on "The Goldilocks Zone", or "Not too hot, not too cold." (NASA, 2003).

White Dwarfs, Life and Dyson Spheres

It is well-known (see any introductory astronomy textbook) that stars are classified by using the so-called Hertzprung-Russel (HR) diagram, where each star is represented as a point in the absolute magnitude-spectral class (i.e. Luminosity-Surface Temperature) plane. The stars are not distributed uniformly on that plane but come in three main groups (Fig. 2). The diagonal band is called the main sequence, the group at the lower left are the white dwarfs, and the group roughly upper right are red giants. The names are appropriate: temperature decreases to the right, and high temperature stars are blue-white, low temperature stars are red. Also, the luminosity of a star in terms of its radius, and surface temperature is given by

L = 4πR2σT4

so we have

R ∝ √ L T2

therefore radius increases from the lower-left to upper right.

It turns out that these three groups represent evolutionary stages in the life of a star. The main sequence consists of stars fusing hydrogen, whereas the red giants are stars who have ended their main-sequence life and now are fusing higher elements at furious rates, white dwarfs are lower mass stars that have exhausted the possible fusion reactions and are slowly cooling by radiation. The white dwarfs represent one of the three possible end-states of stellar evolution, the other two being neutron stars and black holes.

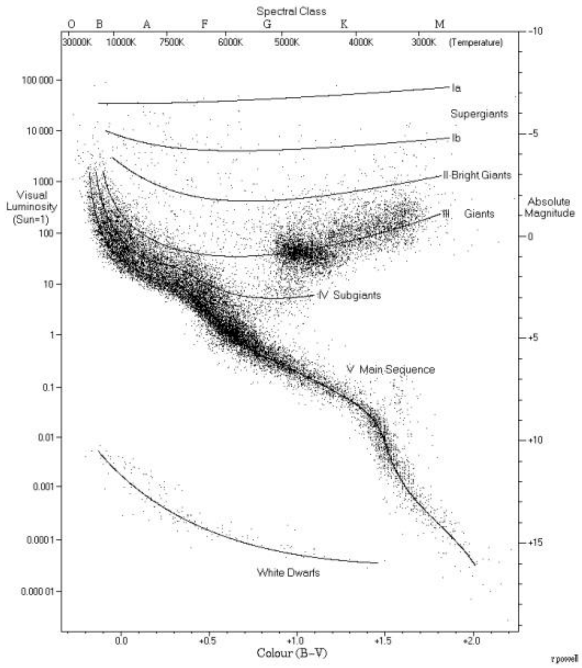


Fig7. The Hertzsprung-Russel Diagram.

Figure: The Hertzsprung-Russel (HR) diagram for a representative sample of stars; 22000 stars from the Hipparcos Catalogue together with 1000 low luminosity stars (red and white dwarfs) from the Gliese Catalogue of Nearby Stars. Adapted from Richard Powell via Wikipedia.

Stars with masses of up to approximately 4 solar masses will eventually become white dwarfs. The limit is uncertain, since stars eject some mass into space during the red giant stage, and the criterion is the mass that remains. Even then, rotation makes a difference, but a non-rotating star will turn into a white dwarf if the remaining mass is less than the Chandrasekhar mass limit which is 1.4 solar masses.

Presumably, conditions should stay consistent for a relatively long time for life to flourish and diversify; extreme deviations result in mass extinctions. Also, presumably, intelligence arises only after a long process of evolution. Since the main-sequence lifetime of a star is roughly proportional to the inverse cube of its mass, one would expect the stars of most planetary systems harboring intelligent life to eventually end up as white dwarfs. If interstellar travel is fundamentally problematic, e.g. due to energy requirements –kinetic energy of a relativistic spaceship must be several, maybe tens of times its rest energy– or the vastness of interstellar distances implying one way or generations-long trips, building a Dyson Sphere around the newly formed white dwarf might be the natural way of sustaining the existence of the civilization.

Actually, the red giant stage is also quite long, about a billion years for a solar-mass star (it decreases with mass), so it might seem that life/intelligence/civilization could also develop during that stage. However, conditions like radiative flux and stellar wind, even the mass of the star, are quite variable during the red giant phase, as opposed to the main-sequence period, when they are stable. Hence, while the astronomically-long-term outlook of an intelligent civilization is subject of conjecture, a civilization set to build a Dyson Sphere as discussed in this work would probably arise during the main sequence period of its star, and find ways to survive the red giant stage; maybe temporarily migrating to an orbit farther from its star, either to a planet, or failing/rejecting[4] that, to orbital habitats a la O'Neill. In fact, such an effort would provide the experience needed before undertaking the construction of the Dyson Sphere around the eventual white dwarf.

Conclusion:

We argued that most stars (if any) harboring intelligent life must end up as white dwarfs, hence it is natural to also consider these objects in addition to main sequence stars as central objects for Dyson Spheres. More importantly, it is possible to find parameters for these DS's such that both the temperature and gravity are close to the values for the type of life we are familiar with. This should be contrasted with the usual idea of the Dyson Sphere, AU-sized and around a main-sequence star, where gravity is negligible on the DS, hence artificial gravity may be needed, a technology which might be impossible. Other benefits are much less need for building materials compared to the 'standard' DS, and the possibility of converting trash into energy at nuclear fission-reactor efficiencies. A drawback is much stricter strength requirement for the building materials. We conclude that 106 km-scale Dyson Spheres built around white dwarfs are at least as realistic as the 'standard' ones, and possibly more probable. Unfortunately, they would also be harder to detect.

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