“Dyson Spheres” as an Alternative to the Dark Matter Explanation of Hidden Masses in Galaxies

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Abstract

The concept of the "Dyson Sphere" is well known – to build an engineering construction around a star to utilize as much of the star's energy as it is possible. Even if the detection of a "Dyson Sphere" by infrared radiation contradicts to the entire idea of the collection of star energy, they still could be detected by the gravity of a star within the "Dyson Sphere" as well as by brightness changes of stars passing behind them.

A star within the "Dyson Sphere" adds the star's gravity into the gravity of the galaxy containing this star, even if the star itself is hidden. Therefore if "Dyson Spheres" exist, the total gravity of light-emitting objects in galaxies must be less than the gravity of the entire galaxy. In fact we observe this effect, which is a well-known effect of "hidden mass" in galaxies. To solve the "hidden mass" puzzle, physicists introduced a new kind of matter – "dark matter". However (as far as the author knows) the "Dyson Spheres" were never seriously taken into account and discussed in scientific literature as a possible solution of the "hidden mass" problem.

Researches of gravitational microlensing put strict limits to the percentage of regular cosmic objects that can pretend to solve the "hidden mass" problem. However these researches are not fully suitable for analysis of "Dyson Spheres" because "Dyson Spheres" have *no* negligible size and because they do not only amplify the brightness of stars (gravitational microlensing) but also *de-amplify* the brightness of a stars when they travel behind the "Dyson Spheres".

Since minimal size of "Dyson Spheres" must not be less than the habitable zone, we infer the "Dyson Spheres" radius for our Sun to be between 1.48×10^8 and 2.54×10^8 km or about 1/6 of the gravitational microlensing size. If "Dyson Spheres" are bigger than habitable zones the graph of star brightness produced by the horizontal movement behind "Dyson Spheres" will be more complex and in some cases the entire effect of microlensing could disappear.

The data accumulated by gravitational microlensing research can still probably be used for testing of the "Dyson Spheres" existence. However we should not only look for $\cap$ -shaped graph of brightness that is created during the movement of a star behind the gravitational lens, as well as for more complex graphs, that may appear during the movement of the star behind the opaque "Dyson Sphere", in particularly for M-shaped (microlens / "Dyson Sphere" shadow / microlens) graphs and even for U-shaped (entering into "Dyson Sphere" shadow / exit the "Dyson Sphere" shadow) graphs.

Another test for "Dyson Spheres" as a replacement for dark matter is related to its artificial nature: First-generation stars do not have planets and life on them, therefore attributing hidden mass of galaxies to "Dyson Spheres", we should observe dependence of ratio [invisible matter]/[visible matter] on z . The further the galaxies – the less hidden matter we should observe in case of attributing the hidden matter to "Dyson Spheres".

The purpose of this article is not to make the statement that "Dyson Spheres" can explain the problem with hidden mass in galaxies without "dark matter". It is merely about asking the question, whether the "Dyson Spheres" explanation of hidden mass in galaxies can be rejected with current experimental and observational material. In spite of peculiarity of such a hypothesis, in accordance to "Occam's Razor" it is still a more attractive explanation than introduction of this new type of matter.

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1. The “Dyson Sphere” became famous in 1960 when physicist and mathematician Freeman Dyson described this construction in his article "Search for Artificial Stellar Sources of Infra-Red Radiation", published in the journal “Science” (Dyson 1960). Dyson was not the inventor of this engineering concept but merely the first scientist who popularized and suggested methods to detect it.

The concept of the “Dyson Sphere” is basically very simple – to build the construction around a star to utilize as much of the star’s energy as it is possible. Some models (“Dyson shell” for example) allow in theory to utilize 100% of the star’s energy. For contrast: the entire Earth receives less than 10^{-9} of energy it could receive from the “Dyson Sphere” built on the Earth’s orbit.

The “Dyson Sphere” cannot be built as a solid object, since it is technically impossible. However different version of the “Dyson Sphere” (Dyson swarm, Dyson bubble, Dyson net or rotating double semi-sphere (below, Fig.1)) could be feasible with future technology.

Fig.1. Illustration of version of “Dyson Sphere” made with 2 “cylinders” with open ends.

2. Predicted observational effects.

Having this thought construction in mind we can wonder how the “Dyson Sphere” can be detected.

Detection of excessive infrared radiation of the “Dyson Sphere” does not appear the right method since the main purpose of the “Dyson Sphere” is the collection of the star’s energy. It would appear strange if the civilization that built the “Dyson Sphere” lets infrared radiation to radiate into space, since it contradicts the entire concept of such a construction.

Obviously we cannot predict how this collection will be achieved. The "Dyson Sphere" may for example have a second layer that focuses and converts the infrared and radio emission to electrical power, similar to current radio and infrared telescopes. Or possibly the "direct" conversion of excessive energy to matter (per Einstein's $m=E/c^2$) can be achieved with the use of this extra matter as building material for the Dyson Sphere's expansion? Obviously we cannot answer this question now.

