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A4_3 Habitable Dyson Sphere

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Abstract

Dyson Freeman described the concept of the Dyson Sphere in the paper "Search for Artificial Stellar Sources of Infra-Red Radiation" [1]. This is a spherical structure built around a star by a technologically advanced civilization, designed to collect the energy output of its host star. This report explores the possibility of creating artificial gravity via rotation on a Dyson Sphere made of multi-layer graphene. By knowing the ultimate tensile strength of graphene, a maximum equatorial velocity can be calculated, and used to create artificial gravity. The maximum achievable acceleration is found to be ~0.01% of the gravity on Earth, which is barely noticeable.

Introduction

In 1960, Dyson Freeman described how the exponential rise in energy requirements by a technological civilization might lead to the construction of a Dyson Sphere around a star. This is a hypothetical mega-structure encapsulating a star in order to completely capture its energy output. A habitable surface would offer the additional bonus of having extra space for a continually expanding civilization. Therefore, the discovery of such an object would be an indicator of intelligent life.

This report examines the potential use of graphene as a building material for a rigid rotating Dyson Sphere featuring artificial gravity.

Discussion:

The reason for the use of graphene is its intrinsic strength. An ultimate tensile strength of 42 N/m for monolayer graphene, which corresponds to 130GPa for bulk graphite (multi-layer graphene) makes this the strongest contemporary material [2].

A rotating sphere is subjected to tensile stress. The structure will break if the pressure generated by the centripetal acceleration becomes greater than the intrinsic strength of the material. The question is what centripetal acceleration is achievable. This can be answered by knowing the strength of graphite and the radius of the sphere.

Equation 1[3] expresses the tensile stress on a rotating sphere depending on the centripetal acceleration and its radius and density.

$$S = \frac{1}{2} a_{ct} \rho R \qquad (1)$$

where S is the stress, a_{ct} is the centripetal acceleration, ρ is the density of the material and R is the radius of the Dyson Sphere. Rearranging equation 1 and taking the stress to be equal to the intrinsic strength of graphite, it is found that the maximum artificial gravitational acceleration is:

$$g = \frac{2S}{\rho R}$$

With a density of 2267 kg/m^3 [4], at a distance of one astronomical unit (1.496×10^{11}m), the resultant acceleration is 9.5×10^{-4}, or ~0.01% of the gravity on Earth.

This means that Earth-like gravity cannot be achieved on a Dyson sphere with a radius of one astronomical unit. For such a sphere, a maximum radius of 1/10,000 of 1AU (15,000 km) would give a gravitational pull equalling that on Earth. This radius is so small compared to the radius of the Sun that such a sphere would reside in the current solar interior – it is only twice the Earth's radius. The choice would be to place the structure in orbit around the Sun rather than encapsulating it.

To allow mass to be stored on the inside of the sphere, its radius would need to be reduced in order to decrease the tensile stress on the material. This would bring the structure to a size comparable to that of Earth's.

Conclusion

Using multi-layer graphene for a rigid Dyson Sphere can only generate minute artificial gravity, smaller than that of the Sun at a distance of 1AU (0.01% of the gravity of Earth). To achieve the desired effects, a different Dyson Sphere design or different material could be used. A rotating graphene sphere of much smaller radius orbiting the Sun could be used for the same purpose. However, a sphere of Earth's size would defeat its purpose because of its low energy collection capability. An alternative would be to establish a colony on Mars and cover its surface with solar panels. This would also be much less technologically demanding.

References

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