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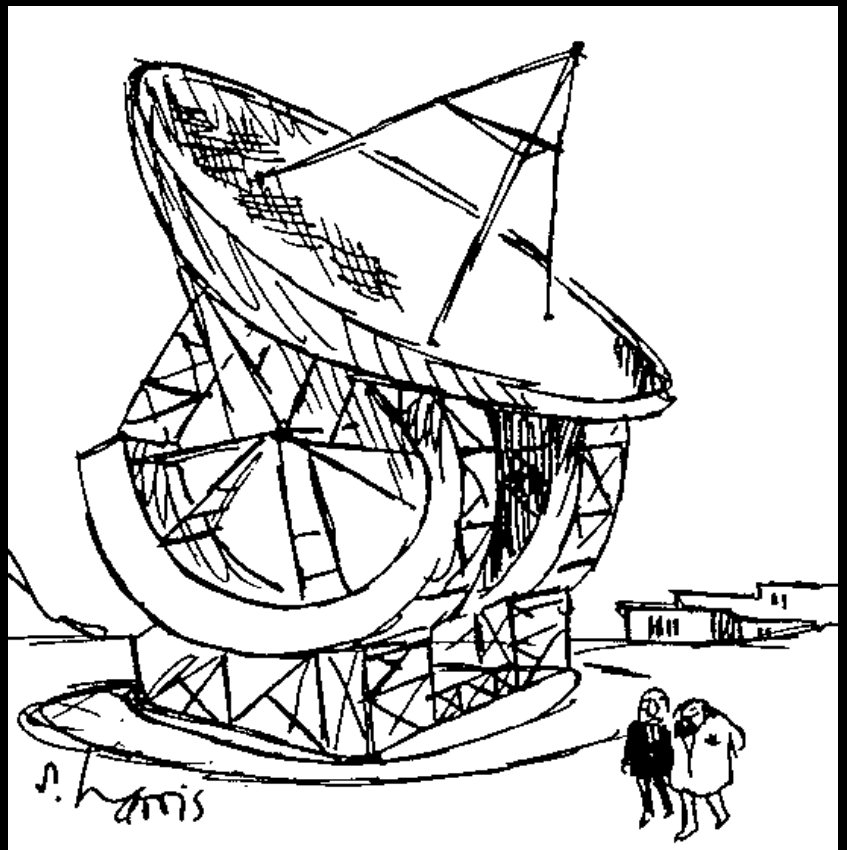
Searching for Other Civilizations

"He says he's been trying to get through for ages, but the line's always busy."



" We sent a message to any extraterrestrial beings in deep space. It was picked up by an observatory in Great Britain. They didn't understand it."

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How can we find other civilizations?

- Direct exploration
- Indirect evidence of civilization around other stars
- What have we done to make ourselves known?
- Searching for signals from other beings
- Sending signals – and waiting for their response
- Searching for signals from other systems

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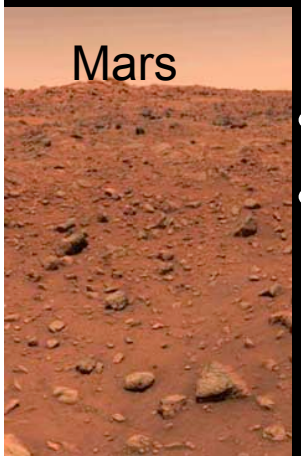
Direct exploration of our Solar System:

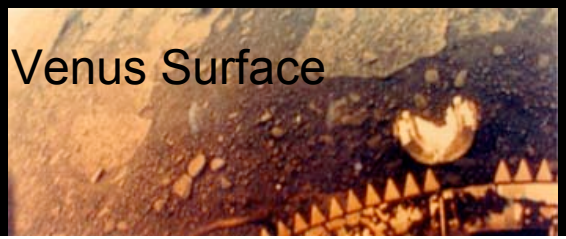
We have sent probes for close flybys of all of the planets
(alas poor Pluto has a probe on the way)

- No visible artificial structures from meters to 10s of meters size.
- No evidence of non-natural signals.

We have landed people and/or probes on the Moon, Mars, Venus, and Titan

- No visible evidence of life.
- No successful detection of microbial life.





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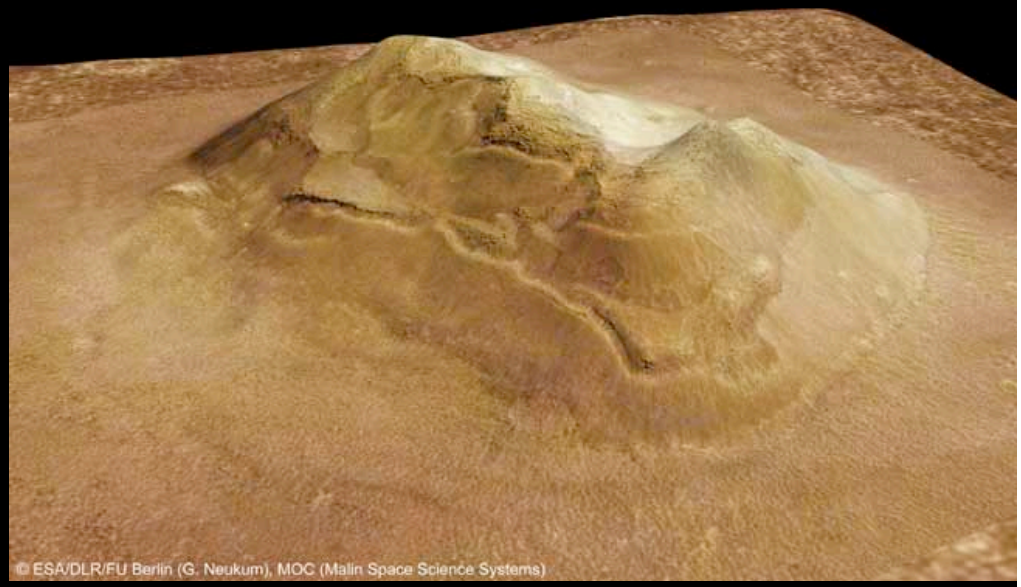
Direct exploration of our Solar System:

Famous face on Mars – is just a volcanic mountain



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Where could life be hiding on our Solar System?

Polar caps of Mars?
Oceans of Titan?
Atmosphere of Jupiter or Saturn?
Elsewhere?

But it is extremely unlikely that there are civilizations capable of space communication unless you believe that they are hiding on purpose and are very advanced compared to us.

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Once the Solar System is ruled out… it is unlikely that we will do direct exploration for civilizations for the next hundred or more years….

Fastest spacecraft to date headed to outer Solar System travels at 62,000 km/hr… 80,000 years to reach the nearest star!

What about indirect detection of civilizations?

For example what would the Earth look like if it were around a nearby star?

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Indirect detection of civilizations around other stars?

The Earth at 5 pc would be too faint and too close to its star to be imaged directly with current telescopes.

It is technically possible to build a space-based telescope system capable of imaging an Earth around a nearby star….

