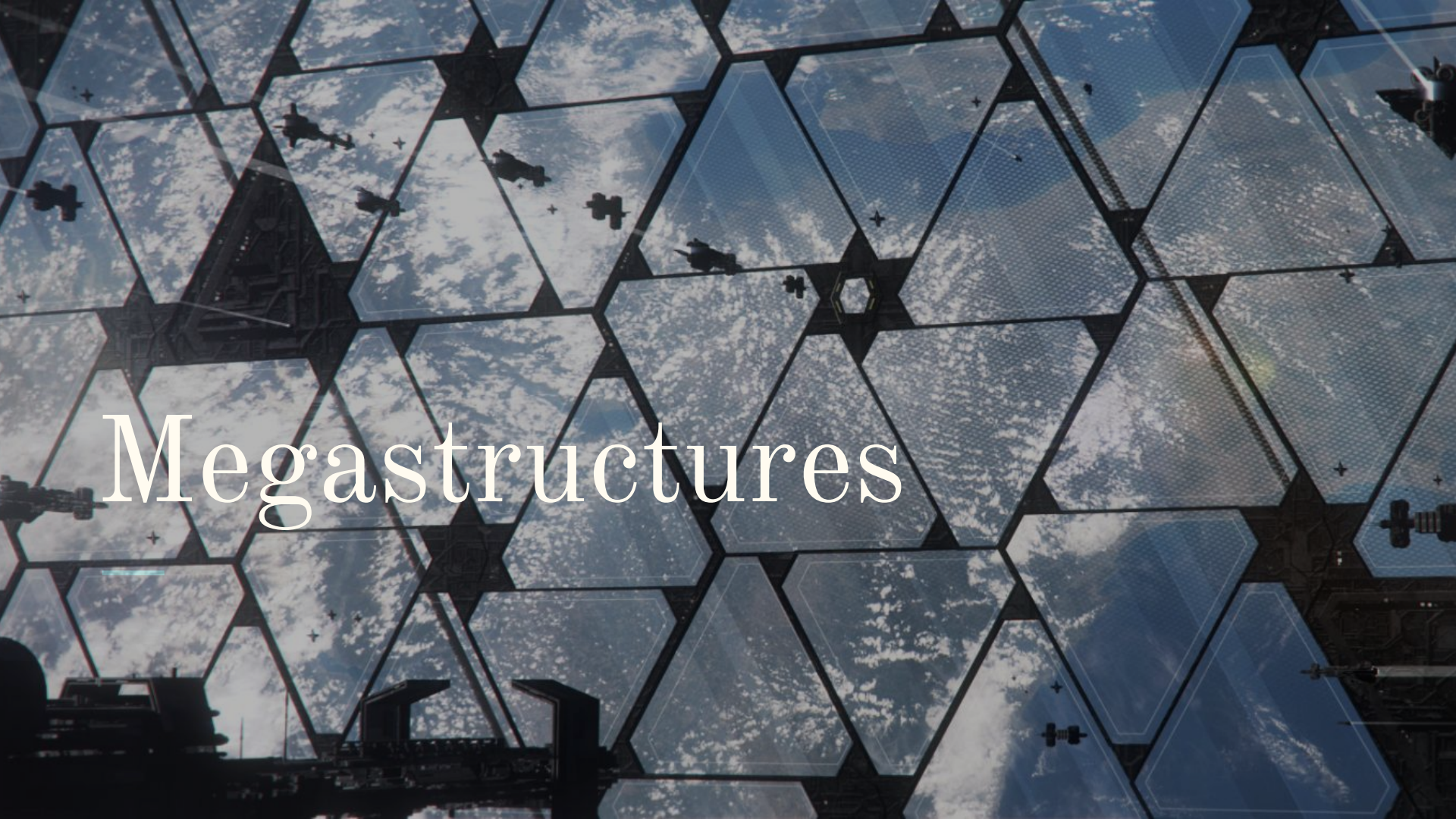


Dyson Spheres and other Megastructures



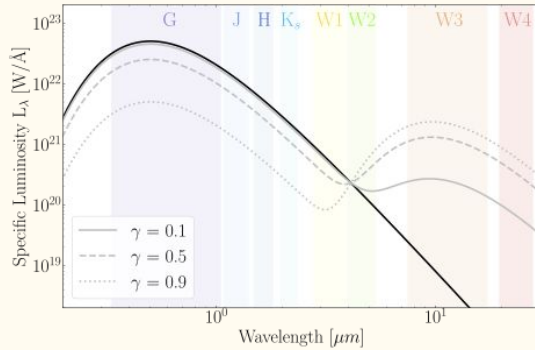
John Harrold

Harvard Energy Journal Club sp2023



Megastructures

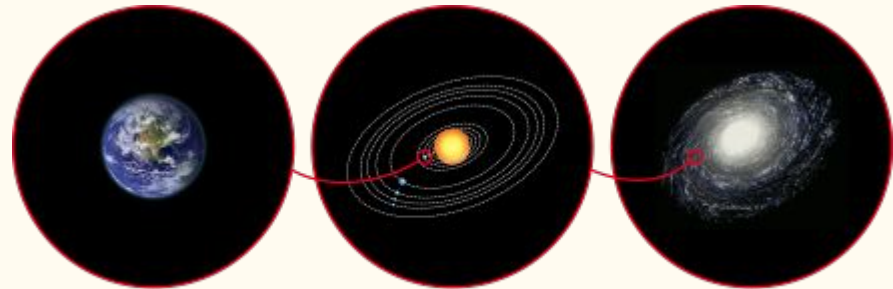
Megastuctures are vast artificial structures generally in the scope starting at 10^6 m or 1 megameter (Mm)



Freeman Dyson published the concept of a structure to harness the entire energy output of a star in Science 1960 in the context of SETI.

Kardashev scale

$$K = \frac{\text{Log}_{10} P - 6}{10}$$



Type I: 10^{16} W

Type II: 10^{26} W

Type III: 10^{36} W



Dyson Spheres

and other related structures



Dyson Shell

First theorized by Olaf Stapledon in his science fiction book *Star Maker* (1937)

Luminosity of the sun 382.8×10^{24} J/s ^[1]

Ideally the size would be 1 AU radius.

