Search for Extraterrestrial Intelligence
ASTR 101

Jordan Ell
jordan.ell7@gmail.com
V00660306

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Instructor: Jillian Scudder

1 Objective

This report will demonstrate how to properly estimate the number of intelligent civilizations there may be inside of the Milky Way Galaxy and how one can calculate how far away the nearest one to Earth may live.

2 Introduction

The search for extraterrestrial life (SETI) in our universe is a number of methods and procedures carried out my professional and amateur astronomers in the hopes of detecting other forms of life, specifically, intelligent life. Methods include electromagnetic radiation monitoring with radio or other types of telescopes [1] seeing as it would be the quickest way to communicate across the largest distances. The first of these listening methods was conducted against Mars in 1924 with large radio telescopes [2], to which people thought they might get a response from little green men.

With the recent discoveries and influx of planetary discoveries in our universe, scientists have begun to wonder if there is actually a high percentage of possibility that life exists in complex forms not just on our planet. Given that the Zoo Hypothesis [3] is not a likely solution, the Drake Equation tries to tackle this problem.

The equation discovered by Frank Drake in 1961 is a composite of the obstacles which are believed to be the larger circumstance which make up the possibility for complex life to form. These obstacles include how many stars have plants, how likely is life to form and evolve and so on. The problem with this equation and SETI in general is that all fields are virtually unknown. Only very rough estimates can be made for each filed, although they continue to become better estimates.

While these estimates become better through scientific measurements, report lab will focus on the Drake equation in a much more reduced manor. This report will attempt to count the number of intelligent civilizations that are currently alive inside of our Milky Way Galaxy. This reports will make use of much given data and very large estimates based on largely accept numbers about human existence, life existence on Earth etc. However, not all of the given data is strong enough to rely heavily on the outcome of this report. After the number of civilizations is derived, this report will hold a minor discussion in Section 8 about possibilities of communication and contact with these civilizations.

The major assumptions this lab report makes are as follows: stars are spread evenly across the Milky Way; many small planets are undetectable by current means but do exist; surface temperature of a planet is caused mostly by distance from its star; wherever life can form it will rapidly; intelligent civilizations can craft tools; the human civilization will last for at least 500,000 years which may be a good approximation for such a largely unknown factor [4].

3 Equipment

The equipment used for this lab is as follows: an image of the centre of the Milky Way Galaxy, a measurement magnifying glass, a Sharp EL-510R calculator, a computer running Windows XP, and a modelling program for radial velocity and star luminosity calculations and data graphs.

4 Procedure

Given an image of the centre of the Milky Way Galaxy, the first step done was to measure how many stars appear inside of a 1mm squared area on the picture. This was done using the provided measurement magnifying glass. The result of this measurement can be seen inside of Table 1. Next, Equation 1 was used to extrapolate this information into the number of total stars inside of the Milky Way Galaxy.

Next, the given computers with the modelling program installed were used. This program was used to determine whether or not current methods could detect planets of size Earth and Jupiter. This was done by editing the planet models radius, mass and orbital inclination inside of the program. The results for these finding can be found in Section 8. Then, an estimate for what fraction of stars have planets was made based off of the given data from the Kepler space telescope which was observing around 4000 stars with approximately 2000 planet candidates. The result of this estimation were calculation with Equation 2 and results can be seen inside of Table 1.

Next, and estimation of how many habitable planets there are inside of each solar system. This was done by assuming that habitable means there is liquid water on the planet. Therefore, maximum and minimum distances away from the star were calculated using Equation 3 for a given planet to have liquid water. These distance were put onto the data given in Table 2. Equation 4 was then used in order to give a rough estimate on average how many solar systems have planets. Results can be seen inside of Table 1.

Next, an estimate was made of what fraction of habitable planets contain life. This was done by looking at Earth as an example and given the data that Earth has had liquid water for 4 billion years and life for 3.9 billion years. The result of this estimation were calculation with Equation 5 and results can be seen inside of Table 1.

