AST 309L

The Search for Extraterrestrial Intelligence

Now let's discuss SETI:
the Search for Extraterrestrial Intelligence!

Briefly its history, what we are searching for, and whether we've found anything!

A brief history of SETI

- SETI with radio signals was first suggested by Nikola Tesla and Guglielmo Marconi in the **early 1900s.**

- First searches were done with frequencies that can't get through the atmosphere!

- Mid 1900s, astronomers thought to search using **radio dishes** around the **frequency of a Hydrogen atom spectral feature.**

- First such search: Frank Drake in 1960!

Army Martian radio search in 1924

Photo from U. and U.

Army radio operators thruout the country "listened in" for messages from Mars last month—without much success. Corp. John H. Sadler of the Signal Corps is shown at a radio station of the War Department.

We have focused most of our SETI research on radio signals...

What kinds of radio signals do you think we'd detect?

What types of radio signals might we expect to detect?

1. **Local communications signals** such as radio, television, or radar here on Earth.

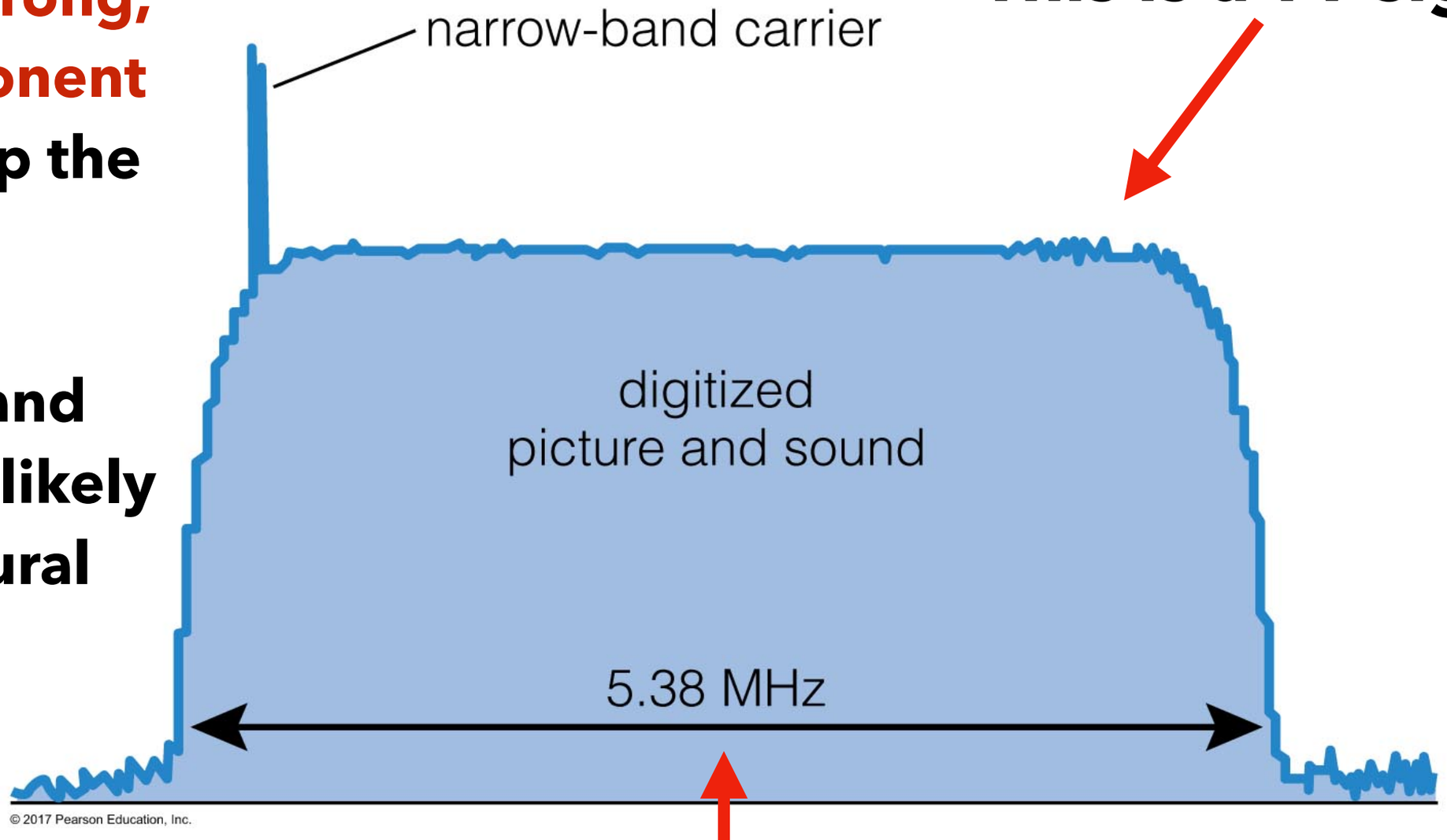
2. **Interplanetary communications signals** – like those we use to communicate with spacecraft but stronger.

