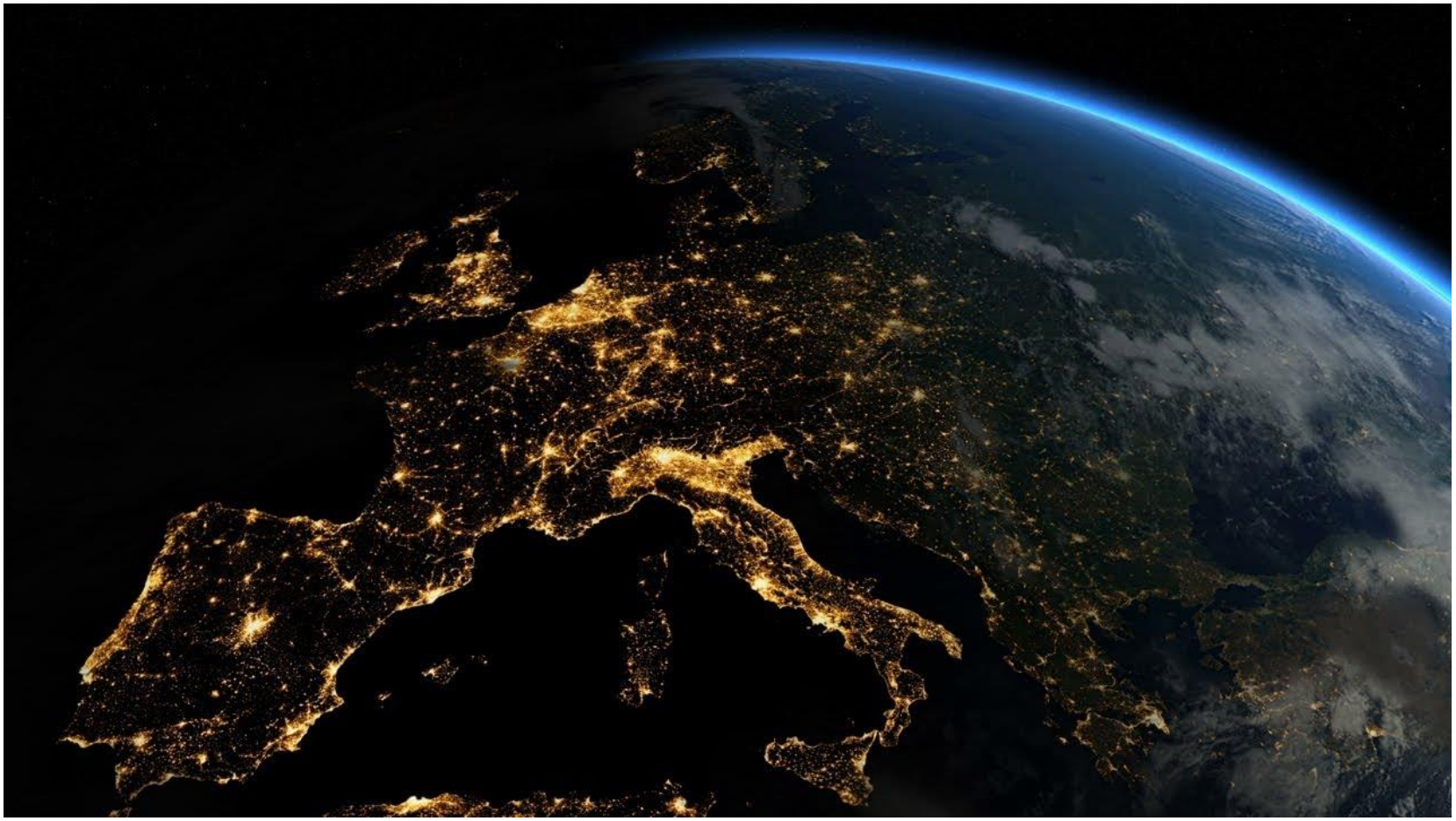
Astrobiology and Exoplanets Part 2

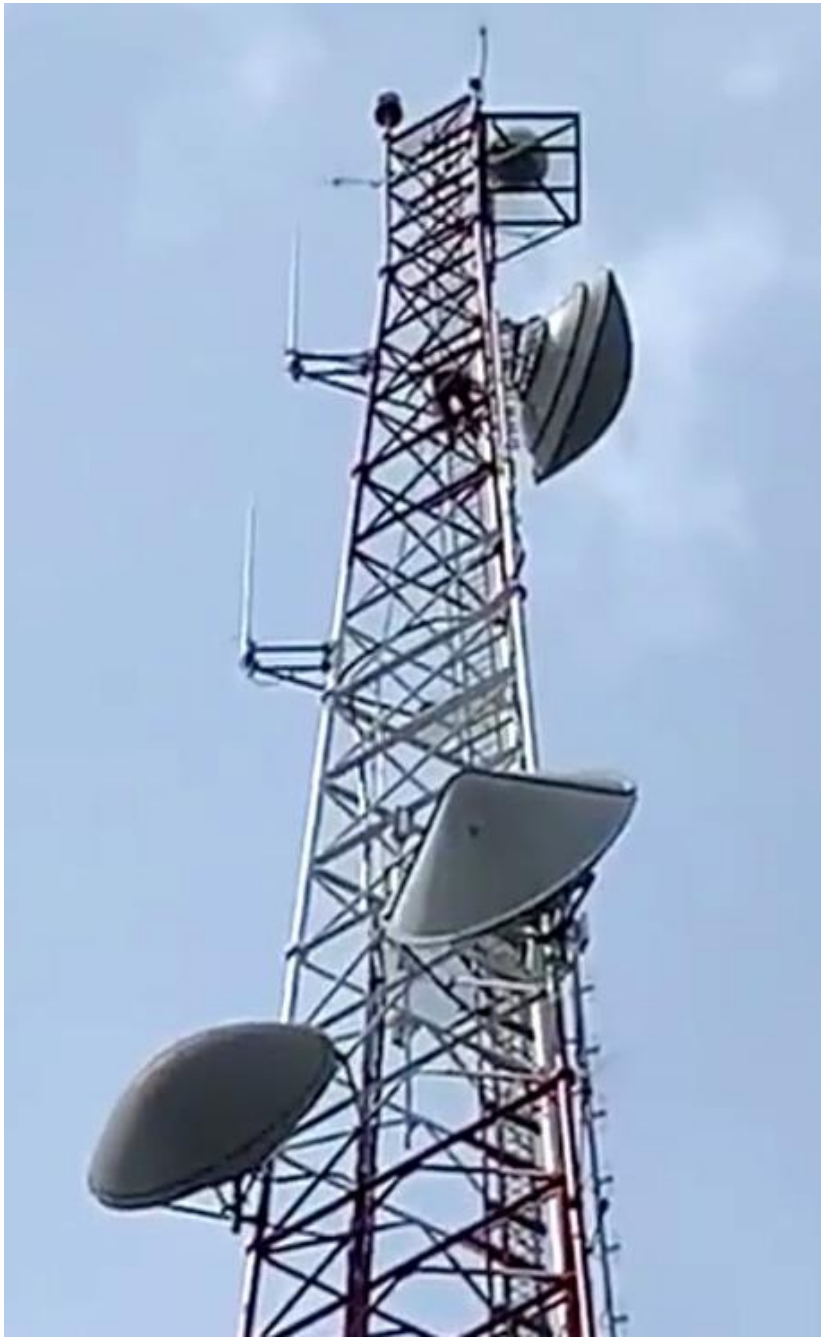
Humans are considered

1. Intelligent species/intelligent civilization
2. Intelligent species that is technologically advanced.
3. Intelligent species that has radio communication.



Earth's History of Radio Communication

1895: First radio signal (Marconi)
1920: First AM radio broadcast (Detroit, MI)
1927: First television moving picture broadcast (Farnsworth)
1948: First FM radio broadcast (Columbus, OH)
1952: First UHF television broadcast (Portland, OR)
1962: First satellite television broadcast
1973: First cellular telephone (Motorola)



Humans have been broadcasting radio signals for communication purposes for 130 years.

Radio is a class of light.

All light travels through space at light speed 300,000 km/s.

