Search for Extra-Terrestrial Intelligence

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Astronomy Club
SET

• Does it make sense? (is anyone out there?)

• How To

Or a few selected things about it!
Part I

Is Anyone Out There?
Is Anyone Out There?

There may be, because, to begin with,

The Universe is a big place
Is Anyone Out There?

There may be, because:

The Universe is a big BIG place

The Earth is just a planet around the Sun, which is a star in a spiral arm at 30 thousand light-years from the center of our galaxy (the Milky Way)

Our galaxy has another 30 billion stars, in a disc 100 million light-years across

There are about 100 billion galaxies in the Universe

It's full of stars!
Is Anyone Out There?

It didn't take long for life to appear on Earth, so it may not be that hard for it to happen naturally (creationists may disagree)

Intelligent life seems kind of harder (but not as much since Republicans leave the Office)

We are very special... like everybody else (no privileges - “Copernican principle”)
How many talking ETIs are there?

A way to estimate the probability:

\[ N = R^* \times f_p \times n_e \times f_l \times f_i \times f_c \times L \]

The Drake equation

N = Number of civilizations in our galaxy with detectable emissions

\( R^* \) = Rate of star formation
\( f_p \) = Fraction of those stars with planetary systems
\( n_e \) = Number of planets, per solar system, with an environment suitable for life
\( f_l \) = Fraction on which life actually appears
\( f_i \) = Fraction of life bearing planets on which intelligent life emerges
\( f_c \) = Fraction of civilizations that develop a technology that releases detectable signs of their existence into space.

L = The length of time such civilizations release detectable signals into space (survival time)

A nice way to sort our ignorance... let's play the game!
Part II

How To
How To... communicate?

Even if they are far away, we can listen to (and send them) signals in the form of electromagnetic radiation (radio, light et al)

It's easy to produce, travels fast and is easy to detect. If they want to send us information, it is very likely that they use it.
How to... listen to e.m. radiation?

The atmosphere blocks many frequencies:

- Radio is easy
- Light can be very focalized (lasers)
- There is only so much you can do on the Earth's surface

Diagram:
- Gamma Rays, X-Rays and Ultraviolet Light blocked by the upper atmosphere (best observed from space).
- Visible Light observable from Earth, with some atmospheric distortion.
- Most of the Infrared spectrum absorbed by atmospheric gasses (best observed from space).
- Radio Waves observable from Earth.
- Long-wavelength Radio Waves blocked.
How to... listen to all those frequencies?

Maybe we don't have to.

The most abundant element, H, emits a natural radio signal at a wavelength of 21 cm. It also happens to be at a minimum of the background noise from the galaxy, and is free from absorption by the interstellar medium and our atmosphere.

There is also a natural emission from OH at 18 cm. OH and H make, of course... water! (which is vital for life on Earth).

ETIs know all this. They might gather around this “waterhole” to chat.
How... did people do in the past?

* 1931 – Radio Astronomy “discovered” by UW-Madison and Bell Labs physicist Karl Jansky.
* 1959 – Cocconi and Morrision first propose SETI.
* 1960 – Frank Drake’s Project Ozma, the first SETI. Two stars are observed for two weeks.
* 1960s – Several soviet projects using omnidirectional antennas
* 1961 – Drake presents his Equation for the first SETI conference.
* 1963 – Ohio State University’s “Big Ear”.
* 1967 – Discovery of pulsars cause false alarm.
* 1971 – First international SETI conference, held in Armenia, USSR.
* 1972 – Pioneer 10 & 11 sent with Carl Sagan’s plaque.
* 1974 – Arecibo message.
* 1977 – Voyager 1 & 2 sent with Carl Sagan’s discs.
* 1979 – SERENDIP at UC Berkeley.
* 1986 – SERENDIP II.

..............................

* 1999 – SETI@home.
How To… transmit information?

How do you say something to someone whose language you don't even know?

What kind of things would you like to tell them? (If they were communicating, what would you like them to tell you?)

You'll want to exploit what you have in common: maths and physics!

Let's see an example: the Arecibo Message
The Arecibo Message

1679 (=73x23) bits sent at 2380 MHz, modulated by shifting the frequency by 10 Hz, with a power of 1000 kW

What does it mean?

- Numbers (in binary)
- Atomic numbers of H, C, N, O, P (DNA components)
- Formulas for the sugars and bases in A, C, G, T
- Number of nucleotides in DNA and double helix
- Human, its dimensions and population
- Solar system
- Arecibo Telescope and diameter

We expect them to do something like that
How To... actually listen?

How can you actually search for an extraterrestrial signal?

Which kind of signal do we look for?