3. **Intentional signals to communicate with us** or other civilizations in our galaxy

What does a radio signal look like here on Earth?

Signal has a strong, narrow component to help pick up the signal

This is a TV signal



A narrow-band signal is more likely to be unnatural

Frequency of the signal is referred to as its band
Width of the signal is called the bandwidth

So our best bet to detect an alien radio signal would be for a high intensity, narrow-band signal

How do we detect these radio signals? How does that search happen?

- We use **radio dishes** – or arrays of dishes – to look for signals in narrow bands covering various parts of the radio spectrum.

- Two types of searches: **targeted search** and **sky survey**

- Past SETI searches have often **piggybacked on telescopes** and observations for astronomy.

- **Interference** is always an issue, and separating extraterrestrial signals from terrestrial signals is important!

- SETI searches are often **privately funded.**

How do we detect these radio signals? How does that search happen?

Radio dish arrays (Allen array, Square Kilometer Array)! The Allen Array is largely used for SETI!

Single radio dishes (Arecibo, Green Bank, FAST)

How strong of a signal can we detect, and how far away can the ETs be?

How does the amount of light received from a source depend on the distance from it?

→ **Inverse square law!** The further away you are the stronger the signals must be to detect it.

How does the amount of light detected depend on the size of your telescope?

→ **The area of the telescope!** The larger the telescope the weaker the signal can be to detect it.

$$\text{Signal Strength} = \frac{\text{Output Power}}{d^2} \times \text{Telescope Area}$$

An example:

Let’s say we have detected an alien signal from a star system 10 light years away.

If the same power signal was transmitted by a civilization 50 light years away, how much larger would our telescope have to be to pick up the signal?

From the inverse square law – a signal from 5x further away would be $5^2 = 25$ times weaker, so we would need a telescope 25x as large!

$$\text{Signal Strength} = \frac{\text{Output Power}}{d^2} \times \text{Telescope Area}$$

How strong of a signal can we detect, and how far away can the ETs be?

TABLE 12.1 Major Current Radio SETI Surveys

Name	*Institution*	*Telescope*	*Total Number of Channels*	*Width of Single Channel*	*Band Covered*	*Detectable Power for 100-Meter Transmitter at 100 Light-Years*
Inner Galactic Plane Survey*	SETI Institute	Allen Telescope Array	450 million	1 Hz	1390–1720 MHz	70 megawatts
SERENDIP	University of California, Berkeley**	Arecibo Radio Telescope (305 m)	168 million	0.6 Hz	1370–1470 MHz	1 megawatt
SETI Italia	Istituto di Radioastronomia, Bologna	Medicina radio telescope (32 m)	24 million	0.6 Hz	Bands centered at 1.4, 2.8, 6.4, and 22.4 thousand MHz	Typically 30 megawatts

