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GAVRT/SETI Activity 

What Are Our Chances of Discovering a Signal?

Overview: Is there other intelligent life in the Universe or in our own Milky Way Galaxy? That is a question that has long caused us to look up at the stars and ponder if we are alone in the Universe. Considering all the stars that are sprinkled in the heavens above us, what are the possibilities of a signal from an intelligent civilization being discovered? What is the probability of finding such an indicator of intelligent life?

Purpose: The purpose of this lesson is to help students use probability to describe the chances of finding that one signal among billions of stars that would indicate intelligent life.

Required Background Knowledge:

- Read the summaries of statistics and probability.
- Read the paragraph about the number of stars in the Universe, Milky Way, and galactic plane of the Milky Way.
- Read Drake's Equation found at http://www.seti.org/drakeequation
- View Carl Sagan's comments on Drake's equation http://www.youtube.com/watch?v=0Ztl8CG3Sys

Students will be able to: discuss their chances of discovering a signal using probability.

Standards:
From the National Science Standards:
All students should realize:

- As a result of this activity in grades 5-8 and 9-12, all students should develop an understanding of science as a human endeavor, nature of science, abilities of technological design, and understanding about science and technology.
- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they

encounter new experimental evidence that does not match their existing explanations.

- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.

From National Math Standards.

- understand and use appropriate terminology to describe complementary and mutually exclusive events;
- use proportionality and a basic understanding of probability to make and test conjectures about the results of experiments and simulations;

Web Links for Further Investigation These should open.

- Number of stars in the universe http://blogs.discovermagazine.com/80beats/2010/12/01/the-estimated-number-of-stars-in-the-universe-just-tripled/
- Number of stars in the Milky Way http://www.universetoday.com/22380/how-many-stars-are-in-the-milky-way/
- Number of stars in the galactic plane Could not find a site
- Number of stars in the galactic plane that GAVRT can see Could not find a site
- Drake's equation http://www.seti.org/drakeequation
- View Carl Sagan's comments on Drake's equation http://www.youtube.com/watch?v=0Ztl8CG3Sys

Resource/Materials Needed:

- Summaries of statistics and probability
- Summary of number of stars in Milky Way
- Computer to use to investigate the listed URLs
- Paper and pencils

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One-Computer Classroom:

If there is only one computer in the classroom, it is recommended that teachers allow for teams of students to view the listed URLs. The articles on statistics, probability, How Many Stars in the Milky Way, and Drake's equation can be printed so that other students can review the material until it is their turn to visit the URLs on the computer.

Teacher notes:

- It is suggested that you read through the material summaries and look at the URLs before attempting to do this activity with your students.
- Have your students make a prediction about the chances or probability of discovering a signal before they attempt the activities or read any of the summaries.
- Print the statistics and probability summaries.
- Print the summary about the Milky Way and Drake's equation.
- You may want to have your students work in groups of 4 or 5.

Student Activity:

Part one:

Before you read any of the summaries, make a prediction about the probability of discovering an extraterrestrial signal. You may make your predication in a ratio, percentage, or just make a statement about the chance of finding such a signal.

My prediction on the chances of us finding an extraterrestrial signal is…

_____

_____

Part two:

Read the summaries of statistics and probability.

Now you are to figure out the probability of finding a black marble in a spherical fish bowl the size of the Houston Astrodome that is filled white marbles. Here are some facts you will need.

- A marble is about .50 inches
- The spherical fish bowl is 660 feet in diameter (notice this is the diameter)
- The formula for figuring the volume of a sphere is 4/3(symbol for pi)radius3 (radius cubed)
- Please notice that the marble is in inches, and the fish bowl is in feet. You will need to adjust one of them to be in feet or inches.

- Once you get the volume of the Astrodome fish bowl, how many white marble the size of your black one would fit in the bowl?
- Once you have established how many white marble would fit into the fish bowl, what is the probability of finding the black marble?
- Look back at the summaries of statistics and probability. Write a brief essay of you findings using the terms you see in the summaries.

Part three:
Read the Milky Way Summary and digest the figures. Look back at your original prediction. Make a new prediction based on the facts in the summary. You will have to do a little math.