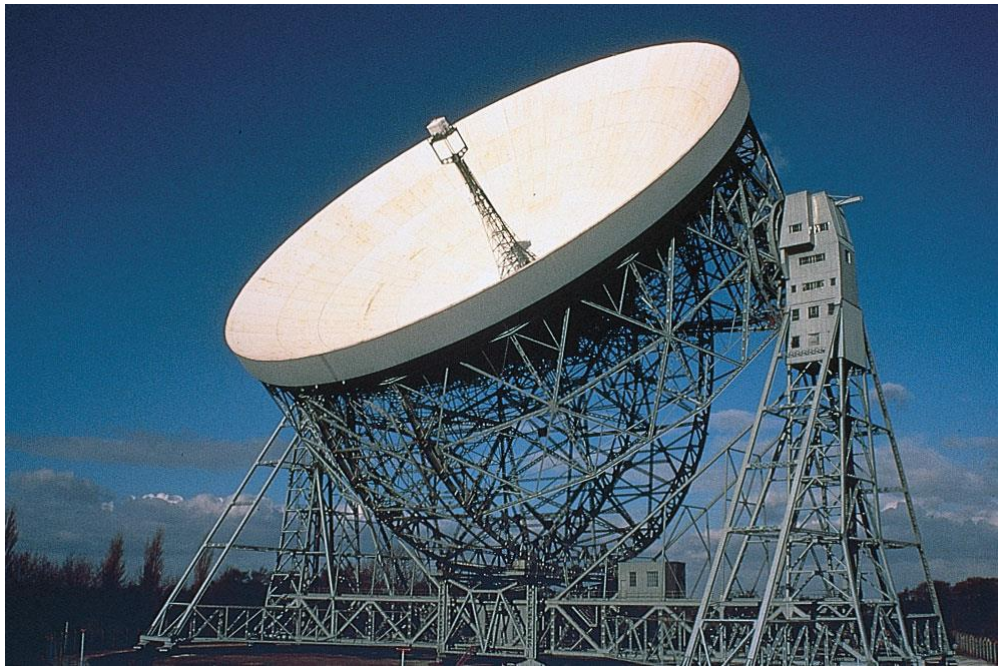
All light travels a distance of 1 light year each year.

I Love Lucy: Original broadcast 1951

- Radio signals from that original broadcast has moved through space from Earth at the speed of light for 70 years.
- I Love Lucy, season 1 episode 1, is now arriving at any star (or planet) 70 light years distance from Earth.

If modern human civilization is intelligent, technologically advanced, and able to radio communicate through space…

by default, any intelligent extraterrestrial civilization in the Milky Way galaxy should also be able to radio communicate through space.



Radio telescopes receive radio (light) from space. Most observe distant quasars and galaxy emissions. Some scan the radio frequency range for "extraterrestrial" radio emissions.

What is the **probability** of an **intelligent, technologically-advanced civilization that has the means to use radio communication** in the Milky Way Galaxy?

Why radio?

- Interstellar travel is time prohibitive for physical travel between solar systems.
- Light will continue to move until it is intercepted by matter or a black hole.
- We will NEVER encounter an alien lifeform in person, but it is more likely to intercept its communications.

Drake Equation

Frank Drake, in 1961, one of the founding members the SETI Institute (Search or Extraterrestrial Intelligence), developed the Drake Equation.

Drake equation is a probabilistic model for estimating the number of intelligent civilizations that use radio communication in the Milky Way.

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

N = number of radio communicating advanced civilizations.

R_* = rate of star formation in the Milky Way

f_p = fraction of stars with planets.

n_e = mean number of planets that can support life

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

f_l = fraction of planets in which life develops.

f_i = fraction of planets in which life develops intelligence.

f_c = fraction of civilizations that develop radio communication.

L = The number of years that a civilization will have radio communication.

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

R_* = rate of star formation in the Milky Way

In the Milky Way, there are approximately 1-10 new stars created each year (based on the estimate of 3 solar masses of nebular material forming a new star).

1/yr
2/yr
3/yr
10/yr

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

f_p = fraction of stars with planets.

- Binary stars vs. Solitary stars
- Main sequence stars vs. giant, supergiant, and white dwarf stars.

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

n_e = mean number of planets that can support life.

- Terrestrial vs. Jovian planets
- Habitable zone planets

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

f_l = fraction of planets in which life develops.

- Lifespan of star (short or long enough)
- Chemical probabilistic estimates.

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

f_i = fraction of life in which life develops intelligence.

Variable answers. Evolution dependent.

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

f_c = fraction of intelligent civilizations that develop radio communication.

Depends on education, war, disease, and other factors.

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

L = The number of years that a civilization will have radio communication.

- Advanced civilizations are self-destructive and will eventually doom themselves.
- Humans already have 130 years of radio communication…

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

Let's Try it!