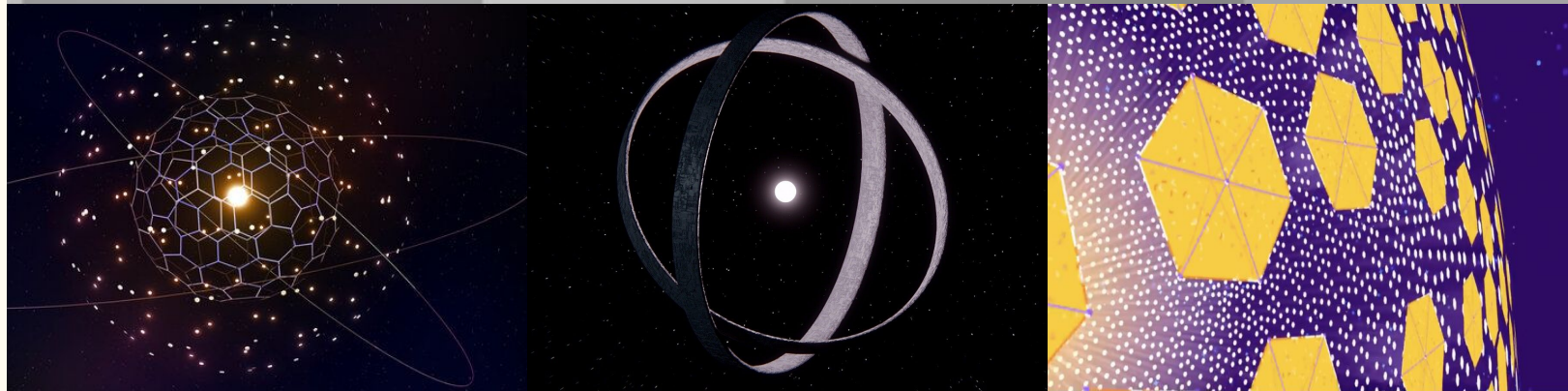
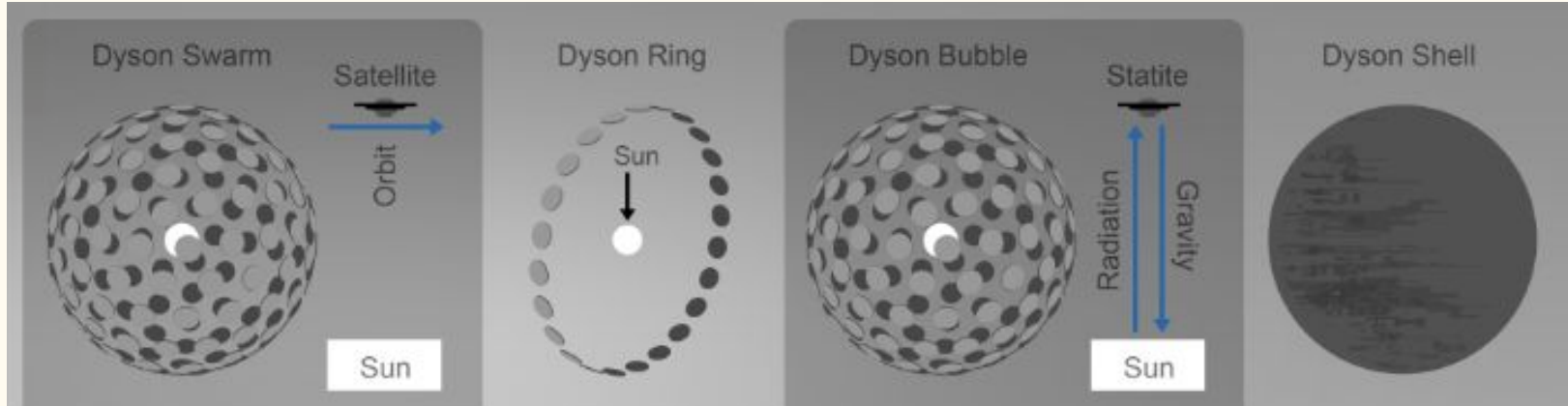
Typical imagery, but less practical

Needs 1.82×10^{26} Kg (about 31 Earths)

[1] <https://nssdc.gsfc.nasa.gov/planetary/factsheet/sunfact.htm>

[2] <https://www.aleph.se/Nada/dysonFAQ.html>

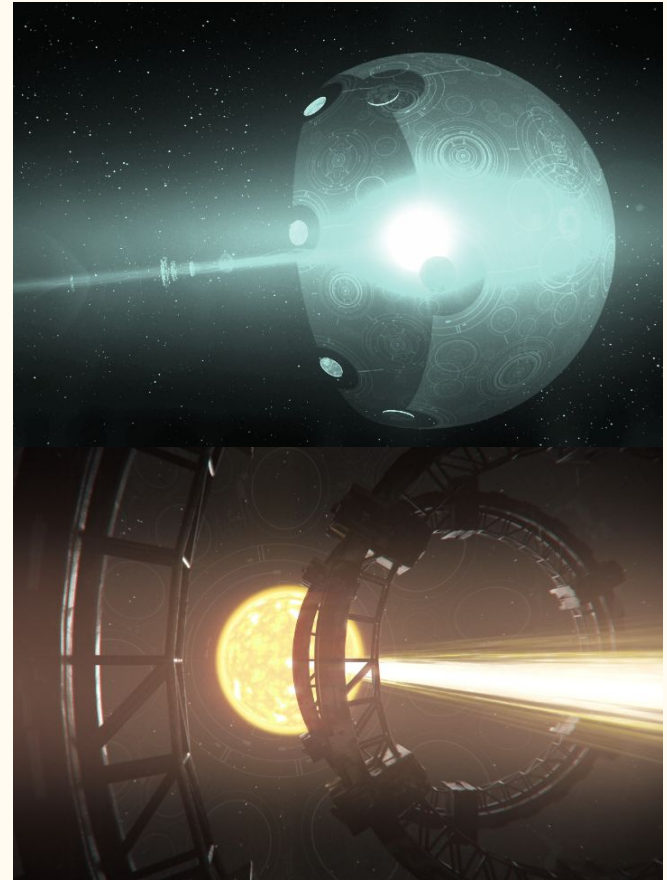
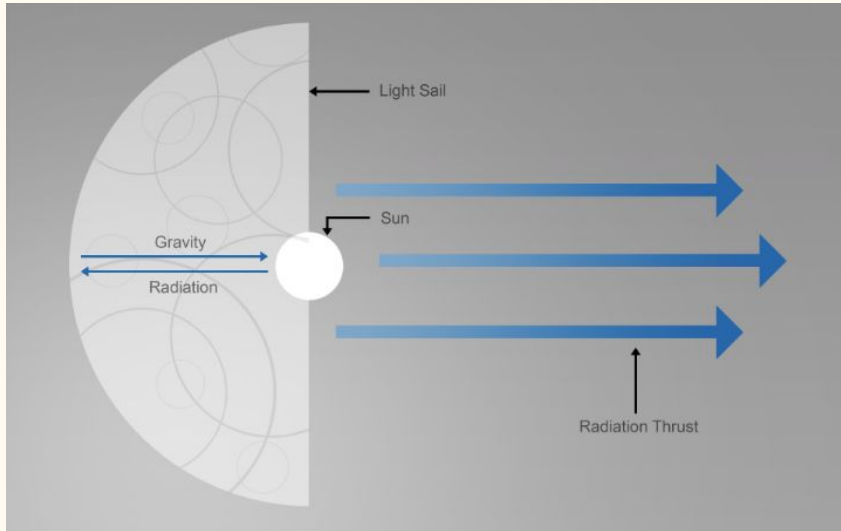
More practical Dyson Sphere designs