My second prediction for the probability of finding an extraterrestrial signal in the Milky Way Galactic Plane is…

When something is difficult to find, there is an old saying, "It is like finding a needle in a hay stack." The black marble in the huge fish tank would not be any easier to locate. You now understand the great odds we are up against when we try to find a signal from an alien civilization. Even though the probability of finding an extraterrestrial signal is slim, you just might be the group of scientists that records the first alien radio signal. Then we would know we are not alone in the Universe.

Part four
Read the summary of Drake's equation. Compare his equation with its additional constraints with what you have discovered about the problems of finding an alien signal. Do his ideas add to the difficulties of finding a signal? Are there other constraints that you can think of? Write a brief summary that includes Drakes ideas and your own findings. Did the probability change because of these additional ideas?

Additional Information:

Short Summary of Statistics

Statistics is a collection of data that is organized so that it makes sense. It can deal with data from surveys to experiments. The statistical data that you will analyze will be in the form of a waterfall plot. Your plot will provide the tool for you to make a prediction about the information your turn on the radio telescope discovered.

You may want to be familiar with a few terms in statistics.

- Descriptive statistics is used for summarizing or describing data. It can be modeled in such a way to account for randomness (an extraterrestrial signal) in an observation and then be used for making a conclusion about the data. It is used in research such as what you are doing with the radio telescope.
- Inferential statistics is derived from descriptive statistics. When you make an inference or guess about your data you are inferring something that can be further tested.
- Theoretical statistics is concerned with the arguments and the math that are involved when a theory is projected from the data.
- Mathematical statistics involves dealing with probability involved and computation and the design of the research.

Statistics is closely related to probability. You are going to use your data or statistics to make a judgment about the information in your waterfall plot and what the probability is that a signal is included in your plot.

What Is Probability?

What is probability? Proportion, percentage, odds, likelihood, and chance are terms that are often used when describing probability. What you are trying to describe is the chance or likelihood that something will happen or has happened. Probability is based on long-term predictions that involved thousands of trials or observations. Our population must be big enough, such as all the stars GAVRT can see in the galactic plane of the Milky Way, to allow us to make a prediction about the probability of advanced intelligent life beyond Earth.

Some terms involved in probability are:

- An experiment involves chance or the probability that can lead to results called outcomes. What will be the outcome of your run on the 34 meter radio telescope?

- An outcome is the results of a single trial or a single run of the telescope.
- An event is one or more outcomes. An event for us would be if more than one class discovers the same signal during their session.
- Probability is then going to be the measure of how likely an event is. If three or more school "see" the same signal, what is the probability that what was discovered is truly a signal from an extraterrestrial civilization?

How Many Stars?

In order to understand the enormity of the Universe and its population of stars, the next time you go to the beach pick up a handful of sand and try to count the grains in your hand. The Universe contains more stars than all the grains of sand on planet Earth, and you could add two more zeros. That means the Universe has somewhere around 300 sextillion stars or 300,000,000,000,000,000,000,000 or 300 x 10 (21st power).

When you look up in a dark night sky void of city lights, you can see about 2,500 stars, but that's not all there is. The Milky Way contains between 200 billion to 400 billion stars. Our galactic center holds about 60% of our galaxy's stars. How many is that? GAVRT "sees" most of the entire galactic plane of our barred spiral galaxy.

In that galactic plane there are natural cosmic noisemakers, such as pulsars, quasars, and turbulent pockets of interstellar gas. These noise makers cover a wide band of frequencies. The key word here is wide band. The radio signals we are searching for cover a narrow band of radio frequencies, no more than a few Hertz or less wide. Any signal less than 300 Hz must be artificially produced. So the narrow band signals will be beacon for which we will search.

Once you have a number of the possible stars in our Milky Way, imagine a very large fish bowl of yellow, red, white, and blue marbles or stars. In that bowl put one black marble to represent the extraterrestrial signal we are searching for. What is the ratio of signal to the number of stars that we have to investigate? Could there be more than one signal? What would having more than one black marble or signal do to your ratio or percentage of stars to signal? Now that you understand the difficulty of your search, it is time for you to investigate Drake's Equation.

