Advanced Civilizations Below the Dyson Net
Level: Terraformed Goldilocks Planets

Part 1 of the Power Point
To make it fit in email
Advanced Civilizations Below the Dyson Net
Level:Terraformed Goldilocks Planets

By Ron Metzner
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Fairbanks, Alaska, USA
North America, Earth, Sol, Milky Way
So do we qualify as an Advanced Civilization?

“A little learning is a dang’rous thing;
Drink deep, or taste not the Pierian spring:
There shallow draughts intoxicate the brain,
And drinking largely sobers us again.”

Alexander Pope. Essay on Criticism (Part 2)

http://www.poetryfoundation.org
Not yet ...

“A little knowledge is a dangerous thing....
So is a lot.”

Attributed to Albert Einstein

http://www.goodreads.com/quotes
Sol’s Three Planets in the “just right for liquid water” or “Goldilocks” Temperature Zone. The name refers to the “just right” porridge temperature from the children’s folk tale Goldilocks and the 3 Bears.
The Geologic Carbon Dioxide Cycle on Earth

- Volcano
- Rock weathering
- Dissolution
- Subduction
- Sedimentation
- $\text{CO}_2$
- $\text{H}_2\text{CO}_3$
- $\text{CaCO}_3$
Weathering Is a Series of Chemical Reactions

Granite

\[ \text{CO}_2 + \text{CaAl}_2\text{Si}_2\text{O}_8 + 3\text{H}_2\text{O} \leftrightarrow \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + \text{CaCO}_3 \]

Clay

Limestone
Weathering Is a Series of Chemical Reactions

\[
2\text{CO}_2 + 2\text{H}_2\text{O} \quad \Leftrightarrow \quad 2\text{H}^+ + 2\text{HCO}_3^- \\
\text{CaAl}_2\text{Si}_2\text{O}_8 + 2\text{H}^+ + \text{H}_2\text{O} \quad \Leftrightarrow \quad \text{Ca}^{2+} + \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 \\
\text{Ca}^{2+} + 2\text{HCO}_3^- \quad \Leftrightarrow \quad \text{CO}_2 + \text{CaCO}_3 \\
\text{(Calcite or aragonite)}
\]
Weathering Is a Series of Chemical Reactions

\[ 2\text{CO}_2 + 2\text{H}_2\text{O} \iff 2\text{H}^+ + 2\text{HCO}_3^- \]

\[ \text{CaAl}_2\text{Si}_2\text{O}_8 + 2\text{H}^+ + \text{H}_2\text{O} \iff \text{Ca}^{2+} + \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 \]

\[ \text{Ca}^{2+} + 2\text{HCO}_3^- \iff \text{CO}_2 + \text{CaCO}_3 \]

\[ \text{CO}_2 + \text{CaAl}_2\text{Si}_2\text{O}_8 + 3\text{H}_2\text{O} \iff \text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4 + \text{CaCO}_3 \]
Our Earth Photographed from Saturn by the Cassini Spacecraft July 19, 2013. It’s all We’ve Got and it Looks Pretty Small from that Far Away
Apollo 8 was the mission which put humans into lunar orbit for the very first time. Until then, no human eyes had seen the far side of the Moon - (all previous images of the far side of the moon had come from robot spacecraft).

Virtually all of the photographs scheduled for the Apollo 8 mission were to do with capturing high resolution images of the lunar surface - both of the far side and of potential landing sites on the near side.
Artist’s Interpretation of the Top Overlord Karellin from the novel Childhood’s End
New Jerusalem Painting; Map of Africa, Europe and the Arabian Peninsula; the New Jerusalem Base Superimposed as a Square on the Map (centered over Jerusalem)

Centaur of Ice Equivalent to Earth’s Oceans (Solid White Circle) Saturn’s moon Titan (Black Circle)
Impact Circles Compared to New Jerusalem: Square is New Jerusalem base outline. Solid White Circle is Rhea’s diameter. Open Black Circle is Titan’s diameter projected onto the map.
Deep Impact: Accidentally Hit Earth with Objects Intended for Venus
Water World: Accidentally Double the Volume of Water in the Oceans
Accidental Return to Hadean Era
Advanced Civilizations Below the Dyson Net
Level: Terraformed Goldilocks Planets
(continued)

Part 2 of the Power Point
To make it fit in email
Finding the Formula for Kinetic Energy of an Object in Circular Orbit Using Kepler’s 3rd Law

\[
\frac{T^2}{R^3} = 1
\]

Velocity

\[
V = \frac{2 \pi R}{T} \text{ for circular orbits}
\]

Period

\[
T = R^{3/2}
\]

\[
V = \frac{2 \pi R}{R^{3/2}}
\]

\[
V = \frac{2 \pi}{R^{1/2}}
\]

Kinetic energy

\[
KE = \frac{1}{2} M V^2
\]

\[
KE = \frac{1}{2} M \left( \frac{2 \pi}{R^{1/2}} \right)^2
\]

\[
KE = 2 \pi^2 \frac{M}{R}
\]
Finding the Formula for the Change in Kinetic Energy of an Object in One Circular Orbit Dropping to Another Circular Orbit

The change in kinetic energy needed to change orbits is:

$$\Delta KE = 2 \pi^2 \frac{M}{R_f} - 2 \pi^2 \frac{M}{R_i}$$

$$\Delta KE = 2 \pi^2 \frac{M (R_i - R_f)}{R_i R_f}$$
Determining the Mass of a Small Moon Made of Ice with a Diameter of 850 Miles
{and a chance to use what’s called unit analysis (if you are a physicist) or stoichiometry (if you are a chemist)}

\[ M_{\text{ice}} = \rho V = \rho \left(\frac{4}{3} \pi R^3\right) \]

Assume most of the interior ice is at 1.4 Gpa pressure.