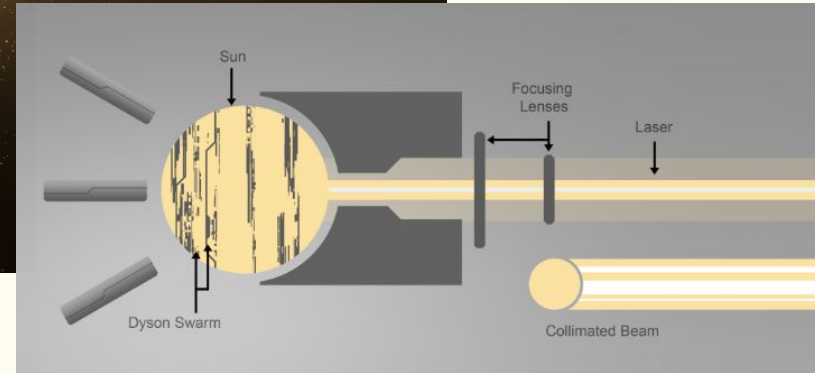
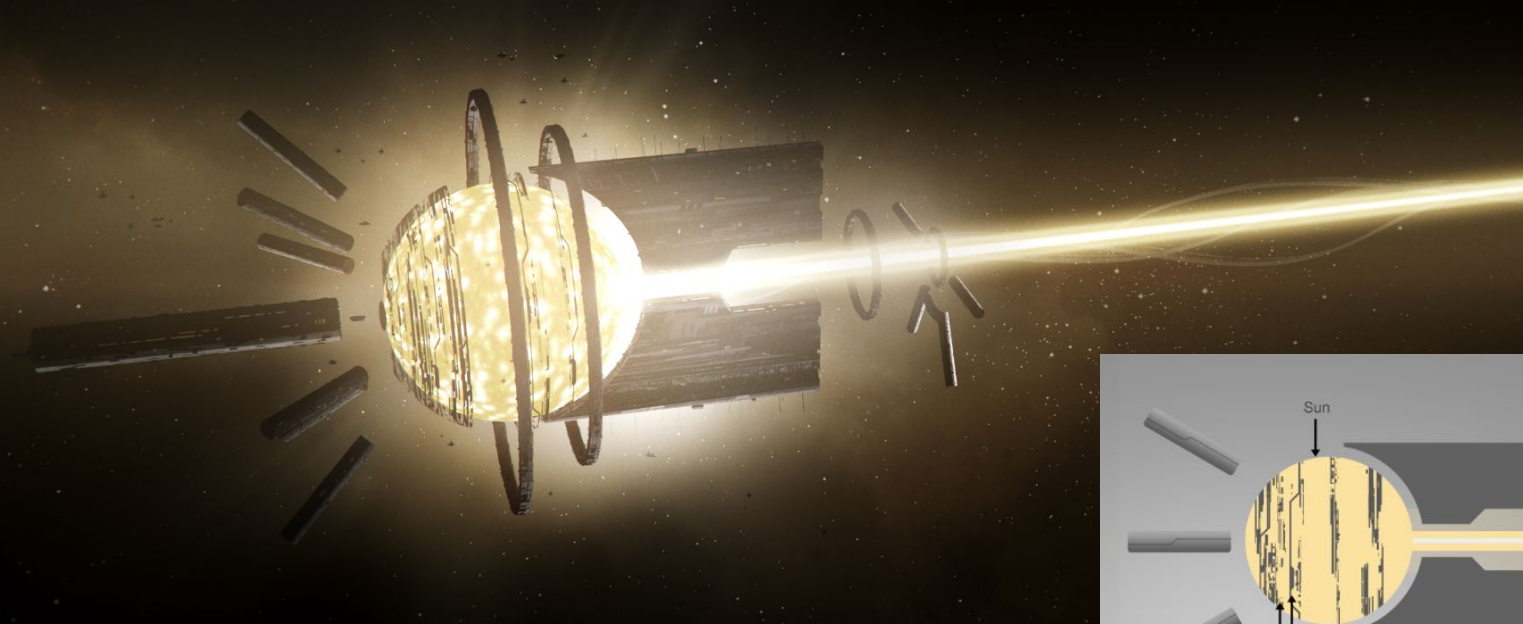
Shkadov Thrusters - Stellar Engines