Won't you be confused by signals coming from natural sources? Or by human-made transmissions?

Let's see an example: SETI@home
SETI@home

Data taken from Arecibo's 2.5 MHz wide band of the SERENDIP IV instrument working piggy-back.

The “@home” part: To look for weak signals in a broad range of frequencies and/or for a large class of signal types takes a lot of resources... what if instead of using special-purpose supercomputers we allow anyone to participate by downloading a chunk of data and using the idle time in their computers?

Launched in 1999.
SETI@home – what to look for?

Something like this?

Not really!
- **Many frequencies.** It costs much power
- **Natural** astronomical **sources** do that

Better have...
- **Narrow** frequency
  (different possible bandwidths)
SETI@home – what to look for?

Even better...

If they put some **information** on it (very likely)

But not only that...

Planets **rotate** (the transmitter and us), so expect a **Doppler shift**. This will not happen in earth-based sources!
Part III

FAQ
Can they visit us?

Very unlikely!

Stars are **very** far away.

It takes a **great deal of resources** for interstellar travel, and it is not very promising.

It is so much easier to **send signals and to listen**... even we can do it!

UFOs still have to do more with extraordinary claims about ordinary phenomena than with little green men.
Is this real astronomy?

Intelligent organisms are probably part of the Universe (and much more interesting than many other things out there).

They will leave their traces, and we can potentially learn a lot from them.

So yes, looking experimentally for something that is expected to be there is real astronomy.
Yours?
“At this very minute, with almost absolute certainty, radio waves sent forth by other intelligent civilizations are falling on the earth. A telescope can be built that, pointed in the right place, and tuned to the right frequency, could discover these waves. Someday, from somewhere out among the stars, will come the answers to many of the oldest, most important, and most exciting questions mankind has asked.”

The End
Outtakes
<table>
<thead>
<tr>
<th>Name</th>
<th>When</th>
<th>What did they use</th>
<th>What they looked at</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozma</td>
<td>1960</td>
<td>25 m radio telescope</td>
<td>2 stars at 1.420 GHz +/-400 kHz, 100 Hz bandwidth</td>
</tr>
<tr>
<td>Ohio State University</td>
<td>1963-1997</td>
<td>110 m x 150 m x 21 m</td>
<td></td>
</tr>
<tr>
<td>Cyclops</td>
<td>(1971)</td>
<td>~1000 radio telescopes</td>
<td>1-3 GHz</td>
</tr>
<tr>
<td>SERENDIP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentinel</td>
<td>1983</td>
<td>26 m radio telescope</td>
<td></td>
</tr>
<tr>
<td>META</td>
<td>1985</td>
<td>8.4 million 0.05 Hz channels</td>
<td></td>
</tr>
<tr>
<td>SERENDIP II</td>
<td>1986</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COSETI</td>
<td>1990</td>
<td></td>
<td>optical</td>
</tr>
<tr>
<td>META II</td>
<td>1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SERENDIP III</td>
<td>1992</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoenix (MOP resurrected)</td>
<td>1995</td>
<td></td>
<td></td>
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<tr>
<td>BETA</td>
<td>1995</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argus</td>
<td>1996</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SERENDIP IV</td>
<td>1997</td>
<td>168 million-channel spectrometer in Arecibo</td>
<td>1.37-1.47 GHz</td>
</tr>
<tr>
<td>ATA</td>
<td>2008-</td>
<td>350 6.1 m Gregorian radio dishes</td>
<td>multibeaming</td>
</tr>
</tbody>
</table>
Sensitivity of Different Projects
The Ultimate How To:
Do it yourself

SETI Net

Amateur SETI Station
Simplified Block Diagram

System design by:
Daniel Boyd-Fox (KF9ET)
SETI Net

The station consists of consumer-grade electronics to minimize cost and to allow this design to be replicated as simply as possible. It has a 3-meter parabolic antenna that can be directed, a low noise amplifier that covers the 1420 MHz spectrum, a receiver to reproduce the wideband audio, and a PC is used for the control.

The antenna can be pointed and locked to one sky location, enabling the system to integrate on it for long periods. All search data is collected and made available on the internet archive.

It started in the early 1980’s as a way to learn about the science of the search, and has developed several software packages for the amateur SETI community (an astronomical clock, a file manager to keep track of SETI data files, a spectrum analyzer optimized for amateur SETI, remote control of the station from the internet, and other packages).
The SETI League and Project Argus

A membership-supported nonprofit organization, founded in 1994 when US Congress cancelled NASA SETI program. Members include amateur and professional radio astronomers, licensed radio amateurs, microwave experimenters, digital signal processing experts and computer enthusiasts.