Ice density = 1.37 gm/cm³ (this is called Ice IX)

\[ M = \frac{1.37 \text{ g} \times 1 \text{ kg}}{1 \text{ cm}^2} \times \frac{10^6 \text{ cm}^3}{1 \text{ m}^3} \times 4 \pi \times \left(\frac{425 \text{ mi}}{1 \text{ mi}} \times \frac{5280 \text{ ft}}{1 \text{ m}} \times 0.3048 \text{ m}\right)^3 \]

\[ M = \frac{1.836 \times 10^{21} \text{ kg}}{1 \text{ cm}^2} \times \frac{1 \text{ m}^3}{1 \text{ cm}^2} \times 3 \times 1 \times \left(\frac{1 \text{ mi}}{1 \text{ m}} \times \frac{1 \text{ ft}}{1 \text{ m}}\right)^3 \]

\[ V^2 \Rightarrow \text{units of velocity}^2 \text{ are A.U.}^2/\text{Years}^2 \]
Determining The Drop in Kinetic Energy to Move a Small Moon from the 79 A.U. to the Orbit of Venus

(more unit analysis)

\[ V^2 \Rightarrow \text{units of velocity}^2 \text{ are } \text{A.U.}^2/\text{Years}^2 \]

\[ \Delta KE = 2 \pi^2 (1.836 \times 10^{21} \text{ kg}) \frac{(R_i - R_f)}{R_i R_f} \]

\[ \Delta KE = 2 \pi^2 (1.836 \times 10^{21}) (0.723 - 79)/(0.723*79) \text{ kg*} \text{A.U.}^2/\text{Year}^2 \]

\[ \Delta KE = \frac{-49.667 \text{ kg} * 1 \text{ A.U.}^2 * 1 \text{ Year}^2}{1 \text{ Year}^2} * \frac{(1.45 * 10^{11} \text{ m})^2 * 10^{21}}{(60 * 60 * 24 * 365.25 \text{ sec})^2} \]

\[ \Delta KE = -9.85 \times 10^{29} \text{ joules}; \]
Determining The Drop in Kinetic Energy to Move a Small Moon from the Orbit of Saturn to the Orbit of Venus (still more unit analysis)

2.) What about a slowing down the same size ice moon from Saturn’s distance 9.582 A.U. to the Venus distance 0.723 A.U.?

\[
\Delta KE = 2 \pi^2 (1.836 \times 10^{21} \text{ kg}) \frac{(R_i - R_f)}{R_i R_f};
\]

Conversion factor: \(1 \text{A.U.}^2/1 \text{yr}^2 = 0.21112 \times 10^8 \text{m}^2/\text{s}^2\)

\[
= 2 \pi^2 (1.836 \times 10^{21}) \frac{0.723 - 9.528}{0.723 \times 9.528} \text{ kg*A.U.}^2/\text{Year}^2
\]

\[
\Delta KE = -2.35 \times 10^{29} \text{ joules} \quad \text{(a little less energy but a heck of a lot closer)}
\]
So how does one slow down a small moon? Consider fusion explosions. A drive based on the principles developed in Project Orion\(^9\) is a possibility. It is analogous to a one piston, external explosion engine. The energy released in a one-megaton explosion is \(4.20 \times 10^{15}\) joules.

3.) A simple number of explosions estimate is:

\[
\text{# of explosions} = 2.347 \times 10^{29} \text{ joules} / (4.2 \times 10^{15} \text{ joules/explosion})
\]

\[
\text{# of explosions} = 5.59 \times 10^{13} \quad (55.9 \text{ trillion explosions. That's a lot!})
\]

This is not something we can do. It is something a more advanced civilization might be able to do.
Spread Sheet Simulation: Ice Centaur Slowed; Changes from 76 A.U. to 0.723 A.U. Circular Orbit

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<th>Sun Earth model</th>
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**ORBIT**

**ENERGY/KG**

- KED (joules/kg)
- PED (joules/kg)
- Total ED (joules/kg)
Drake’s Equation for Estimating the Probability of Finding an Advanced Civilization

\[ N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L \]

The Drake equation, formulated in 1961, estimates the number of alien civilizations we could detect. Recent discoveries of numerous planets in the Milky Way have raised the odds.
Looking Down at the Formation of Earth Starting Point of the 45 meter Timeline Tape Representing 4.5 billion Years of Earth History
Earth’s Geologic Timeline: Standing at the Formation 4.5 billion Years ago Looking towards Recent Times
Reaching the Far End of the Tape from the Formation of Earth
Looking at the Last Millimeter that Represents the Most Recent
100,000 Years of Human History
Advanced Civilizations Below the Dyson Net Level: Terraformed Goldilocks Planets

If stars with all their Goldylocks planets transformed are out there, that implies that civilizations can survive for a LONG time.