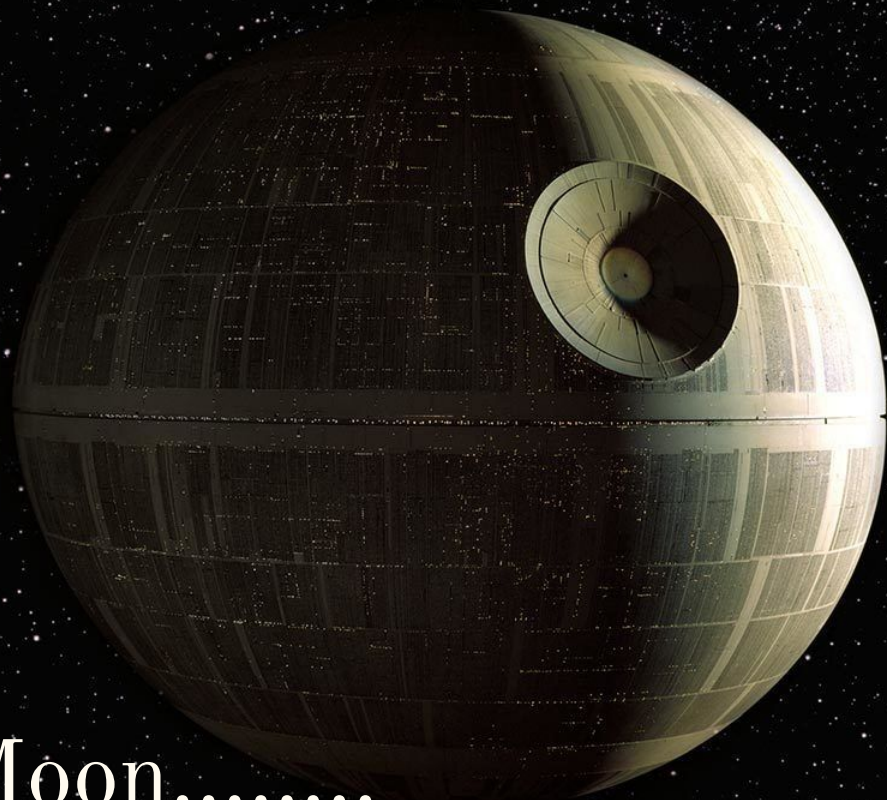
Light sails causing asymmetric radiation pressure on the star, dragging any planetary system along with it.

Sun like stars will accelerate to 20 m/s in 10^6 yr



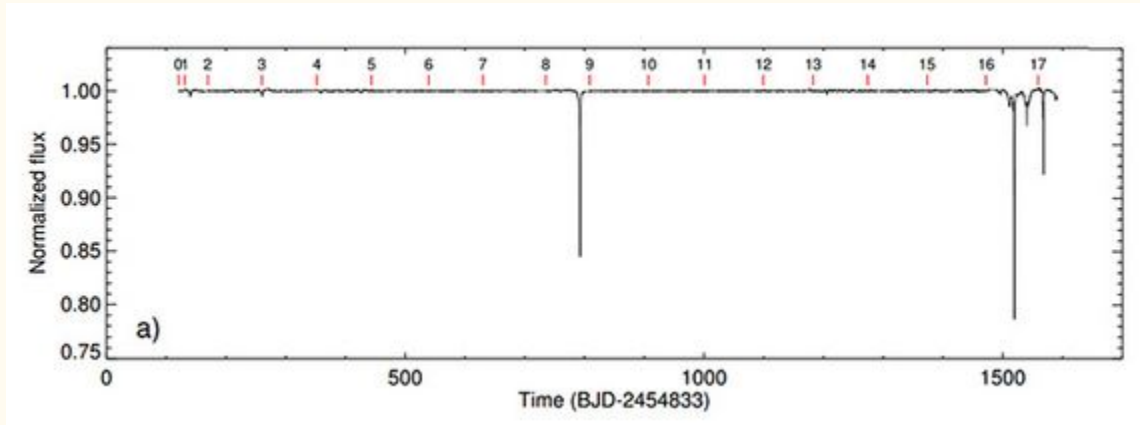
Nicoll-Dyson lasers





That's No Moon.....

Unusual spectrum from KIC 8462852



The light pattern suggests there is a big mess of matter circling the star, in tight formation. That would be expected if the star were young ... But this unusual star isn't young. If it were young, it would be surrounded by dust that would give off extra infrared light. There doesn't seem to be an excess of infrared light around this star.

[1] T. S. Boyajian et al., "Planet Hunters IX. KIC 8462852 - where's the flux?" *Mon. Not. R. Astron. Soc.* **457**, 3988 (2016).

[2] <http://large.stanford.edu/courses/2016/ph240/wee1/>

Challenges



Energy and costs associated with launching the massive number of satellites into space

Materials Supply

We have the energy, now what?



Trans Orbital Megastructures

Examples of transorbital Megastructures

A futuristic space megastructure is shown against a background of Earth from space. The structure consists of a long, dark, multi-lane track or roadway that curves across the frame. A large, circular, multi-layered hub or station is attached to the track. In the background, a satellite or space station is visible in orbit. The Earth's surface shows clouds and landmasses.

