The Drake Equation

How many alien societies exist, and are detectable? The Drake Equation estimates N, the number of radio transmitting societies currently existing in the Milky Way galaxy. The terms are defined as follows:

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

These mean:

N The number of civilizations in the Milky Way galaxy whose electromagnetic emissions are detectable

R_* The rate of formation of stars suitable for the development of intelligent life (number per year).

f_p The fraction of those stars with planetary systems.

n_e The number of planets, per solar system, with an environment suitable for life.

f_l The fraction of suitable planets on which life actually appears.

f_i The fraction of life bearing planets on which intelligent life emerges.

f_c The fraction of civilizations that develop a technology that produces detectable signs of their existence.

L The average length (i.e. number of years) that such civilizations produce such signs.

Usefulness

The Drake equation is a summary of the factors affecting the likelihood that we might detect radio-communication from intelligent extraterrestrial life. The last three parameters, fi, fc, and L, are not known and are very difficult to estimate, with values ranging over many orders of magnitude. Therefore, the usefulness of the Drake equation is not in the solving, but rather in the contemplation of all the various concepts which scientists must incorporate when considering the question of life elsewhere.

The equation has drawn attention to some scientific problems related to life in the universe, for example abiogenesis, the development of multi-cellular life, and the development of intelligence itself.

Values

We have estimates for the first four values of the equation:

R_* The Milky Way star formation rate is 1 - 3 stars per year.

f_p Most stars are seemingly orbited by planets.

n_e There could be as many as 40 billion Earth-sized planets orbiting in the habitable zones of sun-like stars and red dwarf stars within the Milky Way. 11 billion of these estimated planets may be orbiting sun-like stars.] Since there are 100 billion stars in the galaxy, this implies $f_p \cdot n_e$ is roughly 0.4.

f_l Based on geological evidence from the Earth, the fraction of potentially habitable planets that go on to form life may be high.

Criticisms

The Drake Equation was composed in 1961, so it represents the state of technology as it existed at the time. In recent years our ability to detect signs of life directly (using telescopes) has improved considerably.

The Drake equation does not allow for the fact that intelligent civilization may occur on planets where it has happened once.

Since there are no observed extraterrestrial civilizations despite the vast number of stars, at least one step in the Drake Equation must be acting as a filter to reduce the final value. According to this view, either it is very difficult for intelligent life to arise, or the lifetime of such civilizations, or the period of time they reveal their existence must be relatively short.

References

Drake Equation:
https://en.wikipedia.org/wiki/Drake_equation#History

Fermi Paradox:
https://en.wikipedia.org/wiki/Fermi_paradox

Search for extraterrestrial intelligence:
https://en.wikipedia.org/wiki/Search_for_extraterrestrial_intelligence

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