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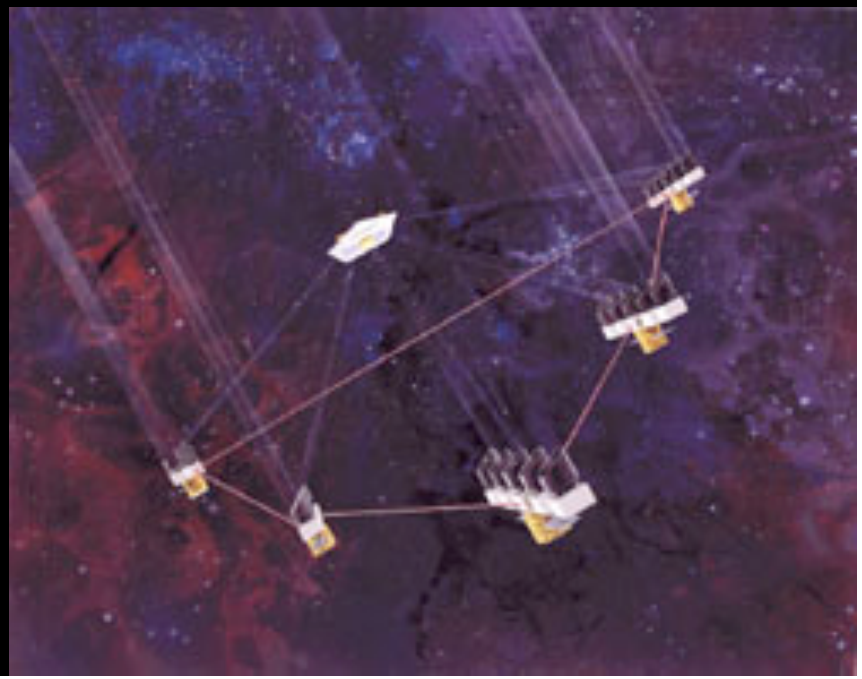
Indirect detection of civilizations around other stars?

Terrestrial Planet Imager – NASA far-future mission concept

5 separate groups of 8-meter telescopes spread over 6,000 km are needed to give 25 x 25 pixel images.

Could this detect man-made structures on Earth?



Largest Structures: Great Wall

- Great Wall of China
- Longest structure on Earth: 6,700 km!
- Much more than 1/25 of Earth, so are we home free?
- Claimed to be naked eye visible from Moon
- Is this possible?

http://www.lehsd.k12.nj.us/users/dupuis/images/Great_Wall_of_China.jpg

Largest Structures: Great Wall

- Great Wall of China
- Longest structure on Earth: 6,700 km!
- Much more than 1/25 of Earth, so are we home free?
- Claimed to be naked eye visible from Moon
- No way!! Too thin, so no chance

http://www.lehsd.k12.nj.us/users/dupuis/images/Great_Wall_of_China.jpg

Largest Buildings: The Pentagon

- Biggest office building in the world
- Each outer wall is 300 meters long
- Would this be visible from several parsecs?

Largest Buildings: The Pentagon

- Biggest office building in the world
- Each outer wall is 300 meters long
- Just 1/40,000 the size of the Earth
- Can't be seen at that resolution: would need absurdly large telescopes!

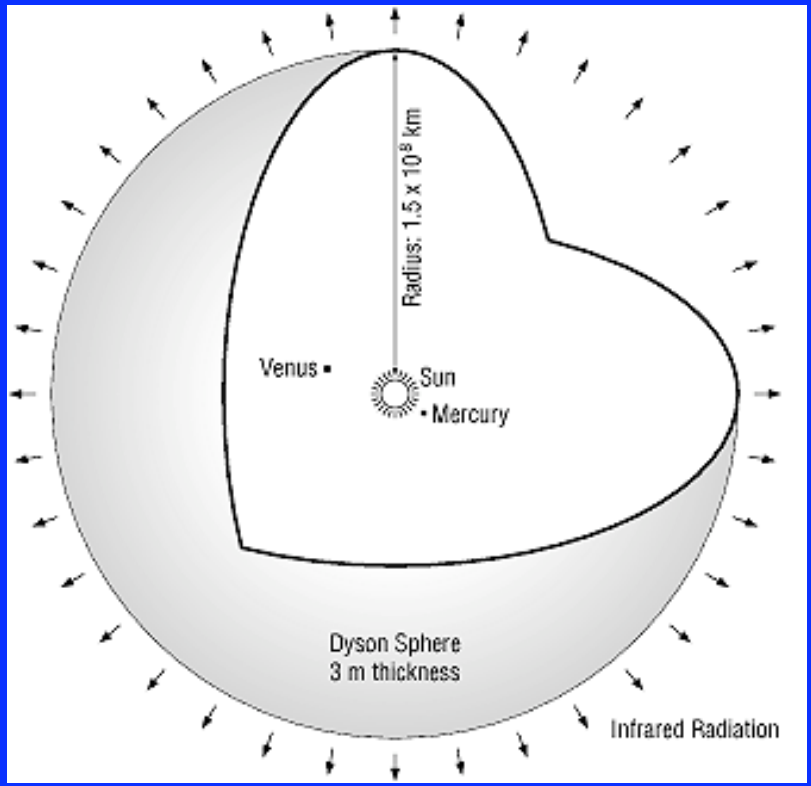
Large Scale: The Earth at Night

- Better! Whole Earth, in principle
- But our total energy emission (most not in lights!) is only 1/(30 trillion) times Sun, and 1/30,000 times what Earth reflects from Sun

http://www.theglitteringeye.com/images/Worldatnight.jpg

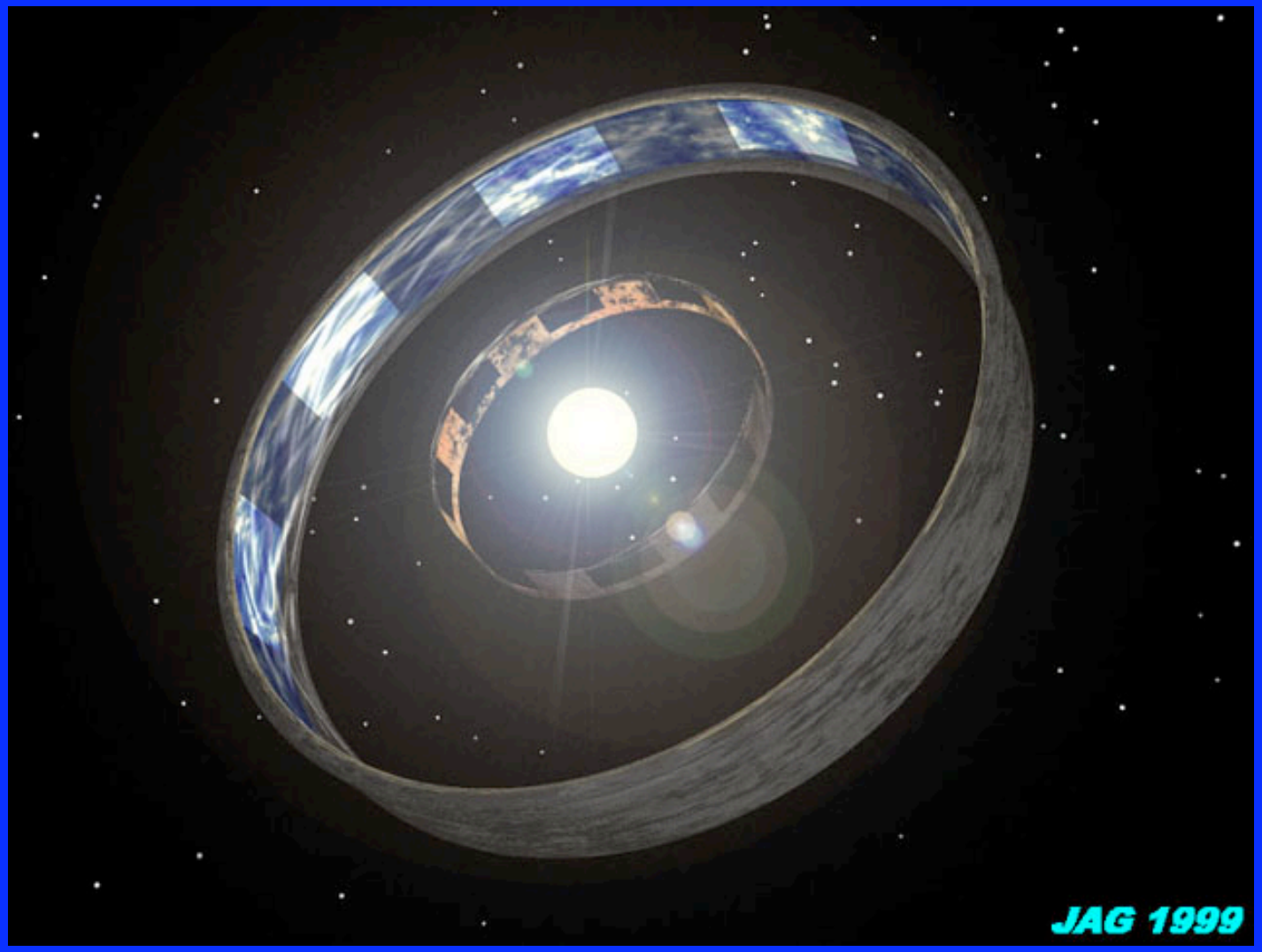
Large Scale: Advanced Civilization?