Space Elevators

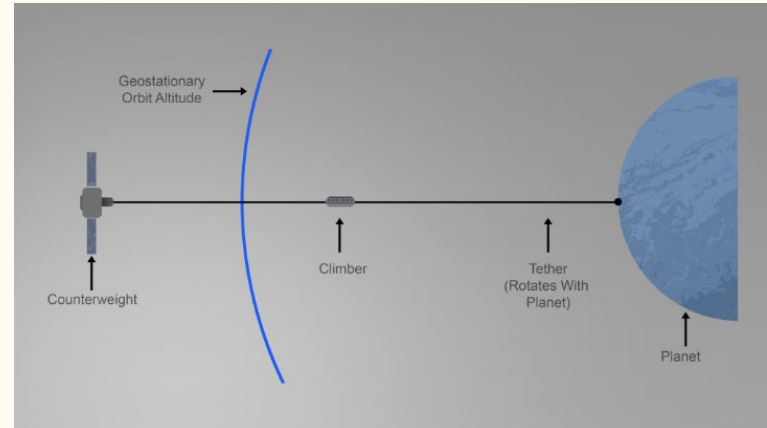
Launch Loop

Tethered Ring

Space Trains



Space Elevators

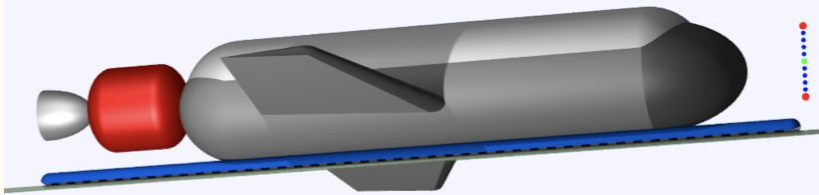
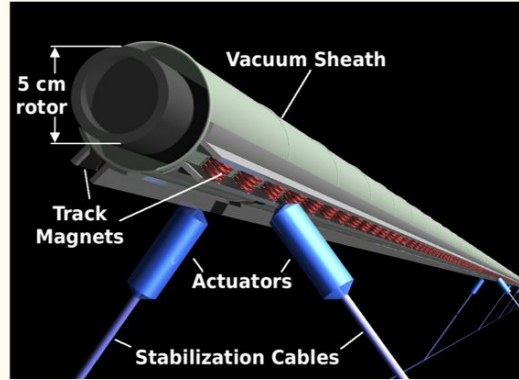
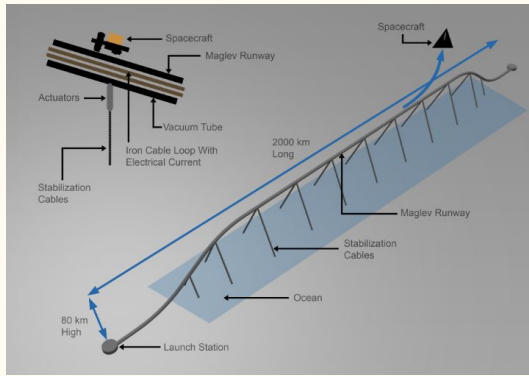


Konstantin Tsiolkovsky in 1895

Cable (teather) and a climber to help launch satellites and ships into space.

Needs strong and light materials for the tether.

Launch Loop

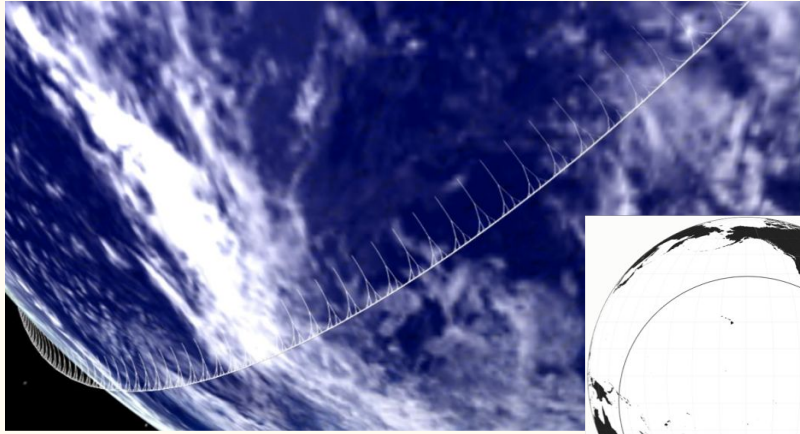


A Launch Loop is a space runway that is a 2000 km actively supported elevated tube under vacuum.

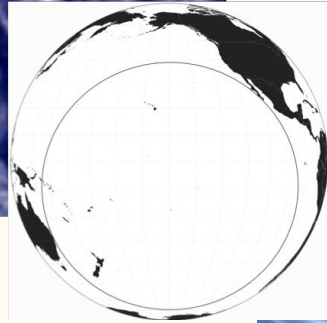
Lofstrom, K.H., 1985. The launch loop-a low cost earth-to-high orbit launch system. AIAA Paper, pp.85-1368. launchloop.com



Tethered ring

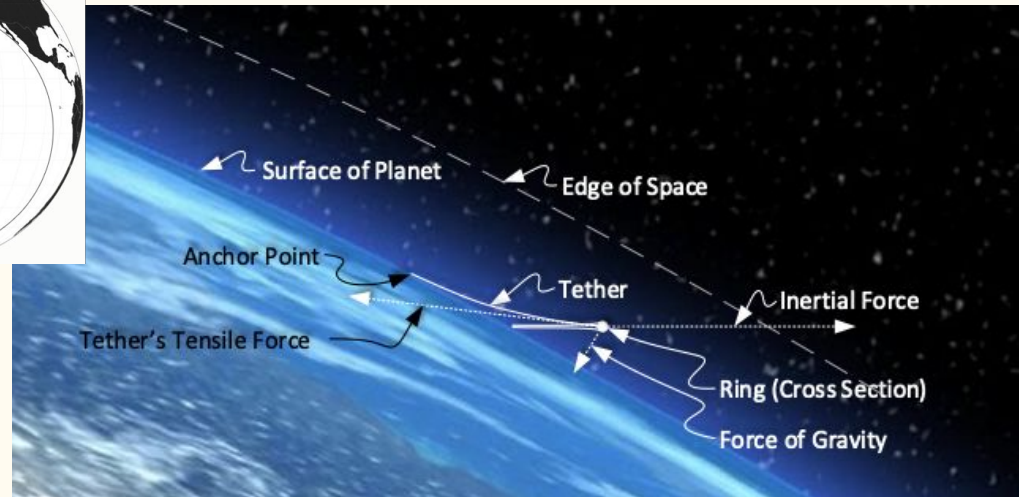


It stays aloft by generating and properly combining inertial forces with tensile forces to offset the pull of gravity.

