Search for Extraterrestrial Intelligence
Astronomy 101

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1 Objective

This lab teaches the Drake equation and all of it's variables. It will calculate the individual variables and then eventually estimate the number of intelligent civilizations that are within reach.

2 Introduction

The search for extraterrestrial intelligence (SETI) is the study performed by many astronomers all over the world with the hopes of discovering extraterrestrial life, but more specifically intelligent extraterrestrial life. Some of the ways we plan to communicate with the *aliens* is by using electromagnetic radiation monitoring with telescopes. This is because that is the quickest method of communication and all our other methods of communication would take far too long.

$$N_c = N_* f_p n_e f_L f_i F_S \tag{1}$$

The Drake equation mentioned above is described in the lab manual is a composition of all the known factors that can be used to compute the chances of intelligent life to form. The equation is very simplified and can only be used as a very rough estimate, and since many of the variables are subjective to the researcher, it is hard to tell what the correct estimate should be. One such variable could be the 'time taken to create a civilization,' for instance.

This report will use the Drake equation in a very rough estimate way, by assuming many values for the variables in the equation in order to simplify the calculations. Further on in the lab I explain each variable and perform the necessary calculations and estimations.

Some of the assumptions this report makes are: evenly spread stars 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, and intelligent civilizations can craft tools (what makes them intelligent).

3 Equipment

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

4 Procedure

Using the measurement magnifying glass, we took the picture of the Milky Way Galaxy and measured how many stars appear in a $1mm^2$ area of the image. This result is shown in Table 1. Next we used Equation 2 to get the total number of stars in the Milky way based on our $1mm^2$ sample.

Then, using the computers and the program to edit the planet model's mass, radius, and inclination inside to find planets similar to the size of Earth and Jupiter. The results for this can be seen in Section 7. Next we used the data from the lab that found 500 extra solar planets out of 4000 observed stars. Therefore the fraction of stars that have planets is 1/8.

Then, we made an estimate for how many habitable planets are in each Solar System. This was done by using data from Earth, and assuming that all life needs water to exist. Therefore the temperature must be in between 273K and 373K. Therfore there must be a minimum and maximum distance from each star and that is calculated with Equation 4 for a given planet to have liquid water. These distance were put onto the data given in Table 3, and then equation 5 was then used in order to give a rough estimate on average how many solar systems have planets.

Next, an estimate was made of what fraction of habitable planets contain life. This was an assumption made to be more optimistic in our results. The assumption is that each habitable planet will have life, therefore the n_e is 1.

Then we made an estimate for what fraction of life is intelligent, which is defined as the ability to create and use tools. Next we assumed that civilizations last 500 thousand years. Results from these calculations with Equation 7 can be see in Table 1.

And finally we were able to plug in all the results into the Drake equation (Equation 8) which calculated the number of intelligent civilizations resulting in 25.78 civilizations being inside of our Milky Way Galaxy. Additionally, it was found that the nearest civilization to ours would be approximately 5553.803 light years away by using Equation 9.

5 Tables and Measurements

Drake Parameter	Measurement	Result
N_*	11	1.65 Billion
f_p	4000,500	1/8
n_e	5, 4	1.25
f_L	-	1.00
f_i	-	0.2
F_s	500,000	$1.00 \text{x} 10^{-5}$

Table 1: Measurements of parameters inside the Drake Equation.

Planetary Property	Value
$\text{Radius}_{\text{planet}}$	1.00 R_j
Inclination	85 degrees
$\text{Mass}_{\text{planet}}$	0.64 M_j
$\text{Orbital}_{\text{period}}$	3.525 days
Semi-Major Axis	0.047 AU
$\text{Radius}_{\text{star}}$	1.15 R_o
$\text{Mass}_{\text{star}}$	1.10 M_o

Table 2: Data recorded from the program for the extrasolar planet.

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

6 Calculations

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 2 below shows this.

$$\mathrm{N}_* = S * 150,000,000 \tag{2}$$

To calculate the fraction of stars which have planets, Equation 3 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.

$$\mathrm{f}_p = \frac{P_{estimated}}{S_{total}} \tag{3}$$

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.

$$\mathrm{D}_p = \frac{82944}{T_P^2} \tag{4}$$

We assume that any planet that is habitable has life on it. Therefore any planet that is in between the distance calculated by 4 will be a planet with life on it.

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

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 7.

$$\mathrm{f}_L = \frac{500,000}{10.0 Billion} \tag{6}$$

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 8.

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

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 9.

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

7 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 civilization's 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 [**?**].

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.

8 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.

9 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.