- For truly advanced civilizations we might do better
- Freeman Dyson proposed "Dyson sphere" around host star
- Absorb/emit huge amount of energy



http://www.astro.psu.edu/users/niel/astro1/slideshows/class44/036-dysonsphere.gif

Another Possibility: Ringworld!



Story and idea by Larry Niven

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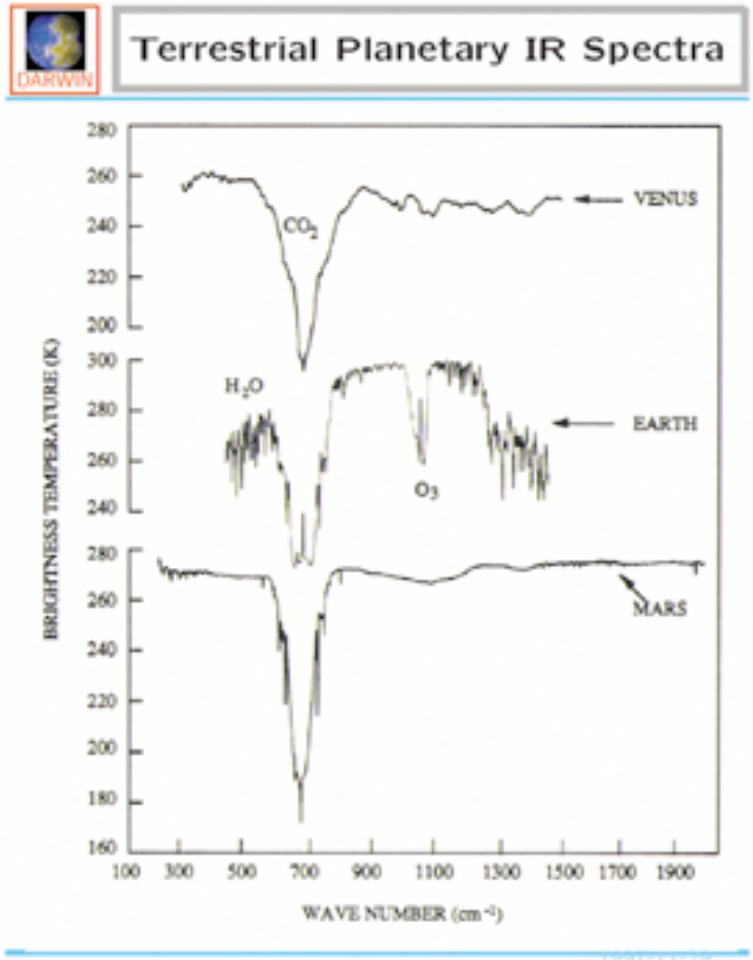
Indirect detection of civilizations around other stars?

Taking the spectrum of Earth is a more promising possibility…

CO_2 is evident on Earth, Mars, and Venus.

Water, oxygen, and ozone are only evident for Earth.



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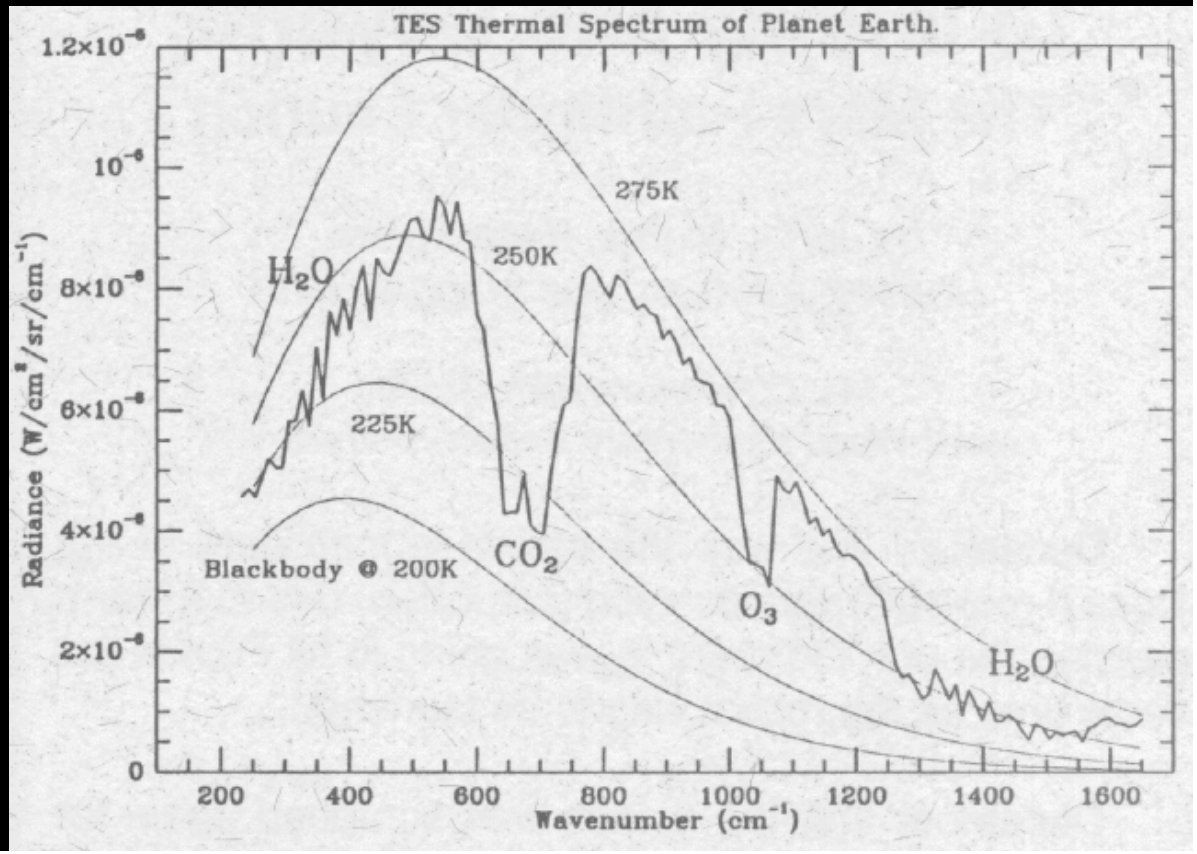
Indirect detection of civilizations around other stars?

The combination of CO_2, O_3, H_2O and CH_4 is argued to be indicative of life – perhaps trace pollutants also there!