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Drake's Equation

In 1960's, a young astronomer turned a radio telescope on a nearby star hoping to receive an extraterrestrial message. Thus began Frank Drake's search and ponderings about the possibility of receiving an alien message. After much thought, Drake developed a formula for evaluating the possibility of hearing an extraterrestrial signal.

$$N = R^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L$$

This formula considers many factors that Drake found to be important when determining the possibility of communicating with an alien civilization.

The number N on the left-hand side represents the number of extraterrestrials that use radio technology. There may be better ways to send signals across space. A more advanced civilization might not use radio signals at all. If so, we will not discover those using radio telescopes.

The first symbol on the other side of the equal sign is R. This is the rate of sun-like stars that are formed in the Milky Way. Why search only in the Milky Way? We only consider looking in our own galaxy because the radio signal from another galaxy would just be too faint for our radio telescopes to capture. There are conflicting numbers for this symbol because of improved scientific instruments. Drake used 10 billion, but today with new knowledge from our space telescopes that number may well be much higher. Carl Sagan suggested that the number may be 400 billion.

The next symbol (f/p) is the fraction of those stars that have planets. Back in the 1960's this number was much lower than it is today. Carl Sagan decided that a quarter of the 400 billion stars would possibly have solar systems revolving around them. That means there could be 100 billion stars with planets. That number may well be much higher. When the James Webb Space Telescope is launched in 2018, we will be able to improve this estimate to more closely match what our Milky Way contains.

The third symbol (n/e) stands for the number of planets in a star system that would be able to support life. Drake initially picked two because in our solar system Earth and Mars were the best chances for planets able to support life. However, after current investigations with outer solar system moons, it may well be that other places such as Titian and Europa also contain forms of life. For now we will leave that factor at two. Meaning in our Milky Way, there may be 200 billion planets with life of some form.

Next (f/l) is a really hard factor to determine. That is how many Earthlike planets are there on which life has arisen. That number is uncertain. Carl Sagan was optimistic and used a factor of one. Drake was more conservative and used .01.

F/i is another factor impossible to determine. It stands for the number of planets with intelligent life. If you are optimistic, you would, like Carl Sagan, believe that once life evolved, it would eventually be what we consider intelligent. At best guess, this is has a factor of about 50%. Using f/l and f/i we can get the number down to 1 billion planets with intelligent life.

The next factor (f/c) after determining the number of planets with intelligent life is to try to determine the numbers that have the ability to communicate with radio waves. This factor has been determined to be between 10% and 20%. However as our civilization continues to improve technologically, we have shifted away from radio waves to buried optical fibers. Our radio traffic is fading. If extraterrestrial life has developed technology beyond radio waves, we will not receive a radio signal from them.

The final factor (L) is the length of time that an intelligent civilization, one that is able to communicate, continues to exist. Civilizations might have succumbed to a natural disaster such as an impact from an asteroid or comet or might have been exterminated by a disaster of their own making such as a nuclear catastrophe. In Drake's time that number was estimated at 10,000 years, but the life span of extraterrestrial civilization may be as long as a million years or longer. Over the long history of the Milky Way, civilizations on extraterrestrial worlds may have come and gone. They may no longer exist during the same time period that we are occupying. This final factor may be 1/millionth.

Drake's final number of possible planets with intelligent life that communicates with radio waves turns out to be around 2,000 stars. 2000 out of all the stars in the Milky Way is a very small number. The hunt is on, and though it may be difficult, it is not impossible!

Questions:

Some of the other questions that you might want to investigate are:

- Do we search a small number of stars in great detail?
- Do we search a large number of stars without looking in great detail?
- What is the possibility of receiving false alarms?
- What is the possibility of receiving noise?

As with all investigations, one question may give rise to more. Keep a journal of your questions as you complete your investigation. If these questions have not been answered when you have finished your GAVRT/SETI scan, you may need to do further investigations using NASA websites. You are on the cutting edge of scientific research. Your journey may need to continue after your project is complete.