THE DETECTION OF A DYSON-HARROP SATELLITE: A TECHNOLOGICALLY FEASIBLE ASTRO-ENGINEERING PROJECT AND ALTERNATIVE TO THE TRADITIONAL DYSON SPHERE. B. L. Harrop[1] and D. Schulze-Makuch[2], [1]Dept. of Physics and Astronomy, Washington State University, Pullman, WA, harrop_b@hotmail.com, [2]School of Earth and Environmental Sciences, Washington State University, dirksm@wsu.edu

Introduction: Since the Dyson sphere was first proposed almost 50 years ago, numerous schemes for detecting large astro-engineering projects have been proposed [1, 2]. However, while a highly advanced alien civilization may posess the technology to build Dyson spheres, there are numerous fundamental issues that make it an unfeasible endeavor for current human technology. In the spirit of the many Dyson sphere variants developed by others [3, 4], we propose the Dyson-Harrop satellite (DHS) as an alternative scenario to the traditional Dyson sphere. Initial numerical modeling suggests the DHS is advantageous for power production, is feasible using modern technology, and is therefore an astro-engineering project that alien civilizations may consider building. However, detection of such a system remains beyond the grasp of modern technology, unless the DHS is very large.

Dyson Sphere Impracticalities: Athough the Dyson sphere can produce very high amounts of power (~4 x 10^{26} W) [5], its design has a number of disadvantages. If all of the matter in a solar system roughly the mass of ours is used to construct a sphere with radius of just 1 AU, the sphere would only be 8 cm thick (with an average density equal to that of steel). Additionally, it has been calculated [6] that the minimal radius of a Dyson sphere must be at least 1.66 AU in order to successfully dissipate thermal energy absorbed by the Sun in a useful fashion—a smaller sphere could suffer a cataclysmic thermal event (e.g. explosion or melting). Currently, there exist no man-made materials that can stand up to the stress that would be felt at every point along the surface of such a gargantuan structure [7].

Aside from the lack of net gravitational force on the inside of the Dyson sphere, a spherical shell around the Sun would have no net gravitational force *on* it either (Divergence Theorem). Drift of the sphere from its concentric location would have to be actively corrected for. Unfortunately, a drift speed of just 2 m/s would require virtually all of the power the sphere collects for the correction.

The Dyson-Harrop Satellite (DHS): Several Dyson variants have been proposed [4, 8], though all share a common theme of solar power collection. The DHS, however, draws energy from the solar wind's electrons, using the Sun's high energy photons only to eject the electrons once their useful electronic energy has been collected.

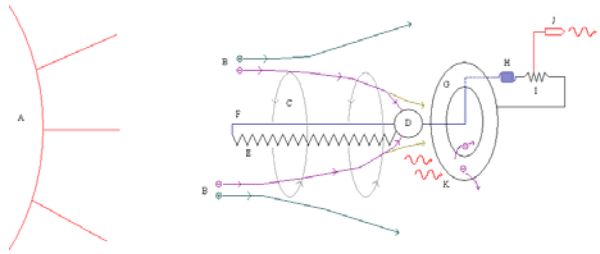

Fig. 1: The Dyson-Harrop Satellite. See text below for design.

The DHS Design (Fig 1): The Sun (A) emits a plasma half-composed of electrons, half of protons and positive ions (B). [9] Electrons are diverted (via Lorentz force from a cylindrical magnetic field (C) from their radial trajectory towards the 'Receiver' (D), a metallic spherical shell. When the Receiver is "full", excess electrons are diverted through the hole in the Sail. The large positive potential on the Sail drives an electron current through the 'Pre-Wire' (E), which is a long, folded wire designed to cancel out the magnetic fields of the current towards the Sun. Once it reaches the end of the Pre-Wire, it travels down the 'Main Wire' (F), creating the magnetic field (C), which makes the field-current a self-sustaining system. The current passes through a hole in the Receiver and then through the 'Sail' (G), passing through the 'Inductor' (H), and the 'Resistor' (I), which draws off all of the electrical power of the Satellite to the 'Laser' (J), which fires the electrical-turned-photonic energy off to a designated target. Drained of its electrical energy, the current continues to "fall" to the Sail (G). Here, electrons will stay until hit by appropriately-energetic photons from the Sun, at which point they will leap off (K) from the Sail towards the Sun, and then be repelled by the magnetic fields (C) and excess solar wind electrons (B) away from the Satellite, imparting kinetic energy to the Satellite away from the Sun.

