

The Nature of Advanced Civilizations I

OLLI5

10/23/2009

Mean lifetime of technological civilizations

This follows an analysis first made by Sebastian von Hoerner.

1. Consider the possible fates possible for a technological civilization.
2. Assign to each a probability and lifetime required to reach that outcome

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Fate	Lifetime (L_i)	Probability (P_i)	$P_i L_i$
Self-destruction via war	100 years	0.2	20
Catastrophic impact	10^7		
Evolution of star	10^9		

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Fate	Lifetime (L_i)	Probability (P_i)	$P_i L_i$
Self-destruction via war	100 years	0.2	20
Plague	200	0.2	40
Famine	200	0.2	40
Eco-catastrophe	300	0.2	60
Global Theocracy	200	0.2	40
Catastrophic impact	10^7	0.001	10^4
Evolution of star	10^9	0.001	10^6

10/23/2009 Mean Lifetime = $\sum P_i L_i \approx 10^6$ years

Far more important result than the actual value
for the mean lifetime:

The largest contribution of the various factors in
 $\sum P_i L$ comes from the cosmically limited
civilizations unless they are extremely
improbable.

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Drake Equation: Conclusions

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*It's hard to estimate N
from the Drake Equation*

*But one can still draw
interesting conclusions.*

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$$N = R_* f_p n_e f_l f_i f_c L$$

R_* is known: 1—10 stars/year

n_e is almost certainly < 1

all f 's are < 1 , so

$$N < 10 L$$

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$$N = R_* f_p n_e f_l f_i f_c L$$

Conclusions:

- Communicating civilizations are plausible
- N is large only if L is large
- Even if L is large N may not be large

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but beware of:

Spin

All of these newly discovered planets make ET life more likely

- It has always been assumed that $f_p \approx 1$
- "Hot jupiters" either eat earthlike planets or
- shake them out of their orbits

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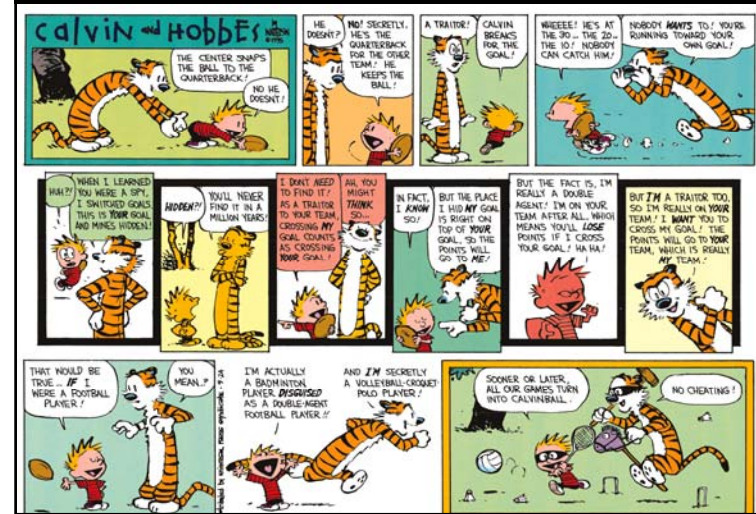
Hidden subscripts

For example:

- If R_* is really $R_{\text{solar-type star 5Gyr old}}$ then $R_* \approx 10^{-3}$ stars/year
- If we can only detect beacons then $-L = L_{\text{beacon-broadcasting}}$

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"Gotchas"



Drake Equation "Gotchas"
Gotchas are like the rules in Calvin ball. You don't know about them until it's too late

For example:

- Real Jupiters: necessary to avoid a dinosaur basher impact every 10^5 years*
- The Moon: necessary to stabilize the tilt of the Earth's axis*

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2 other simple results

- Unless civilizations which have a cosmic limit on L are very rare ($P \ll 10^{-3}$), they are the ones we are most likely to contact.*
- We are most likely to contact the most "luminous" civilizations.*

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2 other simple results

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My spin on this

There is no significant chance for success unless L is very large --- millions or billions of year as a technological civilization.

At a 100 years we are probably the youngest TC in the Galaxy

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Energy is an essential resource for a technological society

We are in the position of having to project how a technological civilization will evolve over periods of millions or maybe even billion of years. Clearly we cannot do this in any detail.