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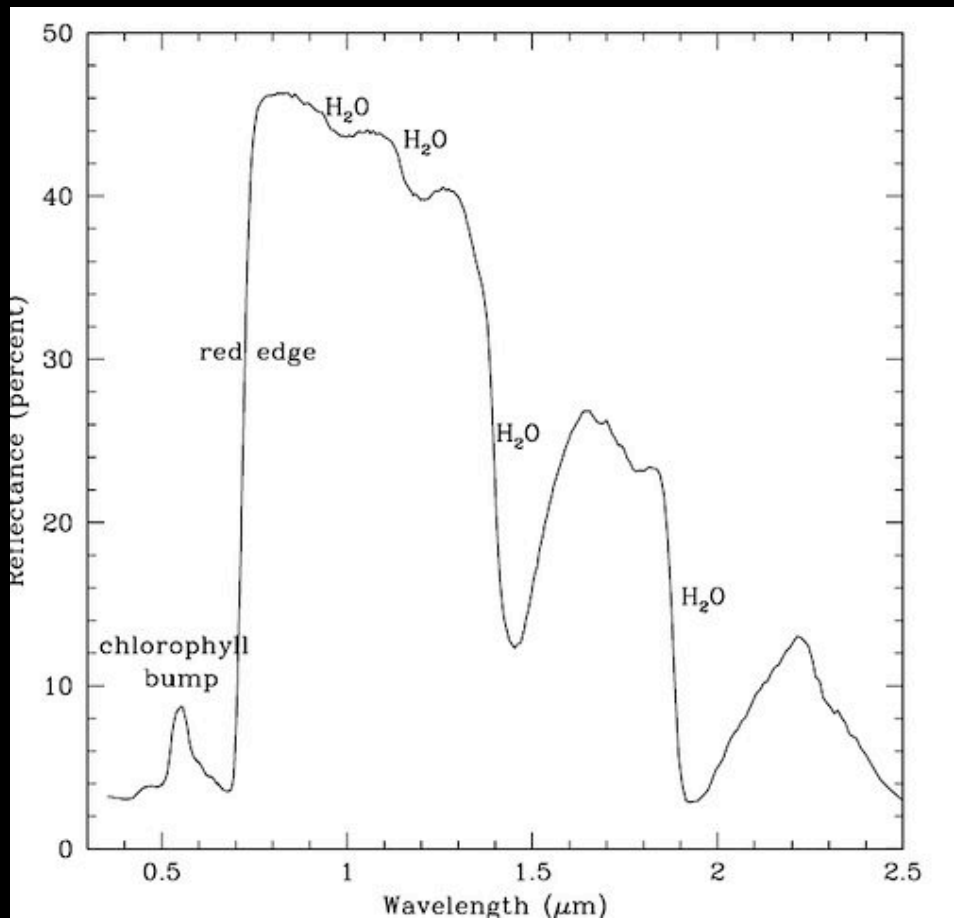
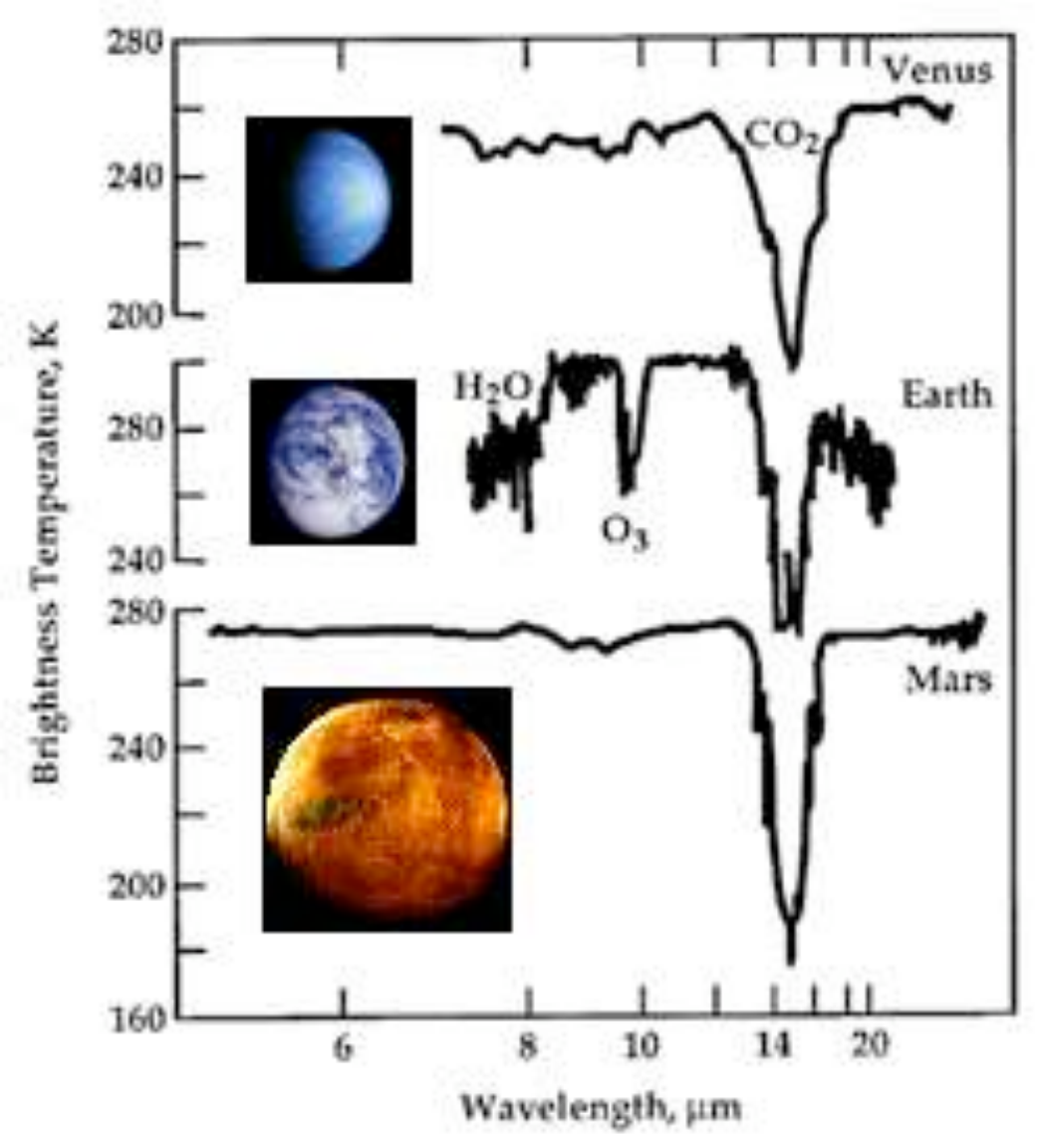
Indirect detection of civilizations around other stars?

On Earth's spectrum, there are features caused by plants – chlorophyll creates the red edge and bump on our spectrum --- could they be there for other Earths?



Mars, Venus, Earth



http://www.astro.psu.edu/users/niel/astro1/slideshows/class44/026-mars-venus-spectra.jpg

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The possibility of detecting and characterizing other Earths is real.

There is a chance of detecting spectral features from life on other Earths.

But the possibility of detecting civilizations around other stars is remote unless they want to be detected and actively do things to make themselves known!