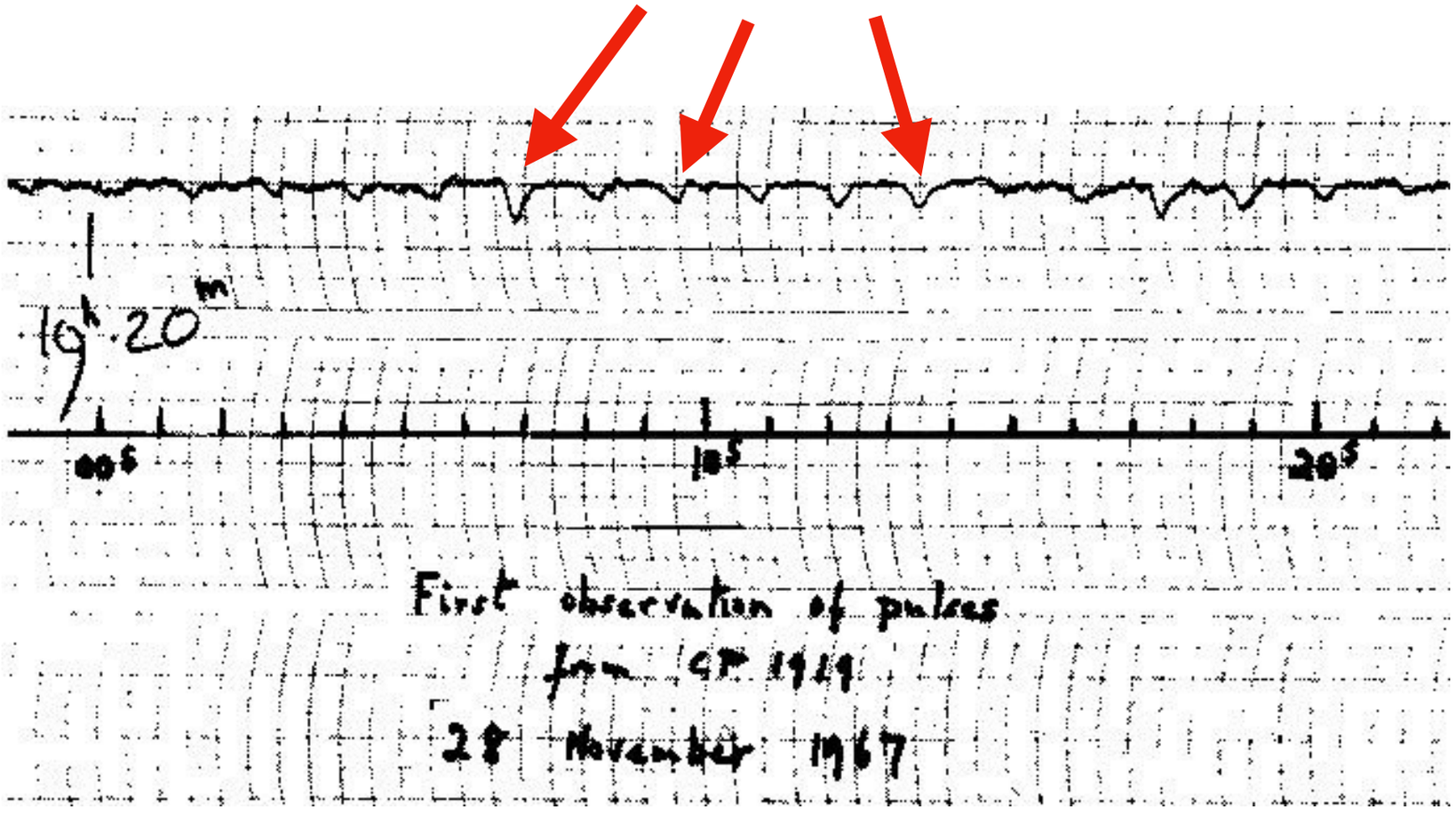
*Values given here are for the Allen Telescope Array capabilities at the beginning of 2015, when 42 of its 6-meter antennas were in operation. If more antennas are added (the design goal is to build 350), the sensitivity will increase.

**About 2.5% of the data collected by the SERENDIP project are being distributed over the Internet for processing on a downloadable screen saver. This project (called SETI@home) has involved more than seven million home computer users.

Radio transmitters here on Earth actually can reach power of multiple megawatts – but not as directed

Have we detected any radio signals that might be ETI?