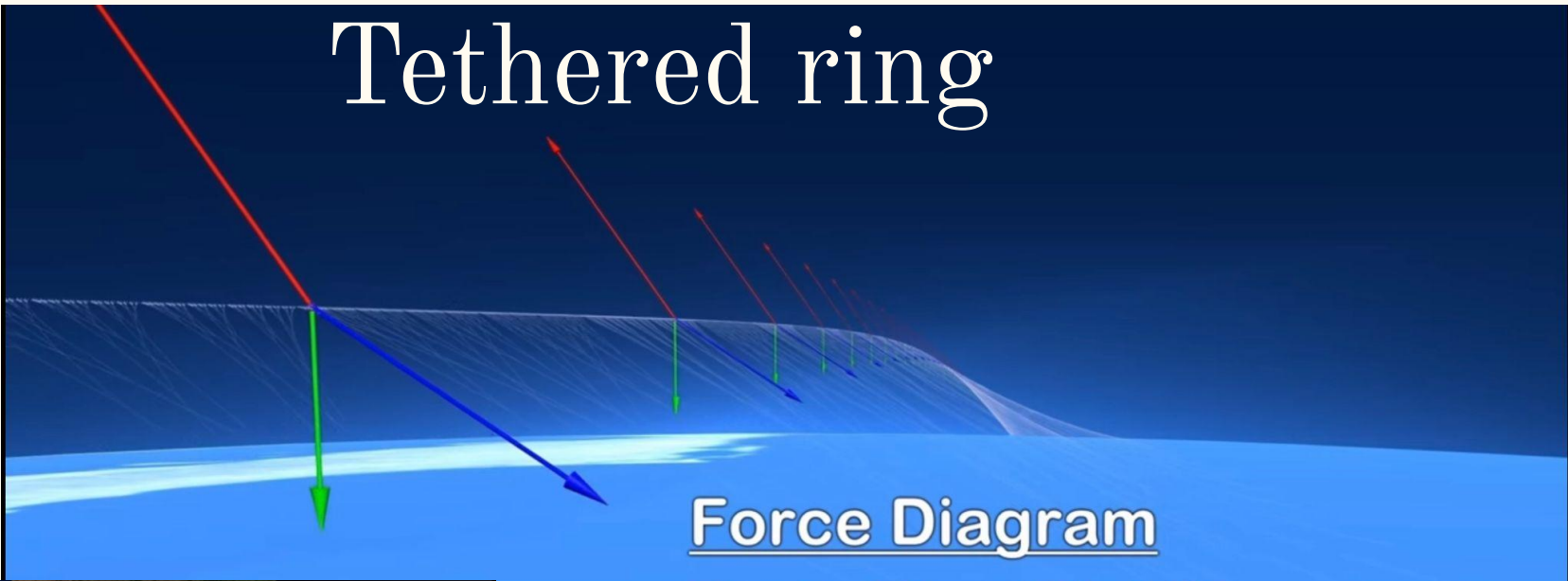


Space launch for 10%
of the current price

Carbon neutral global travel



Tethered ring

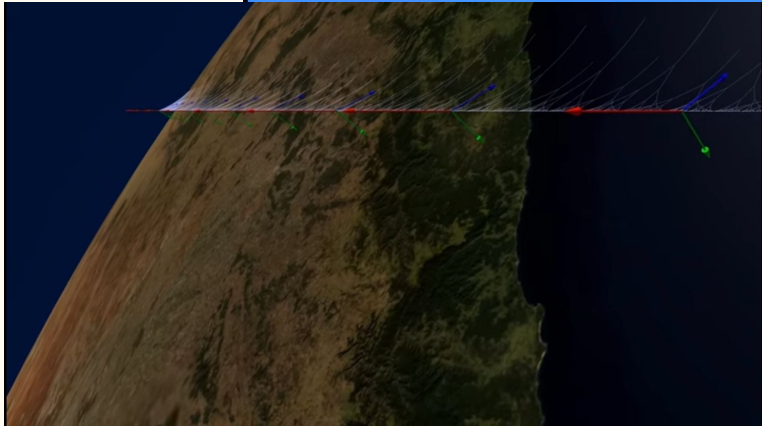


Force Diagram

Red - Ring Rigidity

Green - Earth Gravity

Blue - Tether Pull



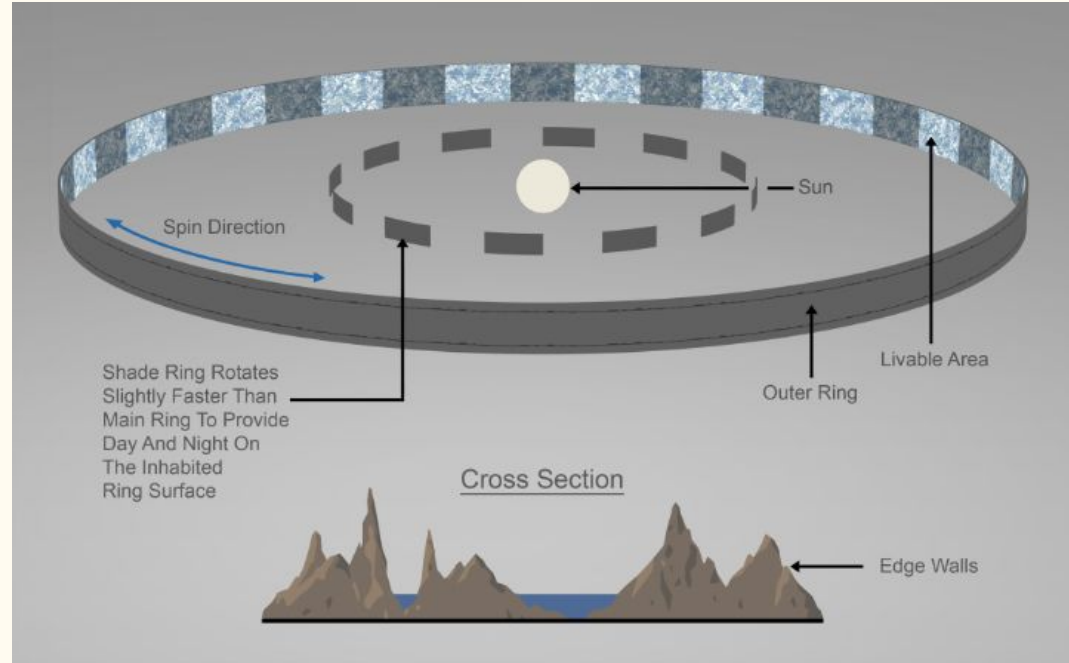
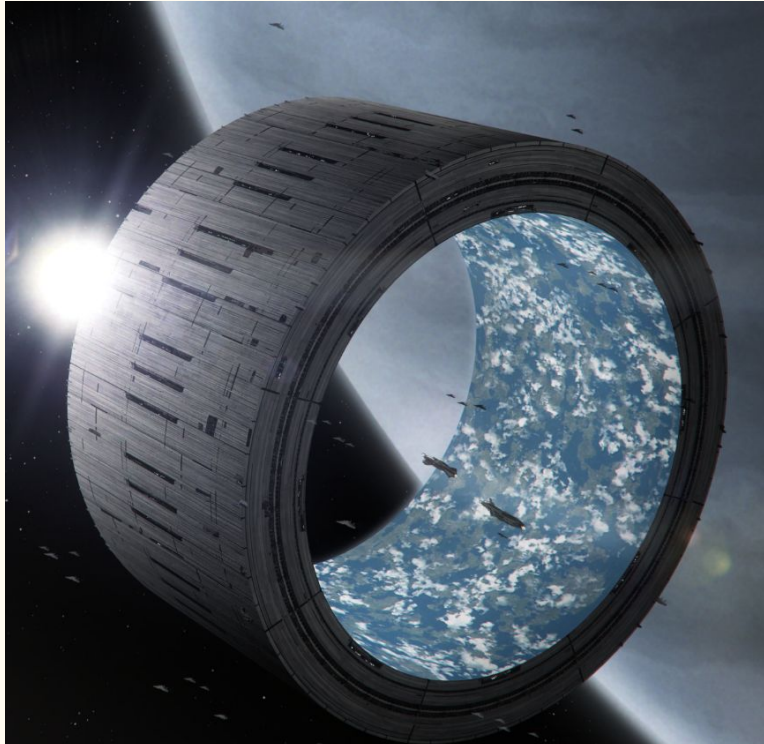
What opportunities lie outside
of Earth's orbit?