Next, an estimate was made of what fraction of life is intelligent. This term intelligent for this report was defined as the ability to create and use tools inside of the civilization. This being the case, it was estimated that civilizations last for 500,000 years given that a civilization ending disaster will occur every 1 million years. This time is also subject to the lifetime of the star that the civilization depends on. The result of this estimation were calculation with Equation 6 and results can be seen inside of Table 1.

Finally, the Drake equation was carried out by multiplying all drake parameters together in Equation 7 which resulted in 17915.625 civilizations being inside of our Milky Way Galaxy. As an extra step, it was found that the nearest civilization to ours would be approximately 595.89 light years away by using Equation 8.

5 Observations

All observations for this report were made on the day of 2012-Nov-19. As all calculations and measurements made inside of this report are based off of given data, weather conditions and time of day have not been reported as they hold no effect. The measurement of how many stars are inside of our Milky Way Galaxy can be found in the Section 6. All other measurements are made using very rough approximations and their explanations can be found inside of Section 4 along with how they were calculated. Rough calculations and measurements can be found at the back of this lab report as well.

6 Tables and Measurements

Drake Parameter	Measurement	Result
N_*	8	1.2 Billion
f_p	2600	.65
n_e	5	1.25
f_L	-	0.98
f_i	-	0.3
F_s	500,000	$6.25\text{x}10^{-5}$

Table 1: Measurements of parameters inside the Drake Equation.

Solar System	Planet	Distance (AU)
Our Solar System	Mercury	0.387
Our Solar System	Venus	0.723
Our Solar System	Earth	1.00
Our Solar System	Mars	1.524
Our Solar System	Jupiter	5.203
Ups Andromedae	-	0.06
Ups Andromedae	-	0.83
Ups Andromedae	-	2.51
55 Cancre	-	0.04
55 Cancre	-	0.11
55 Cancre	-	0.24
55 Cancre	-	0.78
55 Cancre	-	5.77
HD160691	-	0.09
HD160691	-	0.92
HD160691	-	1.5
HD160691	-	4.17

Table 2: Given data of solar system planet's distance from the star.

7 Calculations

To calculate the real number of stars in our Milky Way Galaxy, the measurement of N_* in Table 1 can be multiplied by 150,000,000 to make up the ratio of the measured size of 1 square millimetre. Equation 1 below shows this.

$$\mathrm{N}_* = S * 150,000,000 \tag{1}$$

To calculate the fraction of stars which have planets, Equation 2 below is used. By dividing the measurement of f_p in Table 1 by the total number of stars in our sample size, we get the percentage of stars which are estimated to have planets around them.

$$\mathrm{f}_p = \frac{P_{estimated}}{S_{total}} \tag{2}$$

To calculate the distance a planet must be away from its star to account for a given surface temperature, the following equation may be used.

$$\mathrm{D}_p = \frac{82944}{T_P^2} \tag{3}$$

To calculate the number of habitable planets in each solar system we simply take the measurement of n_e in Table 1 which is the total number of habitable planets in a sample size and divide by the number of total planets in that sample. This can be seen in Equation 4.

$$\mathrm{f}_e = \frac{P_{habitable}}{P_{total}} \tag{4}$$

To calculate the chance that planets have life on them and get the measurement of f_L in Table 1, we take the number of years Earth is known to have like and divide it by the number of years Earth is known to have liquid water on its surface. This can be seen in Equation 5.

$$\mathrm{f}_L = \frac{3.9Billion}{4.0Billion} \tag{5}$$

To calculate the lifetime of a civilization, we take the measurement of F_S in Table 1 which is the estimated lifetime of a civilization and divide it by the lifetime of a normal start such as our Sun. This can be found in Equation 6.

$$\mathrm{f}_L = \frac{500,000}{8.0Billion} \tag{6}$$

To calculate the number of intelligent civilizations inside of out Milky Way Galaxy, we simply take all of the parameters to the Drake equation and multiply them together. This can be seen in Equation 7.

$$\mathrm{I}ntelligentCivilizations = N_* * f_p * n_e * f_L * f_i * F_s \tag{7}$$

To calculate the nearest civilization in our galaxy to ours, we find the average area a civilization occupies in the Galaxy and then take the square root of it. This can be seen below in Equation 8.

$$\mathrm{N}earestCivilization = \sqrt{\frac{\pi * 45,000^2}{IntelligentCivilizations}} \tag{8}$$

8 Questions

The following questions and answers are asked inside of lab 8,Search for Extraterrestrial Intelligence, inside of the lab manual for ASTR101. The questions have been repeated for the reader.