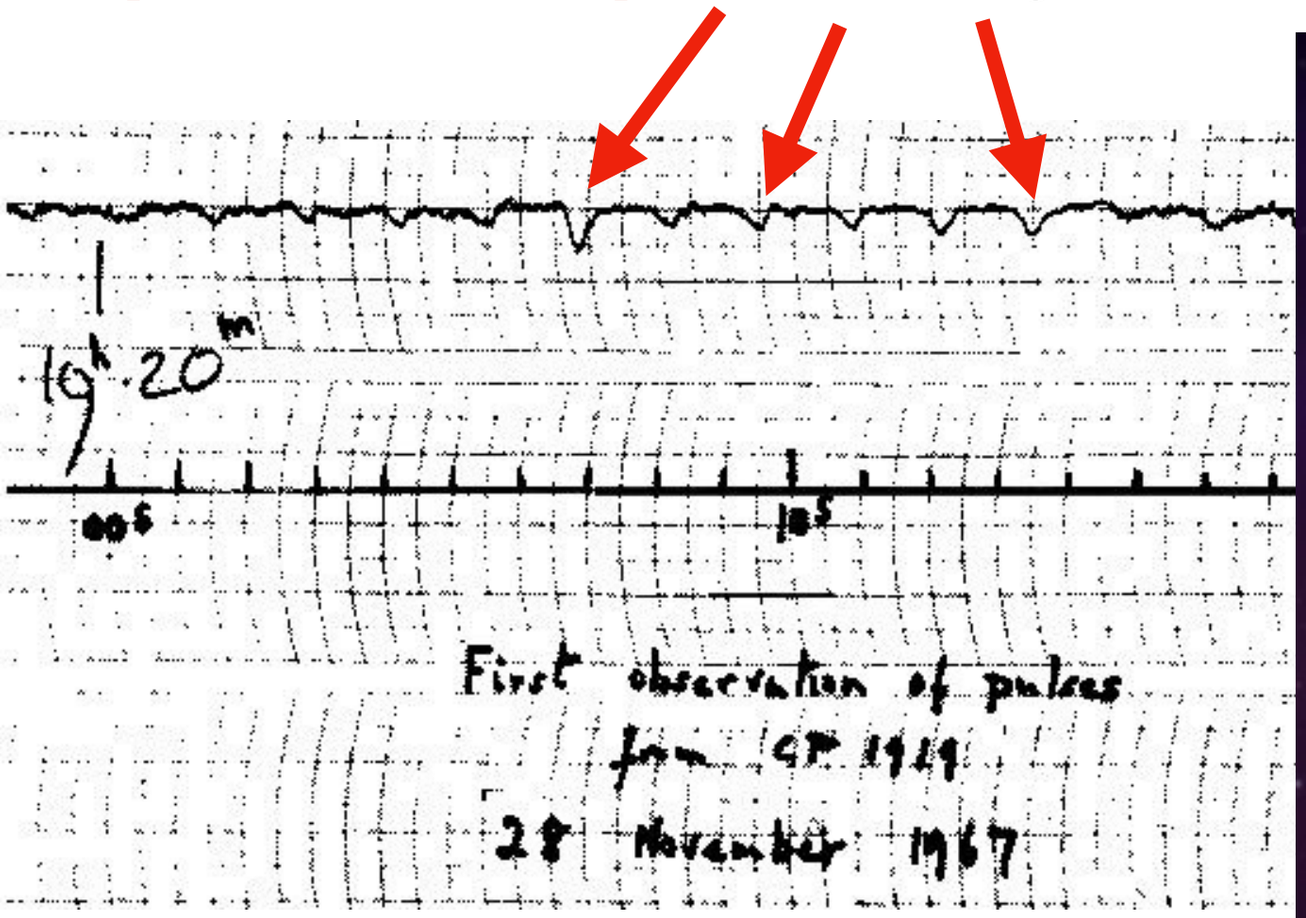
Repeated radio pulses every 1.33 seconds!