However almost certainly the civilization capable of building a "Dyson Sphere" will be able to utilize infrared and radio emission similarly to how it works with optical emission.

However if no radiation may leave the "Dyson Sphere" – is there a way to detect it?

Yes, and at least two methods can be offered.

First – detection of a "Dyson Sphere's" gravity. Even if a star within the "Dyson Sphere" is invisible – it still has gravity, which we can use for detection.

Second – the "Dyson Sphere" is a large enough object (with the size being about the range of the habitable zone or greater). It is a dark, opaque object, which probably does not let the light of other stars to pass through it. (Unless it is made intentionally semi-transparent, to keep only radiation of the "native" star, while letting other stars radiation to pass through. What currently appears impossible to be made).

Let's analyze these methods in more details.

2.1 Gravity effects.

- a. A star within the "Dyson Sphere" adds the star's gravity into the combined gravity of the galaxy containing this star, even if the star itself is hidden and invisible,
- b. The gravity of a "Dyson Sphere" star also distorts the trajectory of light from stars that are located visually close enough to the invisible "Dyson Sphere" star. This in some cases may produce the gravitational microlensing effect.

2.2 Opaque effects.

- a. The "Dyson Sphere" dark object must decrease (partially or in full) the brightness of stars that are passing behind it during the relative motion of these stars, the observer and the "Dyson Sphere". Because the "Dyson Sphere" supposes to collect all the energy, this brightness decrease will probably be the same in the full electromagnetic diapason. It probably will be a random non-periodical event (because it is not the rotation of the observed planet around the star, but a random single pass of the star behind the "Dyson Sphere"). However sometimes this period can still be produced by the rotation of the Earth around the Sun, where in some Earth orbital points the "Dyson Sphere" appears exactly on the observation line and in other orbit points – does not. The ability to detect this effect depends on the relative distance to the source star, the distance to the "Dyson Sphere" and the resolution of the astronomical equipment.
- b. Again, depending on the above factors, we could observe the cases when a star becomes invisible (because it moves behind the "Dyson Sphere") without any catastrophic events and even suddenly becomes visible (again without any "events").

3. Comparison with observations and discussion.

In accordance to the effect described in item 2.1.a the gravity of “Dyson Sphere” stars should add their gravity into the gravity of the galaxy containing these stars, even if the stars themselves are invisible.

In other words: the total gravity of light-emitting objects in galaxies (sum of visible stars, visible gas etc.) will be less than the gravity of the entire galaxy. Simply because, we do not count the gravity of the “Dyson Sphere” stars, which are invisible but still imprint their input into the gravity of the entire galaxy. Do we observe this effect?

Actually we do. During the 20th century, astronomers noted that the rotation of galaxies and dynamic of galaxy clusters does not follow Newton-Einstein gravitational theory if the masses of galaxies are attributed only to light-emitting objects. This is a well known problem of “hidden mass” in galaxies and galaxy clusters. The additional measurements and research have shown that cold (not light-emitting) gas, dust, brown dwarfs, neutron stars, black holes, planets and combined mass of neutrinos can not fix this problem.

To solve this puzzle physicists introduced a new kind of matter – “dark matter”. Currently it is attributed to either baryonic and/or nonbaryonic dark matter and is supported by research of gravitational microlensing and the analysis of cosmic microwave background radiation.

However (as far as the author knows) the “Dyson Spheres” were never seriously taken into account as a possible solution of the “hidden mass” problem and discussed in scientific literature. Let’s discuss this in finer detail:

3.1 In accordance to our current view, the ‘dark matter’ / ‘regular matter’ ratio must be about 5:1 to allow the Newton-Einstein theory of gravity to describe the rotation of galaxies. Can the ratio of stars with “Dyson Spheres” to stars without “Dyson Spheres” be 5:1? This question is rather strange, but the right answer to it is “why not?”. We know that many stars contain planets and some of these planets are located in habitable zones. Counting the millions of years of available time it would not be surprising if intelligent life from some of these planets were able to build “Dyson Spheres”. As well as not necessary only around their home star (where extra-terrestrial life was born) but also around other stars, which it was able to reach.

3.2 Research of gravitational microlensing (Tisserand et al. 2007 and other) put strict limits to the percentage of regular cosmic objects that can pretend to solve the “hidden mass” problem. For example authors of the research (Tisserand et al. 2007) state that “machos in the mass range $0.6 \times 10^{-7} M_s < M < 15M_s$ are ruled out as the primary occupants of the Milky Way Halo.”, where M_s is the mass of Sun and “machos” is the abbreviation of “Massive compact halo objects”.

Does it mean that “Dyson Spheres” as dark cosmic objects made with common baryonic matter can not also pretend to explain the “hidden mass” problem? Probably not.