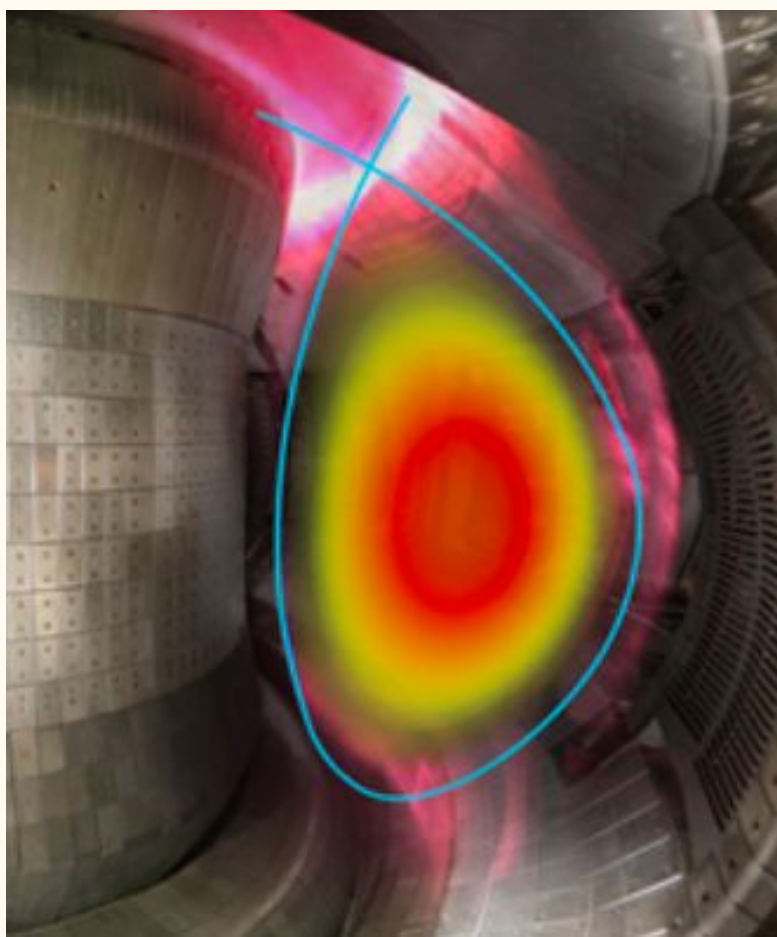


A futuristic space scene featuring a complex network of dark, metallic orbital megastructures. The structures consist of multiple curved, overlapping rings and a central vertical beam, all set against a dark, reddish-brown nebula. A bright, glowing sun or star is positioned in the center, casting a lens flare and illuminating the scene. The overall atmosphere is mysterious and technological.

Orbital Megastructures

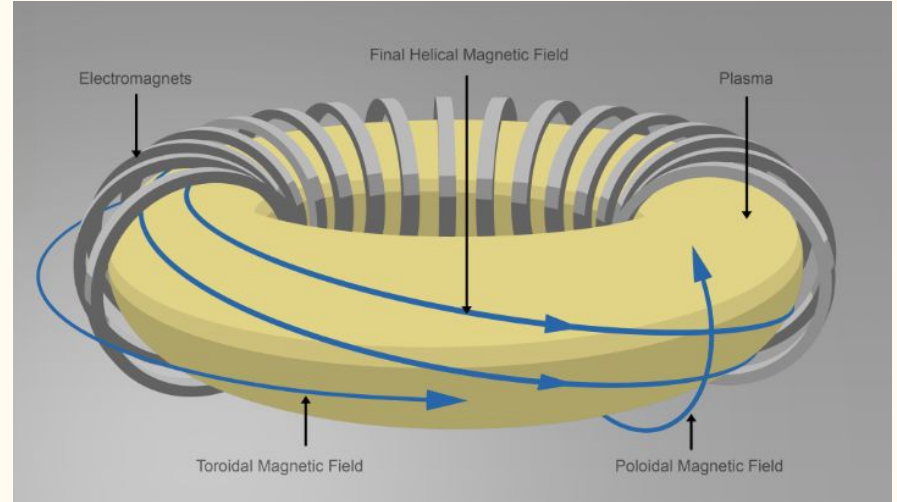
Ring Worlds





Experimental Advanced
Superconducting Tokamak (EAST)