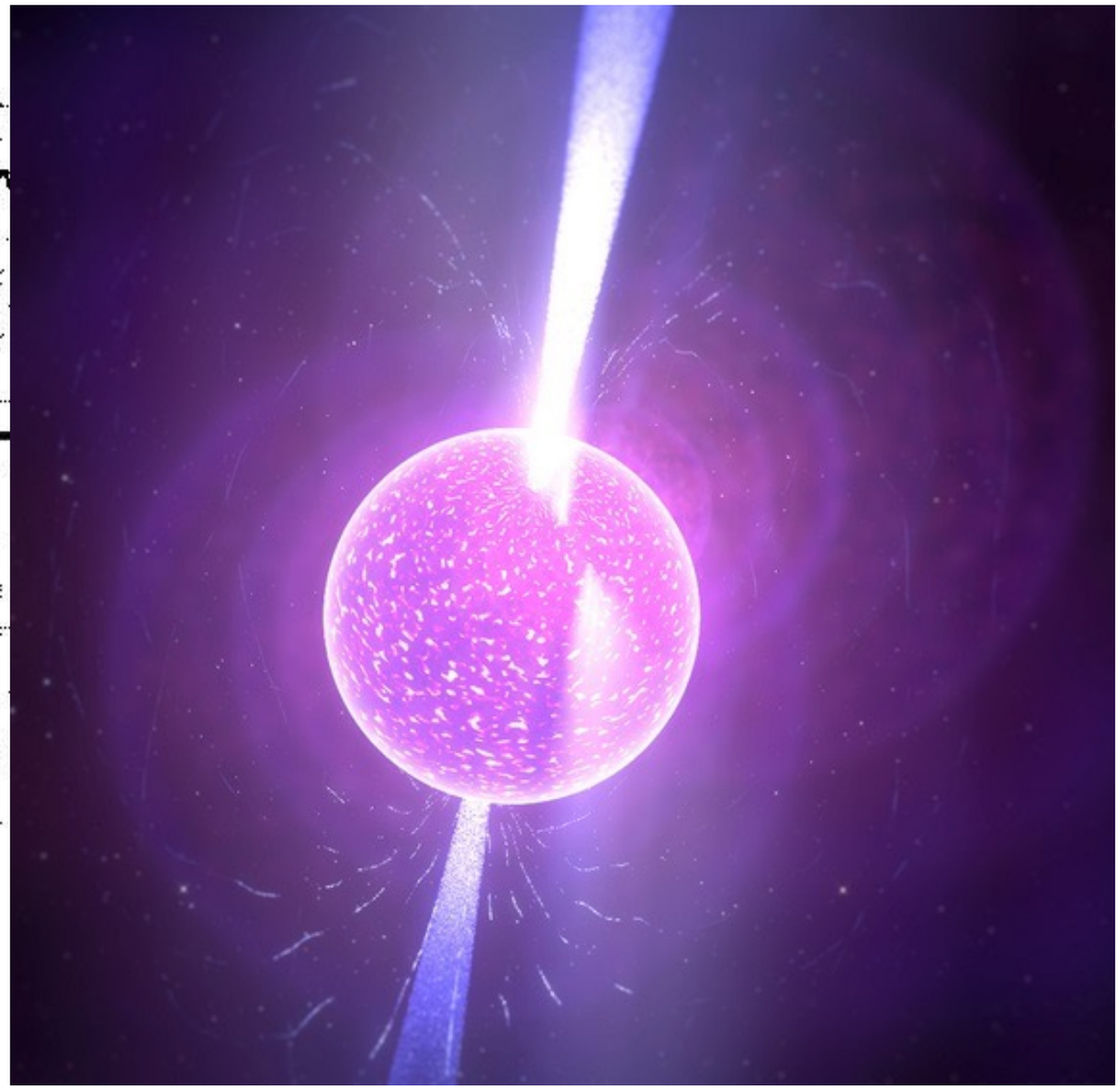


Detected by Jocelyn Bell in 1967 and (jokingly) called LGM-1 upon discovery

Have we detected any radio signals that might be ETI?

Repeated radio pulses every 1.33 seconds!