User-Defined Parameters: Because the Sun emits such a vast number of both electrons and high-frequency photons, the current through the DHS (and, therefore, the power it produces) can be defined by the construction of the satellite; DH satellites can be produced to collect any amount of power desired, up to the total energy of the Sun. This is primarily determined by the capacitance of the Receiver, and $r_{B,max}$, the maximal distance from the Main Wire at which a solar wind electron can successfully be captured by the satellite via its magnetic field.

Advantages: Chiefly, modeling suggests that the DHS can provide power at a rate that increases proportionally to the square of current through the Main Wire. A current of 0.444 A would produce ~1.7 MW of power, while tripling the current produces about 10 times more power.

Aside from being an effective generator, the DHS has several other advantages. It should be relatively cheap to construct, given that the system is composed almost entirely of copper and doesn't require circuitry (but see *Distributing Power*). Since the magnetic field diverts positive particles away from the satellite and electrons toward the Receiver, the DHS remains virtually untouched by excess solar wind particles. And since the satellite ejects electrons when their current cycle is complete, even large satellites have a minimal impact on the Sun's solar wind output. Additionally, the kinetic energy from the photoelectrical ejection of electrons from the Sail provides a strong stabilizing force; in fact, it may be possible to design a satellite that can remain in a *stationary* position.

Disadvantages: Compared to the Dyson sphere, the DHS generates power at a fairly low rate. Initially, its purpose may be better suited to powering individual space projects (e.g., space stations, planetary bases) than providing power for an entire civilization.

The simplicity of the DHS could also be its downfall - this model possesses no method of protecting itself from debris, actively maintaining its position, or even starting the circular field-current system (which the Inductor can help maintain). These issues can be accommodated by extra equipment on the DHS, but it risks further difficulties as complexity of the satellite's construction. Another problem may be heat dissipation.

Distributing Power: The primary concern of all Dyson variants—the DHS included—is that of power distribution. A straight-forward idea is to use a laser system to fire energy off to collectors (simple satellite dishes attached to the projects for which the DHS is to provide power). Fortunately, existing laser systems would serve this purpose adequately [10]. However, *aiming* the laser is expected to be the most difficult issue to circumvent. Hitting a target collector (diameter = 10 m) from 10 m away allows for 28.3º of aim error. Hitting that collector from 100 km permits only 0.0283º of aim error. The DHS may need to distribute power to projects that are ~10^6 km away. The satellite's ability to maintain a stationary position in space may aid with aiming, however, as calculations for aiming would not need to account for its angular motion.

Finding a DHS: Numerous projects have been designed to find Dyson sphere-like objects in distant solar systems [1, 3] by searching for large gravitational objects that serve as point sources for IR radiation. It has been theorized that the energy absorbed by a Dyson sphere would be partially re-emitted as black-body radiation in the infra-red spectrum [1]. Given the impracticalities of the Dyson sphere's design, however, it may be more reasonable to search for more plausible astro-engineering structures like the DHS.

Unfortunately, current technology can only detect deviations in the solar winds of other stars as small as ~10^{-13} M_S/yr (solar masses / year) [11]. Our Sun, for example, emits a solar wind of only ~10^{-14} MS/yr, and the 0.444 A model of the DHS merely diverts ~10^{-14} of the Sun's solar wind (~10^{-28} M_S/yr). Additionally, it may take mere milliseconds or less for the portion of the solar wind diverted by the DHS to re-diffuse with the rest of the wind. Therefore, using current detection methods, the capture radius, $r_{B,max}$, would need to be on the order of 1 AU for a DHS to be seen in distant solar systems. Such a satellite may require a current of ~10^{12} A, theoretically creating a power of about that of a Dyson sphere. To find a DHS, solar wind detection methods must be improved. However, building such a powerful DHS (or a collection of somewhat smaller satellites) is not entirely beyond our current technological prowess, so searching for such deviations may be a productive endeavor in the search for distant intelligent civilizations.

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