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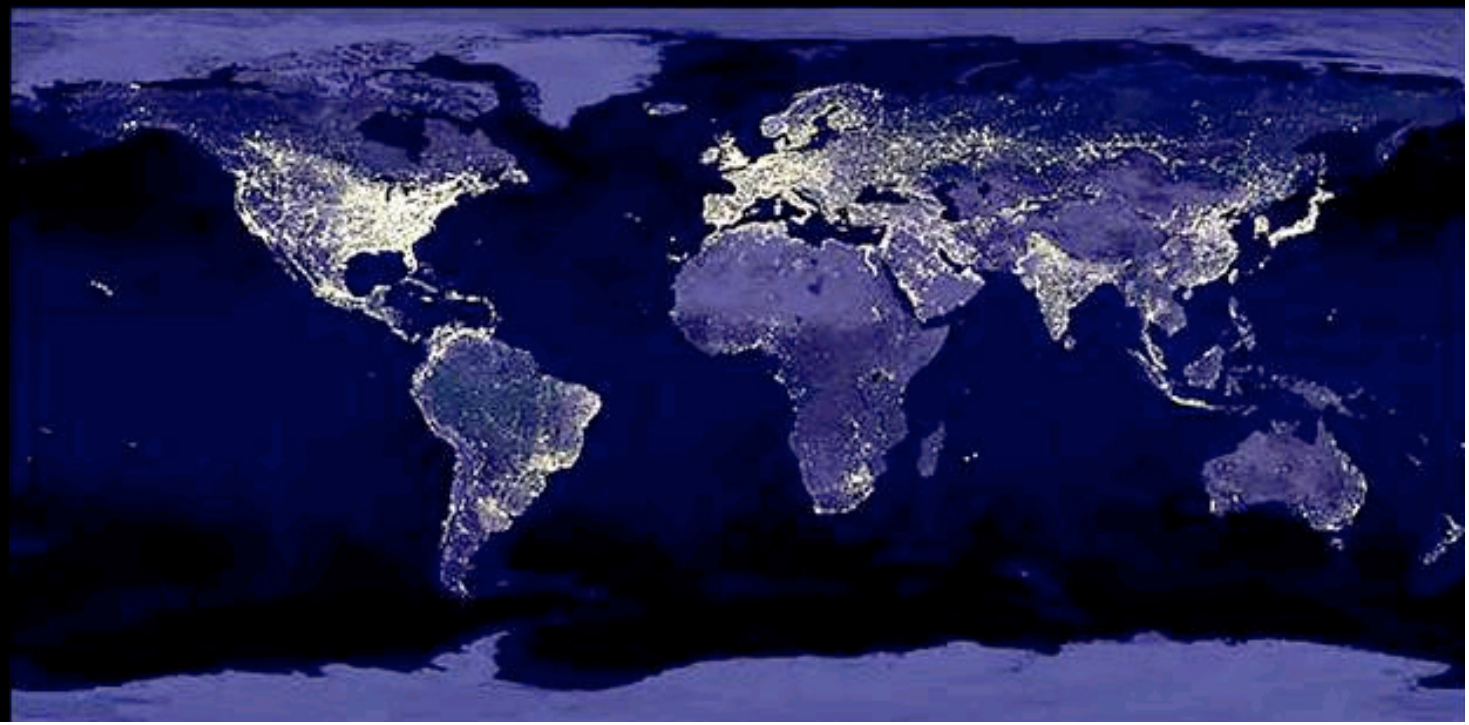
What have we done to make ourselves known?

We have only become even slightly visible as a civilization in the past 60 years….

Lights?

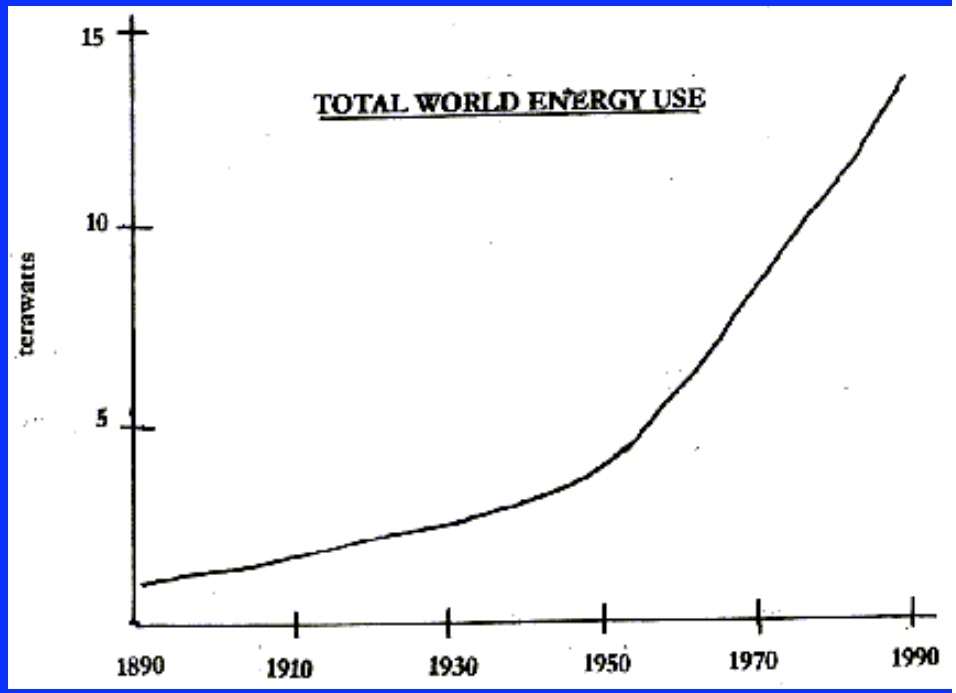
No.

Too weak



Energy Use With Time

- Our energy use is accelerating with time
- Unlikely to be sustainable, but if it were then in a few centuries we might be much more detectable



http://www.egoproject.nl/fig22.gif

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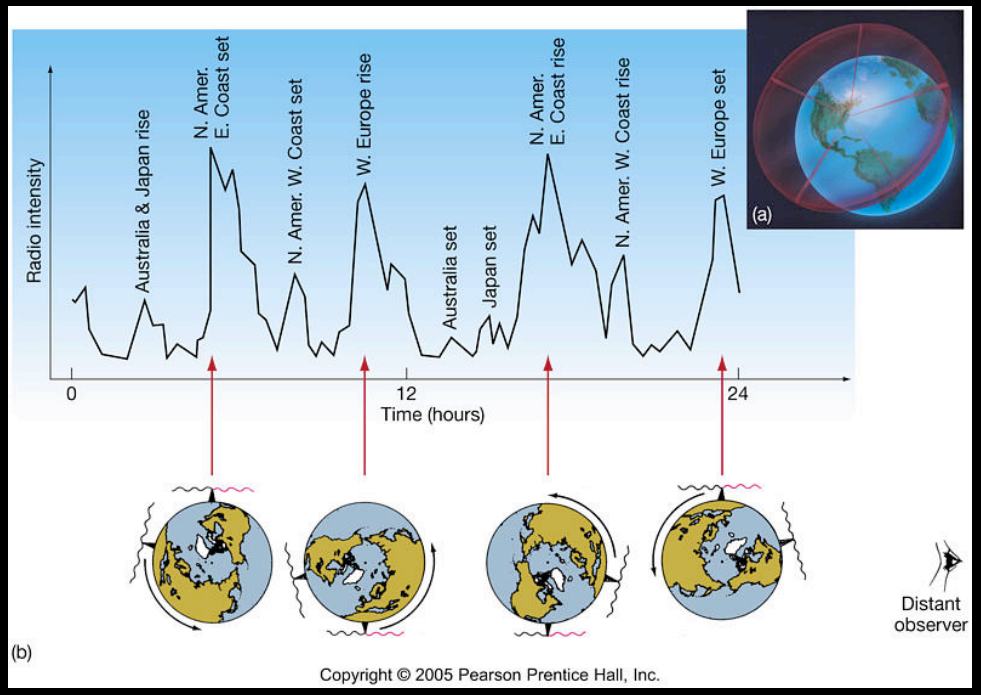
Radio emission from television and even more so from defense radar emissions – accidental emission.