The gravitational microlensing *amplifies* the brightness of the star located behind the lens. The “Dyson Sphere” also amplifies the brightness of the star behind the lens. But in contrast to “machos” the “Dyson Sphere” also *de-amplifies* the brightness of the star behind the lens. This happens because of important differences in *size* between “machos” and “Dyson Spheres”. The objects, which astronomers consider “machos”, are brown dwarfs, neutron stars, black holes and unassociated planets. All of them have very small sizes, which we can neglect during the microlensing observation analysis. However the size of the hypothetic “Dyson Sphere” is *not* negligible. Its size should probably not be less than the “habitable zone” of the star around which it was built. This is simply to not hide their star from the habitable planet(s) that built the “Dyson Sphere”. See the picture Fig.2. below.

Fig.2. Illustration of Dyson sphere locations inside (A) and outside (B) the habitable zone.
A. Dyson Sphere is located between the habitable zone and Sun. People on Earth can not see the Sun.
B. Dyson Sphere is located outside the habitable zone. People on Earth can see the Sun.

Example.: In accordance to Kopparapu et al. (2013), our Sun’s habitable zone has a size between 0.99 and 1.70 AU, or between 1.48×10^8 and 2.54×10^8 km. Note, that the Sun’s diameter is about 1,392,684 km (Emilio et al. (2012)) and therefore the size of the “habitable zone” is about 180 times greater than the size of Sun.

In accordance to the gravitational microlensing research Tisserand et al. (2007), “Microlensing events are characterized by a timescale t_E giving the time for the lens to travel a distance corresponding to its Einstein radius, $t_E = r_E/v_t$ where v_t is the lens’s transverse velocity relative to the line of sight.” Accepting from article Tisserand et al. (2007) the velocity dispersion as 270 km/s and t_E for our Sun as 70 days (formula (3) in Tisserand et al. (2007)) we can estimate the Einstein radius r_E as

$$r_E = t_E * v_t = 270 \text{ km/s} * 70 \text{ days} = 1.63 \times 10^9 \text{ km.}$$

As we see for Sun-like stars the radius of habitable zone (and the minimal size of hypothetic “Dyson Spheres”) is about 1/6 of the gravitational microlensing size even when transverse velocity is at its dispersion level. What this means is that the size of “Dyson Spheres” are *not* negligible for microlensing analysis.

If the Einstein radius r_E is less or if “Dyson Spheres” are bigger than the habitable zone the graph of star brightness produced by the horizontal movement behind “Dyson Spheres” will be more complex and in some cases the entire effect of microlensing may disappear.

This means that the current methodology of selection and elimination of “machos” using microlensing is not fully suitable for selection and elimination of candidates for “Dyson Spheres”. In the same time the excellent data accumulated by gravitational microlensing researchers can probably also be used for testing of “Dyson Spheres” existence. However we should look not for $\cap$ -shaped graph of brightness that is created during the movement of a star behind the gravitational lens, but for more complex graphs, that may appear during the movement of the star behind the opaque “Dyson Sphere”. In some cases we may expect the M-shaped graph of brightness (growth by microlensing, decrease because of “Dyson Spheres” shadow and again brightness growth when the star leaves the “Dyson Spheres” shadow). In some cases the graph of brightness can even be entirely U-shaped (decrease because of “Dyson Spheres” shadow and brightness growth, when the star leaves the “Dyson Spheres” shadow). This may happen when the Einstein radius r_E is less than the “Dyson Sphere” size.

3.3 Another argument in favor of dark matter arrives from the analysis of cosmic microwave background radiation. Without access to this data it is difficult to say if it contradicts, is neutral or supports the “Dyson Spheres” hypothesis. For example, authors of the article Spergel et al. (2003), state from the beginning that they consider the model of “a flat Universe with radiation, baryons, cold dark matter and cosmological constant, and a power-law power spectrum of adiabatic primordial fluctuations”. They ruled-out the warm dark matter, but they never tested the model where “Dyson Spheres” is responsible for the hidden mass.

3.4 Here we can introduce another test for the “Dyson Spheres” hypothesis. “Dyson Spheres” are an artificial construction, and as such it can not be built on first-generation stars. Simply because first-generation stars do not have planets and life on them. If we attribute (at least partially) the hidden mass of galaxies to “Dyson Spheres”, we should observe dependence of ratio [invisible matter]/[visible matter] on z . The further the galaxies – the less hidden matter we should observe in the case of attributing hidden matter to “Dyson Spheres”.

4. Conclusion.

The purpose of this article is not to make the statement that “Dyson Spheres” can explain the problem with hidden mass in galaxies without “dark matter”. It is merely about asking the

question, *whether* the “Dyson Spheres” explanation of hidden mass in galaxies can be rejected with current experimental and observational material.

If current observations can reject the “Dyson Spheres” explanation then let us look for something else, dark matter for example. If however current observations cannot reject the “Dyson Spheres” explanation of hidden masses then in accordance to “Occam's Razor” this hypothesis becomes more favorable than introduction of new type of matter.

If their existence is confirmed, Dyson Spheres can also explain the puzzle “why we do not see the activity of hypothetic extra-terrestrial civilizations in our galaxy?” The answer may be very simple – This is because they live inside the Dyson Spheres and are invisible to external observers.

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