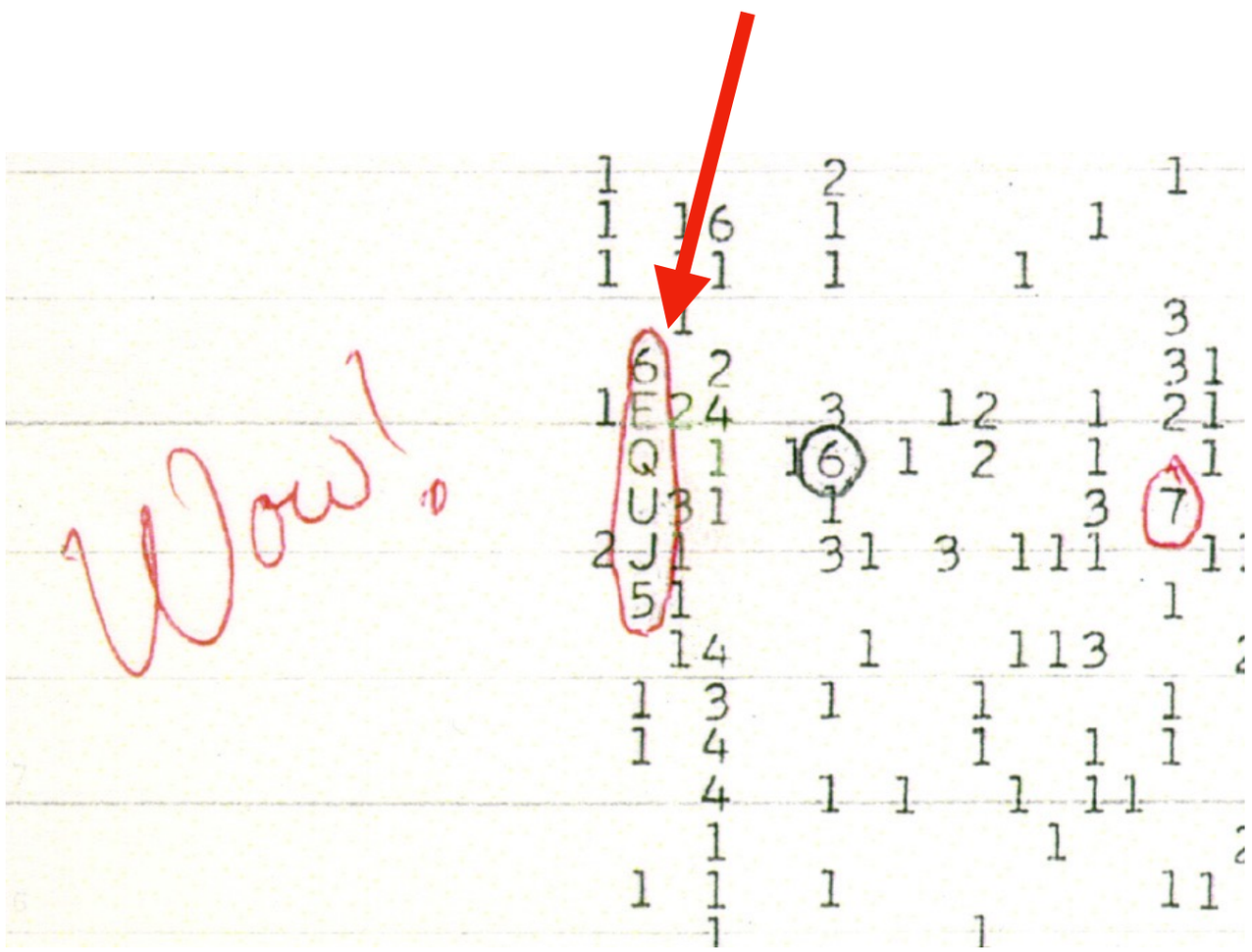


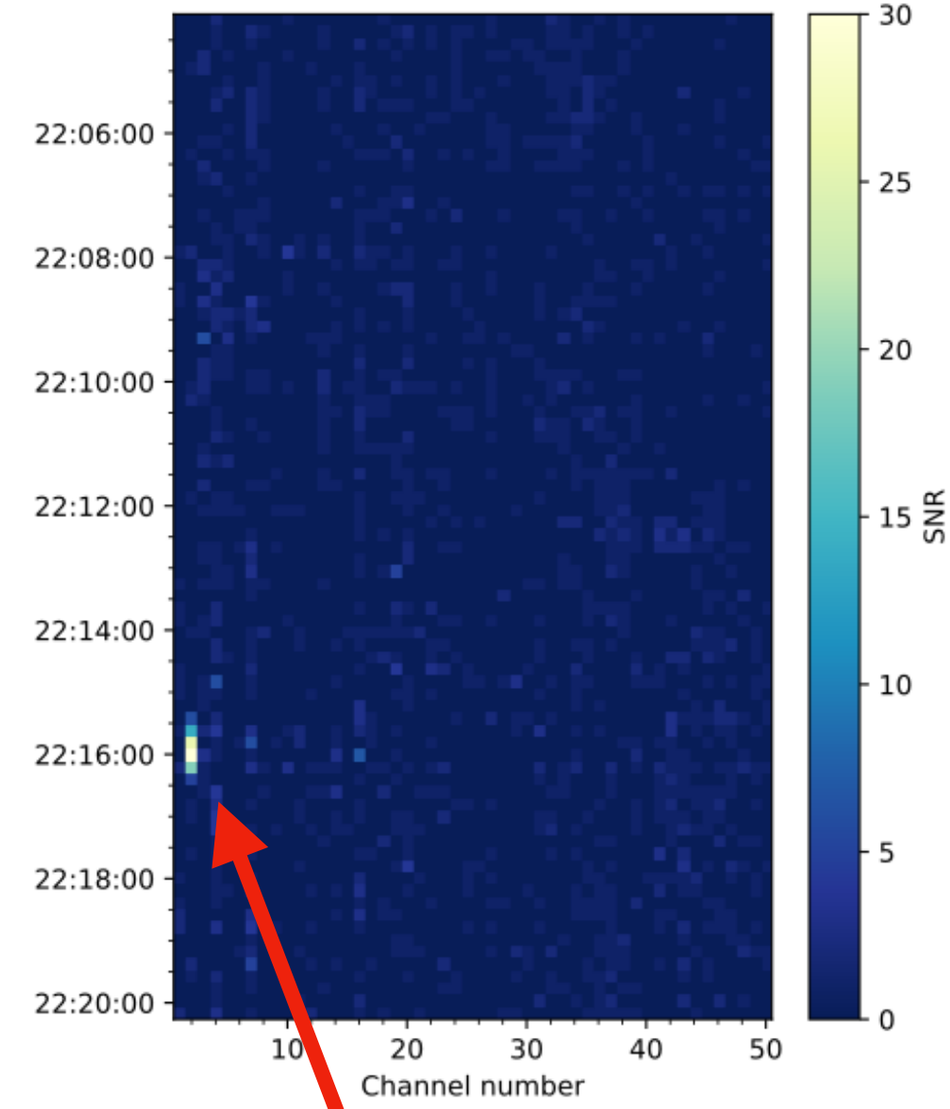
BOOOOO it's just a pulsar...

Have we detected any radio signals that might be ETI?

Big Ear telescope detected a very strong radio signal… WOW!

(Code denotes strength and duration)





A very narrow-band signal at 1420 MHz…

Instapoll #1:

Which of the following signals from an advanced civilization would be easiest to detect?

A. High intensity, narrow bandwidth

B. Low intensity, wide bandwidth

C. High intensity, wide bandwidth

D. Low intensity, narrow bandwidth

Instapoll #2:

Due to increasing amounts of terrestrial radio noise, in the future SETI telescopes may be places