Artificial Star

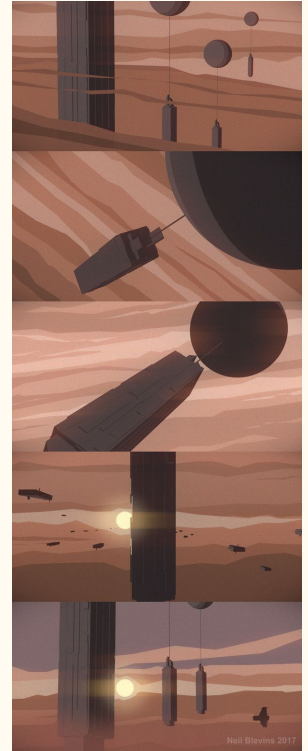
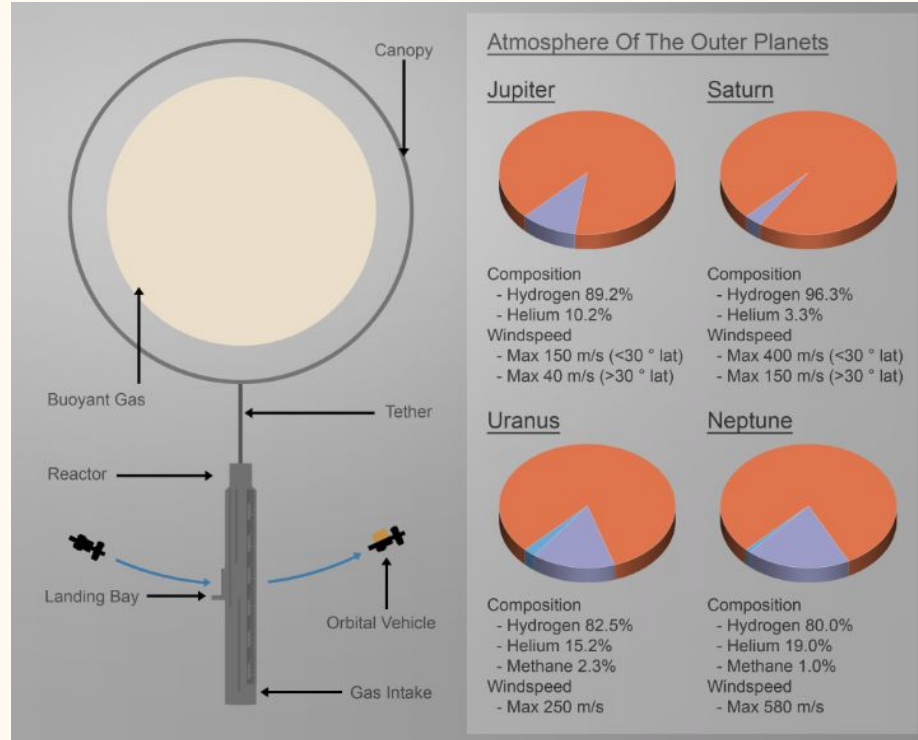


Stellar fusion reactor

Gas Giant Refineries



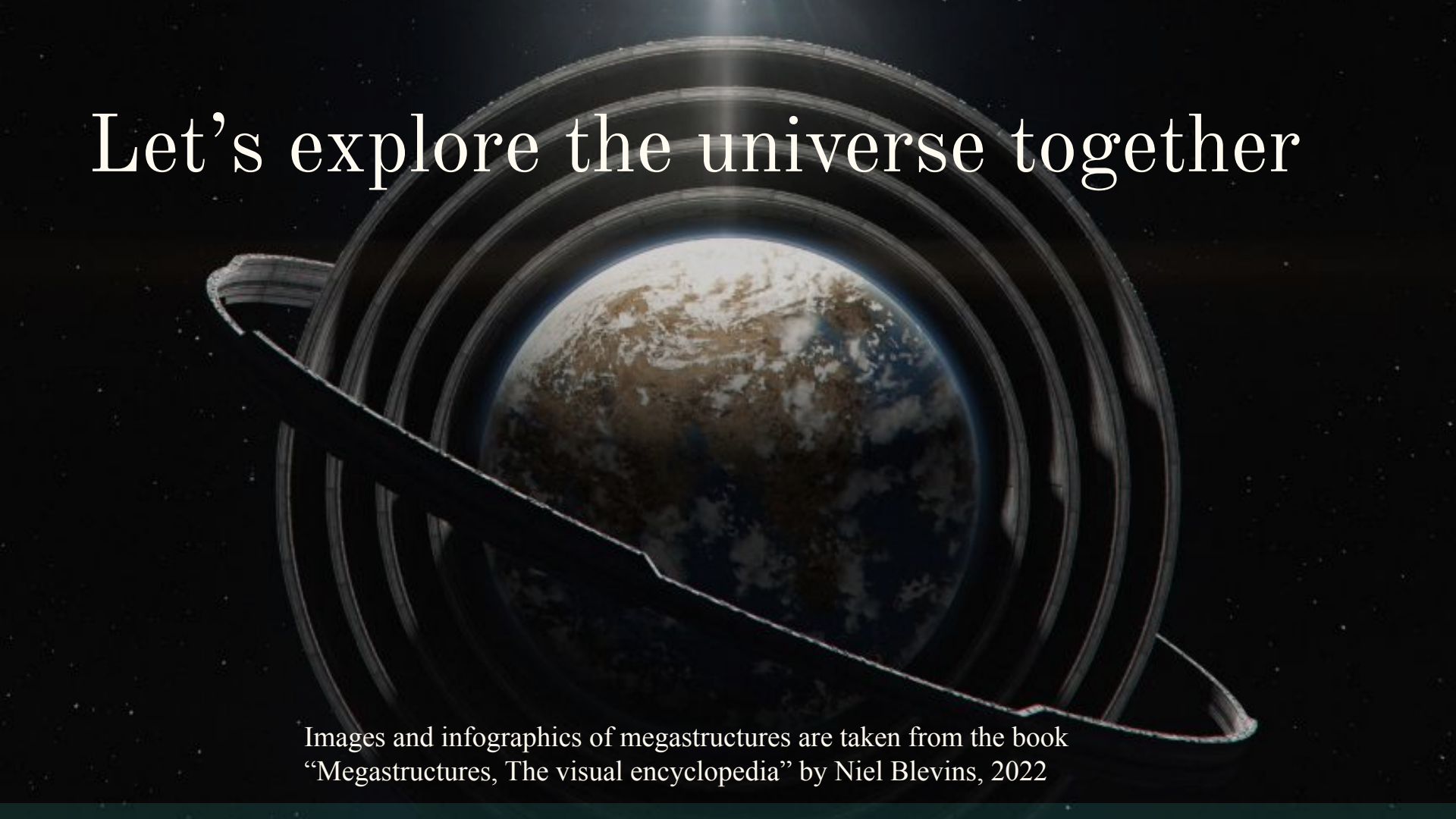
Gas Giant Refineries



Let's explore the universe together



Let's explore the universe together



Images and infographics of megastructures are taken from the book
“Megastructures, The visual encyclopedia” by Niel Blevins, 2022

Further Reading



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Further Reading



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