Shows the conversion of 3-5 m satellite TV dishes into research-grade radio telescopes of modest sensitivity. The organization concentrates on coordinating a global network of small, amateur-built radio telescopes under Project Argus, an all-sky survey seeking to achieve real-time coverage of the entire sky.

Project Argus continues the all-sky survey of the late NASA SETI program (the targeted search having been continued by the SETI Insititute's Project Phoenix). There are currently 135 Project Argus radio telescopes operating. Project Argus instruments typically exhibit sensitivity on the order of 10–23 Watts/square metre, or roughly equivalent to that achieved by the Ohio State University Big Ear radio telescope in 1977, when it detected the landmark "Wow!" candidate signal.
RIO Scale

Select Class of Phenomenon:
- Earth-specific message, or an ET artifact, capable of contact, or a physical encounter.
- Omnidirectional message with decipherable information, or a functioning ET artifact or space probe.
- Earth-specific beacon to draw our attention, or an ET artifact with a message to mankind.
- Omnidirectional beacon designed to draw attention, or an ET artifact with a message of a general character.
- Leakage radiation, without possible interpretation, or an ET artifact the purpose of which is understandable.
- Traces of astroengineering, or any indication of technological activity by an extant or extinct civilization at any distance, or an ET artifact, the purpose of which is unknown.

Select Type of Discovery:
- SETI/SETA observation; steady phenomenon verifiable by repeated observation or investigation.
- Non-SETI/SETA observation; steady phenomenon verifiable by repeated observation or investigation.
- SETI/SETA observation; transient phenomenon that has been verified but never repeated.
- Non-SETI/SETA observation; transient phenomenon that is reliable but never repeated.
- From archival data; a posteriori discovery without possibility of verification.

Select Apparent Distance:
- Within the solar system.
- Within a distance which allows communication (at lightspeed) within a human lifetime.
- Within the Galaxy.
- Extragalactic.

Select Credibility of Report:
- Absolutely reliable, without any doubt.
- Very probable, with verification already carried out.
- Possible, but should be verified before taken seriously.
- Very uncertain, but worthy of verification efforts.
- Obviously fake or fraudulent.

Like the Richter scale for earthquake severity
Extraterrestrial Grammars

Zipf's law

\[ P_n \propto \frac{1}{n^a} \]

Entropy

Artificial languages

Lincos (1960): an artificial language for Cosmic Chat
“Happy families are all alike; every unhappy family is unhappy in its own way.”

All work and no play makes Jack a dull boy.

Entropy: Complexity vs Randomness

Reference:

Reference:
SETI@home

Already successful in some aspects:

More than 5 million computer users in more than 200 countries. 387 TeraFlops (second fastest supercomputer)

BOINC: an environment to support distributed grid computing.

Radio source SHGb02+14a, the most interesting signal analyzed to date.
Optical SETI

Another possible way of communication: sending out pulses of laser light encoded with information. Since 1998, scientists at Harvard University have been conducting a search for laser pulses from other stars using a 61 inch optical telescope and have taken over 20,000 observations.

Another project currently underway is situated at the COSETI Observatory (Columbus Observatory Optical SETI program) in Columbus, Ohio. It uses a smaller 10 inch aperture optical telescope.

In December 2000, Harvard University began the construction of a new 72 inch optical telescope sponsored by the Planetary Society, dedicated to an 'all-sky' optical SETI project. With 1024 ultrafast detectors that can detect pulses of light as short as a billionth of a second, the new telescope will be able to conduct a full-sky survey in 200 nights - by far the most ambitious OSETI program yet initiated.
Links


Search ETI with your own computer: http://setiathome.berkeley.edu/

SETI Institute: http://www.seti.org/

Cronology: http://www.coseti.org/seticron.htm
Other Aspects of SETI

Kardashev scale – level of use of energy by a civilization

Rio scale – importance of a candidate SETI signal (similar to the Richter scale for earthquakes) (http://www.setileague.org/iaaseti/rioscale.htm)

Fermi Paradox

Invitation to ETI in the internet.
Gaussians are the power curves produced when the Arecibo beam scans a steady celestial radio source. The signal is weak at first, strong when it is at the center of the beam, and then fades again. This produces a bell shaped power curve known as a gaussian.

Pulses represent any celestial radio signal of a fixed frequency that is distinguishable above the background noise.

Triplets are a set of 3 equally spaced pulses. Whereas gaussians represent a constant signal from space, triplets may represent a series of pulses transmitted at fixed time intervals.
The “Wow!” Signal
Sending Probes

Pioneer

Voyager
Arecibo message as binary string