These emissions are now 50 light-years away…. and spreading… but we could only detect our own emission out to 1 light year – not even the nearest star

Arecibo, in Puerto Rico

http://www.evlbi.org/evlbi/te024/arecibo.jpg

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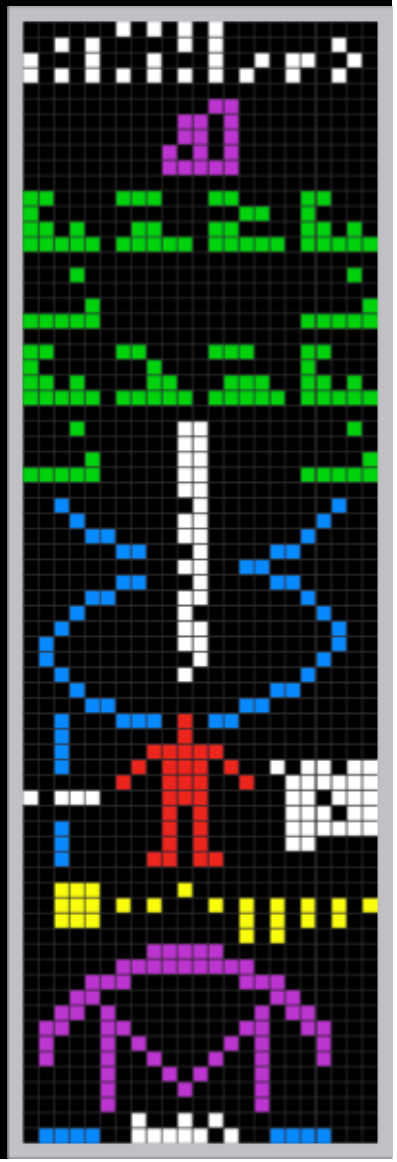
What have we done to make ourselves known?

The 1000ft Arecibo Radio Telescope has been used to send a message to a number of the nearby stars – such directed emission can be seen out to 100s or 1000s of light-years.

Top to bottom and left to right, the message encodes the following:
(a) the numbers one through ten;
(b) the atomic numbers of the elements hydrogen, carbon, nitrogen, oxygen, and phosphorus, which make up deoxyribonucleic acid (DNA);
(c) the formulas for the sugars and bases in DNA;
(d) the number of nucleotides in DNA, and double helix of DNA;
(e) figure of a man, average height, and the population of Earth;
(f) graphic of Earth's solar system; and
(g) graphic of the Arecibo radio telescope and the diameter.



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The same Arecibo Telescope is used to do radar imaging of planets and small bodies in the Solar System.

These radar signals could be seen out to thousands of light-years from the Earth – if someone is looking.

www.naic.edu/~pradar/asteroids

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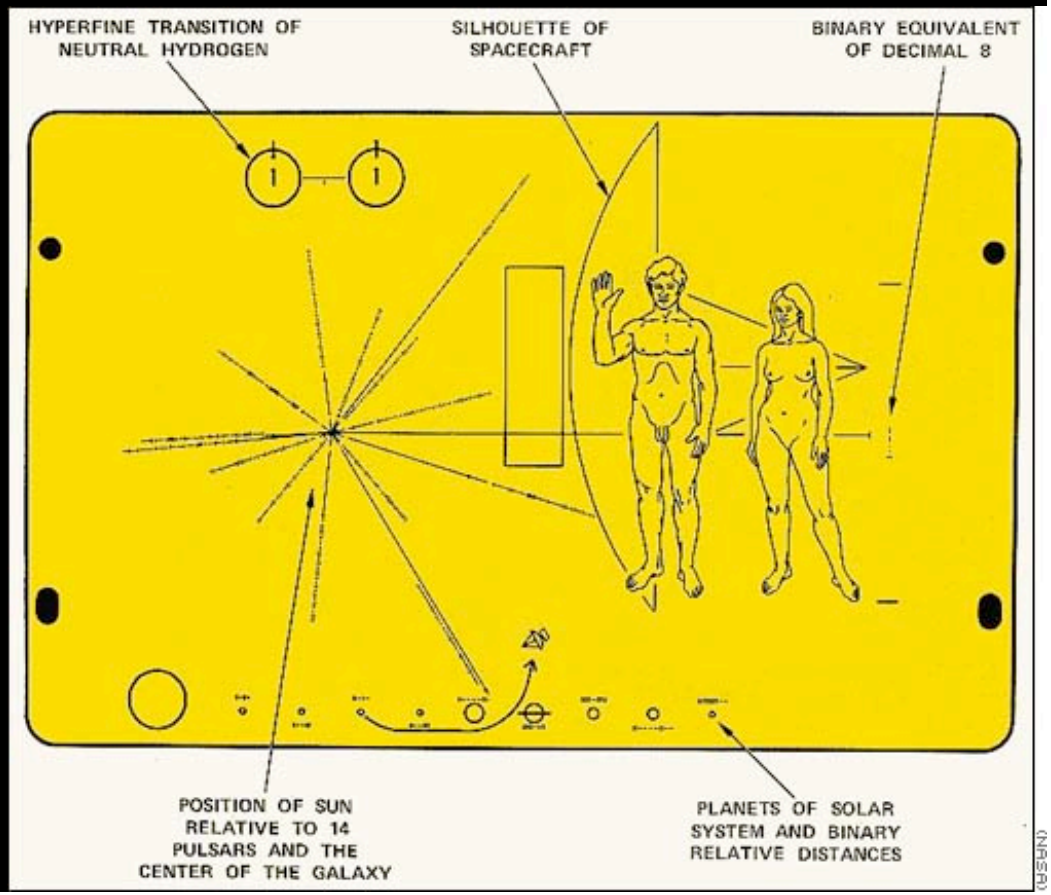
The Pioneer spacecraft carry plaques explaining about us – in case some ET ever finds them…

But the chances are extremely small.



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Searching for signals from other beings.

The big problems are:

- is a signal artificial?
- where to look
- what to look for

Little Green Men?

- 1967, Cambridge, England
- Doctoral student Jocelyn Bell
- Constructed radio telescope
- Found super-regular signals
- Could these be aliens?

http://homepage.mac.com/dtrapp/people2.f/JocelynBell.jpg

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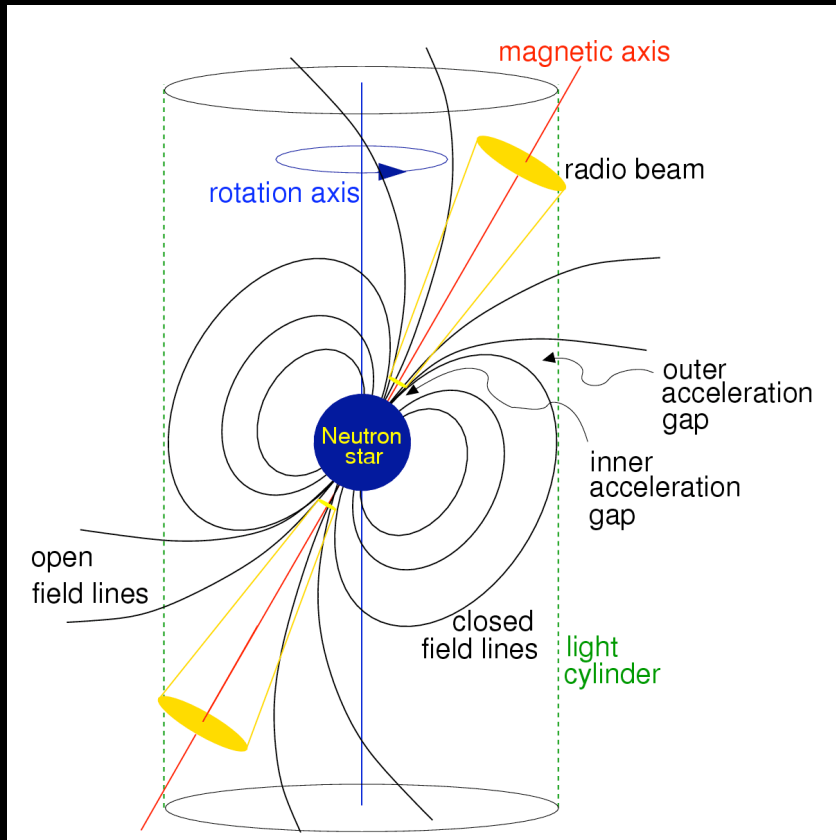
The first pulsars were called LGM 1, 2 and 3 where that stood for Little Green Men – as a half-joke.