We can be fairly sure that the activities of any civilization will be constrained by certain physical laws.

Two crucial laws are:

- Conservation of Energy

- Energy is neither created nor destroyed.
- If a civilization uses energy to do something that energy must come from someplace---they must “pay” for it.
- When dealing with heat, energy conservation is called the 1st Law of Thermodynamics.

- The 2nd Law of Thermodynamics

- Energy cannot be “used” with 100 efficiency.

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Energy cannot be “used” with 100 efficiency.

This is not a precise statement of the law, but gets the idea across in the context we use it.

RTR’s freshman chemistry teacher had a nice summary:

1st Law---You can't win;

2nd Law---Not only can't you win, you can't even break even;

3rd Law (which we're ignoring): If you play long enough you'll lose everything you have.

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Who will send SETI Messages?

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Directed Beacons

For a directed 21 cm beacon broadcast with a 100m antenna the electric power costs $\$10^6/\text{yr}$. A message of few minutes would cost a few \$ to send. This one the reasons Drake embarked on Project OZMA.

A mega\$/yr is neither ridiculously expensive nor cheap. Under what circumstances might their scientists get funding at this level?

- They know we are here from our TV signals

Remember detecting the 0.1 Hz carrier of a terrestrial TV station over interstellar distances requires a Project Cyclops (1000×100 antennae @\$ $10^8/\text{ant}$) level effort.

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Since we have only been broadcasting for about 50 years there must be one closer than 50 ly or 20 pc. To have a good chance for a civilization closer than this the number of civilizations now in the Galaxy must be $> \text{few } 10^7$.

- They can detect planets with O rich atmospheres and thus know there is life on Earth.

It took $\sim 10^9$ years from first appearance of O until a technological civilization emerged. Hence when the funding agency asks

“Well, how long are you going to need this funding at a level of $\$10^6/\text{yr}$ before you can show us some positive results?” The answer has be: 10^{8-9} years. It would be amusing to see the face of a NASA or NSF grants officer in this case.

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Omnidirectional Beacons

Conceptually an omnidirectional beacon is just going fishing for *ETI*, and might be an easier sell.

There is still a problem: for an omnidirectional beacon the cost increases to $\$10^{12}/\text{yr}$!

If they must communicate over galactic distances, say 10 kpc, then a directed beacon costs $\$3 \times 10^{10}/\text{yr}$ and an omnidirectional beacon to $\$10^{17}/\text{yr}$ or the US debt per 4 min.

Clearly broadcasts are a game for power rich societies.

Basically, are there any societies that would consider $\$10^{12}/\text{yr}$ throwaway money?

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Power Rich Societies

Could we become power rich?

The only source of power that offers the potential for large growth in the immediate future is nuclear fusion.

The only functioning fusion reactor is the Sun, which suggests we first consider solar power.

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Energy input or
Total Wattage Intercepted:
Terrestrial or TWIT

1 TWIT $\approx 2 \times 10^{17}$ watts

Total energy use on Earth $\approx 4 \times 10^{13}$ w
 ≈ 0.2 milli-twit

The solar luminosity L_{\odot} is 4×10^{26} watts
= 2 gigatwits

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We are what you might call a “millitwit” society.

If our major source of energy was solar energy the absolute limit to our power usage is 1 twit and realistically probably only a small fraction of that.

Suppose we develop some new source of energy. Even if that energy source pollutes in no other way, the Second Law of Thermodynamics guarantees that there will be heat pollution. The new source of power will be an additional heat input to the Earth.

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Ice ages: $-7C \sim 10$ milli-twit

CO₂ Greenhouse: $3C \sim 4$ milli-twit

Major climate change if energy input into lower atmosphere changes by a few 10's of milli-twit.

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If we remain on Earth

Our ultimate power use is limited to only a factor of a few 100 more than now. With an annual growth rate of 3% we saturate in a few centuries.

Broadly speaking we will always be a millitwit society.

SETI broadcasts will never seem cheap.

The same will apply to any civilization which lives on a planet.

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Civilizations that are power rich and can afford SETI broadcasts not only must abandon their home planet

They must abandon all planets!

Colonizing Mars and the Moon would only buy us a factor of 2—3. We need factors of millions.

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