Q. Would you be able to detect a Jupiter mass planet in a one year orbit?

A. You would be able to detect a Jupiter mass planet as it has enough mass to pull the star around giving a reading in radial velocity and it is also large enough to give off a dip in the star's luminosity reading. Being able to see these types of planets is a direct cause of the selection effect with our current detection methods.

Q. Would it be possible to detect planets like the Earth?

A. An Earth sized planet would not be able to be detected because it is too small to show a dip in the star's luminosity and it is not massive enough to show movement in the star causing radial velocity. These are the reasons the main methods of searching for planets right now do not often show Earth sized planets that are around 1AU away from the star.

Q. Compare the average distance between civilizations to the lifetime of a civilization.

A. In this report's estimated case, the distance to the nearest civilization is 595.89 light years while each civilization is estimated to survive for around 500,000 years. This means that the civilizations would be detectable sometime during the lifetime of the civilizations. They would be able to send about 830 messages in total between civilizations in this time span.

Q. Would our earliest radio signals have made it to the nearest civilizations yet?

A. Seeing as our earliest radio signals have only been travelling for about 50-60 years, these distant civilizations would not have picked up on them, nor would they see them for another 520 years.

Q. Based upon your above calculated distance to the nearest alien civilizations, do you expect it to detect any civilizations? Would conversations between civilizations be possible?

A. I would expect, that sometime during our civilizations lifetime, we would be able to detect some of the more near civilizations in our Galaxy. Communications would be possible, however the full time for one conversation would be well over 1000 years, thus no single human would be able to carry our such a conversation. Also, being able to send and receive signals is one thing, but given the amount of radio noise inside of space and Earth and supposedly another advanced civilizations, just detecting them from the noise may prove to be a large part of the problem [5].

Q. What can you decipher about the creatures that made this plaque? Explain what you base it on.

A. We can determine that the satellite left from the third planet of its origin solar system and the direction it took to leave that solar system. We know there are two different sexes among the same origin species. We know the origin species height in comparison to the satellite. We can see how the origin species has mapped their star given certain distances away from pulsars and which pulsars are indicated by the distance and spin rate given in the left hand side of the plaque. Finally, we know the hydrogen molecule for a standard measuring device.

9 Conclusions / Discussions

This report has shown how to calculated an estimated number for how many intelligent civilizations there may be inside of our own Milky Way Galaxy as well as how close those civilizations may be to Earth. This report has also answered, through these calculations, the likelihood of contact with these civilizations.

10 Evaluation

I found this report and lab very tedious. I believe that the Drake equation is one of the most ludicrous equations ever created inside of the sciences. Why have we continued to indulge an equation who's margin of error approaches 100%? This makes the equation itself meaningless. Although, the equation does have us thinking in the correct direction and bring to the surface many of the variables that would have to be understood. I am a user of the SETI@home project though and found this report an interesting little side note to the data that is actually be collected and processed in the real world.

References

[1] Schenkel, Peter (May 2006). "SETI Requires a Skeptical Reappraisal". Skeptical Inquirer. Retrieved June 28, 2009.

[2] Dick, Steven (1999). The Biological Universe: The Twentieth Century Extraterrestrial Life Debate. ISBN 0-521-34326-7.

[3] Ball, John A. (Jul 1973). "The Zoo Hypothesis". Icarus 19 (3): 347349

[4] "PBS NOVA: Origins - The Drake Equation". Pbs.org. Retrieved 7 March 2010.

[5] Radio noise. ITU-R Recommendation P.372, International Telecommunication Union, Geneva.