The signals have extremely fast and regular periods which are very unusual – we now know that this arises from the spins of pulsars.



What Would Be Artificial?

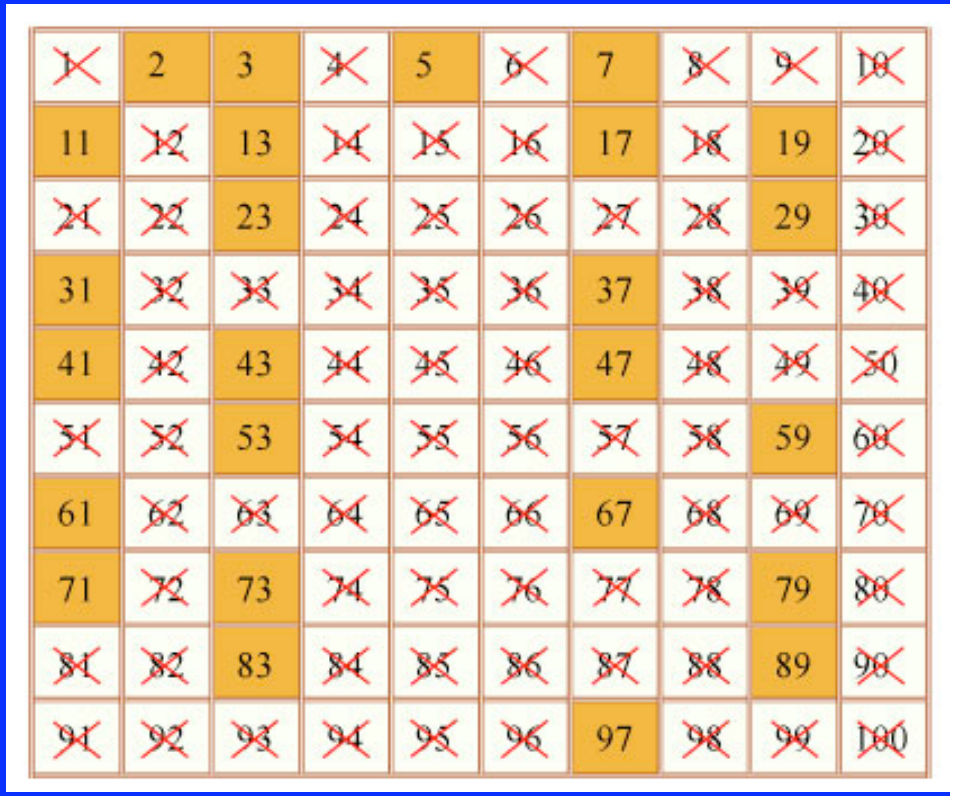
- Suppose you wanted to send a signal that any intelligent aliens would identify immediately as artificial
- What would be your best bet?

What Would Be Artificial?

- Suppose you wanted to send a signal that any intelligent aliens would identify immediately as artificial
- What would be your best bet?
- Most people would say that prime numbers are the way to go; can't be formed by natural process, and no language problems

Prime Numbers

- Numbers divisible only by themselves and 1
- Advantage: no regular pattern, and cannot be duplicated by natural processes
- If signal repeats 2, 3, 5, 7, ... a few times it has to be artificial



http://ocw.mit.edu/NR/rdonlyres/CBCC8193-3AF9-4FD2-A5AA-97DF6659A77C/0/chp_prime_numbrs.jpg

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Where to look? Each star – one at a time – can take a long time.

What to look for? Radio, optical, X-ray? What specific frequency of radio or X-ray?

What is Best Frequency?

- Considerations include energy to send signal and bandwidth allowed
- Lower-energy (longer wavelength) are more energy efficient
- However, shorter wavelength has higher frequency, thus higher bandwidth, thus can send more information
- Also, what about host star interference?
- Compromise is not clear

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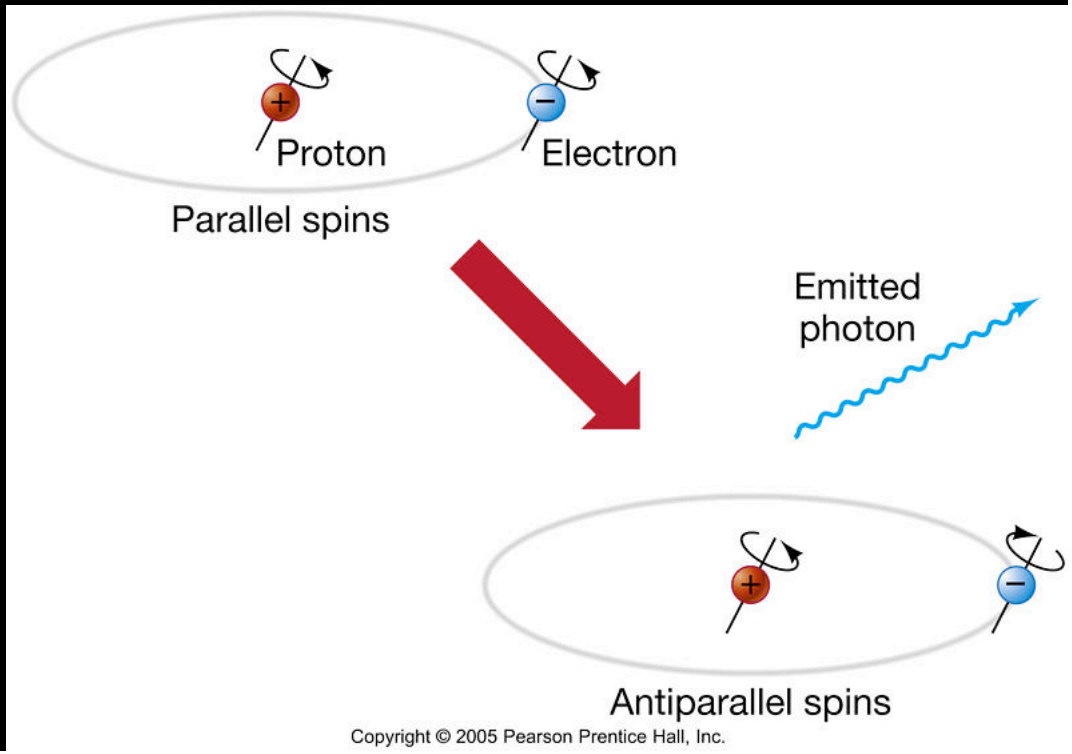
The hydrogen emission line that comes from the spin flip transition of molecular hydrogen?

The first searches by Frank Drake were done towards stars at the frequency of this line – Project Ozma.



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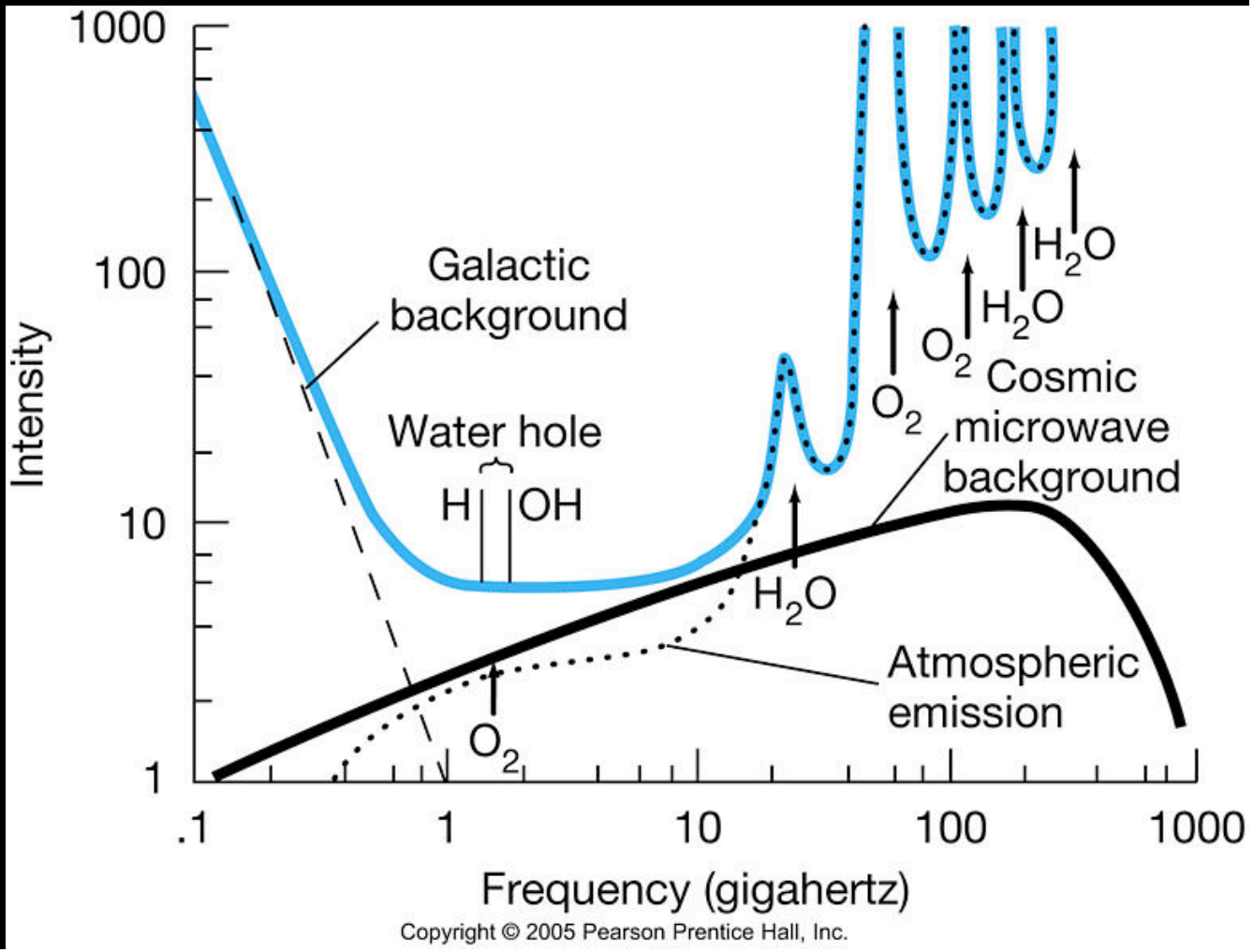
The water hole… a minimum in galactic emission and a pointer to our origins.



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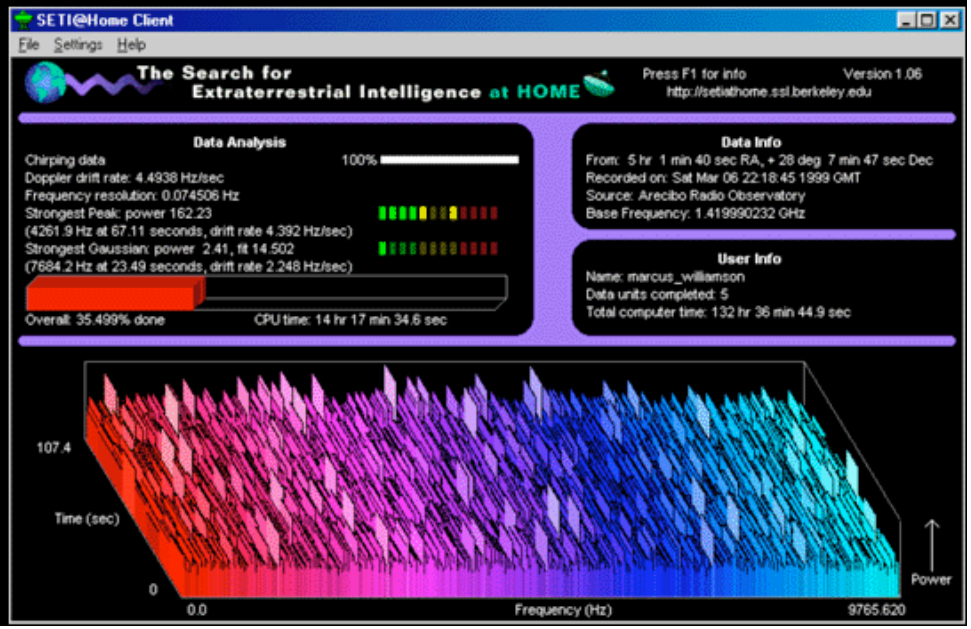
Project Phoenix:

Run by the SETI Institute from 1995 to 2004 using radio telescopes to look at 800 stars within 240 light-years (http://www.seti.org). No signals detected!

SETI@HOME is a computing experiment to use thousands of home computers to analyze radio telescope data to look for ET signals.



You too can participate!
(http://setiathome.ssl.berkeley.edu/)

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The Allen Telescope Array – 42 six-meter antennas

Being built by the SETI institute and UC Berkeley with money from Paul Allen (Microsoft co-founder).

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Searching for signals from other beings.

Most intense searches to date have been done at radio wavelengths because that has been easy and better than optical wavelengths where stars dominate.

Limited optical searches have been done and continue to look for short bursts of light, patterns…..

It is also possible that X-rays would be better.

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There are no detections to date at any wavelength.

The searchers are very motivated and committed to making their results public!

So what does this mean?

What would it mean if we continue to detect nothing for 100 years?

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Two critical questions in interpreting the lack of detections are:

How likely is it that ET wants to communicate with us?
-- very hard to guess at this.
-- perhaps only hope is “accidental” emissions…

How long does a civilization broadcast freely into space?
-- perhaps after 100 years we will use optical fiber, or something new and the Earth will be radio quiet….

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Drake Equation:

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

where:

N is the number of civilizations in our galaxy for us to talk to today.
R∗ is the average rate of star formation in our galaxy 5 – 15 stars/year
fp is the fraction of those stars that have planets 0.05 – 0.2
ne is the number of planets that can support life per star that has planets ??
f_ℓ is the fraction of the above that actually develop life ??
fi is the fraction of the above that develop intelligent life ??
fc is the fraction of civilizations that develop interstellar communication 0.2
L is the length of time civilizations send detectable signals into space. 100 yrs to 1,000,000 yrs

N = 10 x 0.1 x 0.1 x 0.01 x 0.2 x 0.2 * 100 = 0.004 – No hope!
1,000,000 = 40 – Unlikely!
N = 10 x 0.2 x 0.5 x 1 x 0.1 x 0.5 x 100,000 = 5,000 – Busy

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Remember: If one other civilization exists in our Galaxy, AND

1. Started 1,000,000 years before us….
2. And does space travel…… 5-10 light year distances…
3. And colonizes a new stellar systems every 20,000 years
4. And is long lived…..

It would span every stellar system in our galaxy with suitable Earth-like planets right now!

But then where are they?

Summary

- No detections yet
- Seeing intelligent life probably means patiently waiting until we receive some signal
- We currently have the capability to broadcast a signal, and have used it