A. On the tops of tall mountains

B. In near-earth orbit

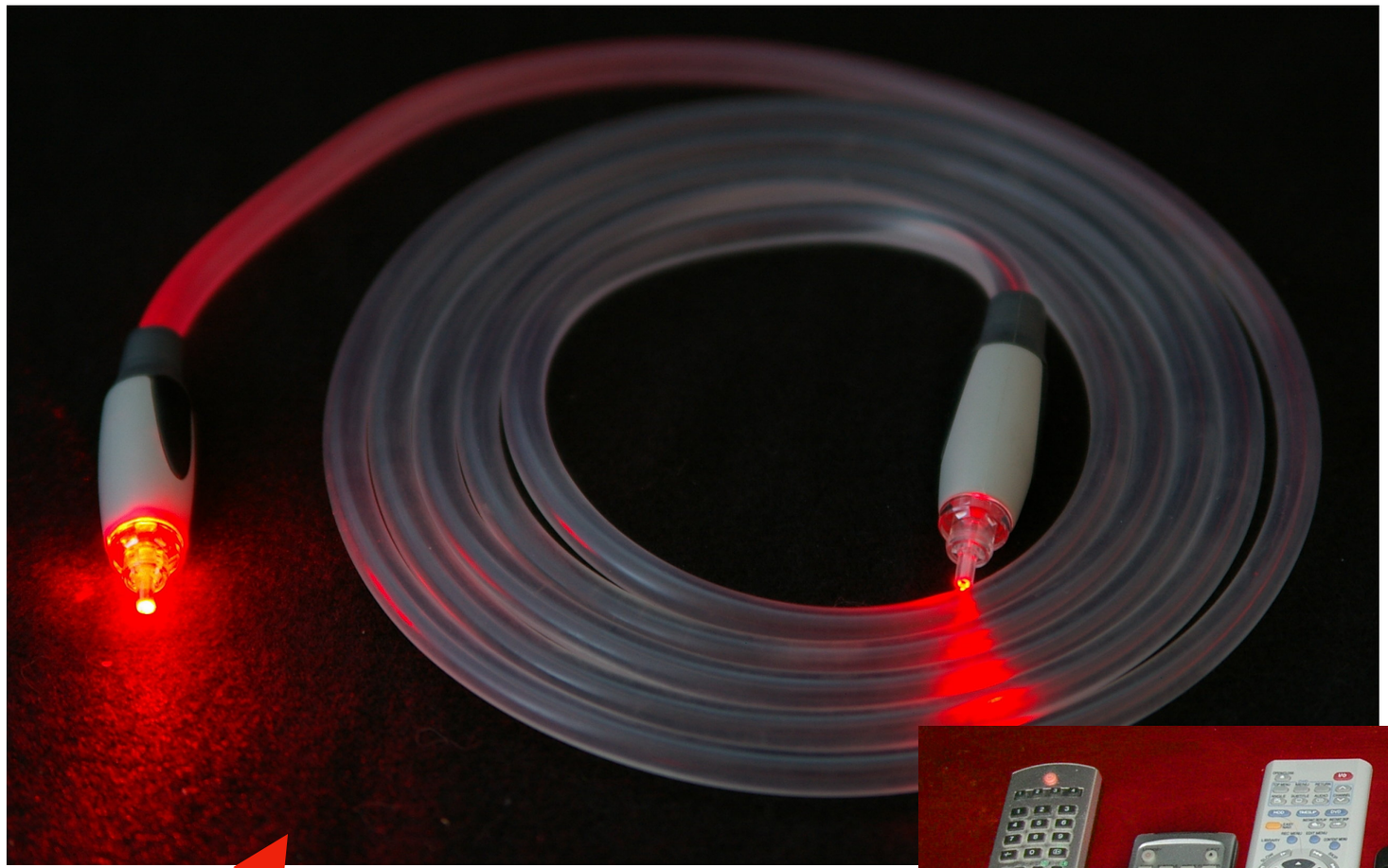
C. On the far side of the moon

D. In remote desert locations

Of course remember that radio is just one part of the electromagnetic spectrum...

What about other kinds of light?

How about using visible or infrared light to communicate?



All local communication, with relatively weak signals!

Fiber optics (optical) and remote controls (IR)

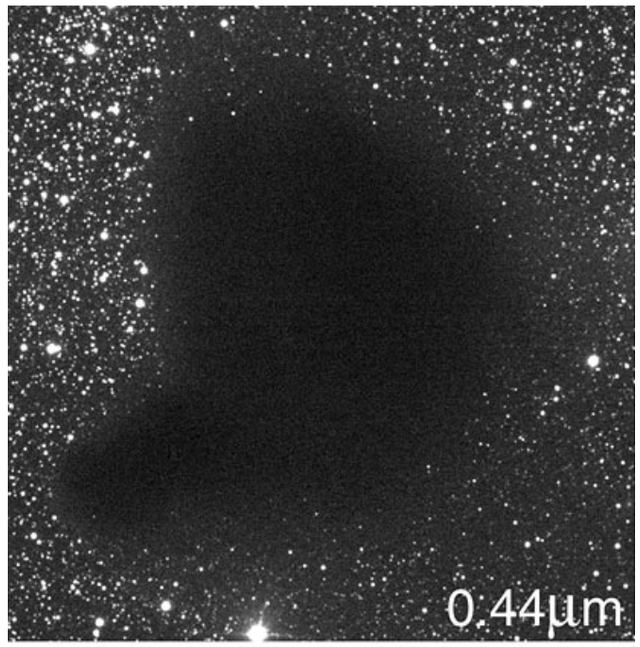
How would interstellar optical communication work?

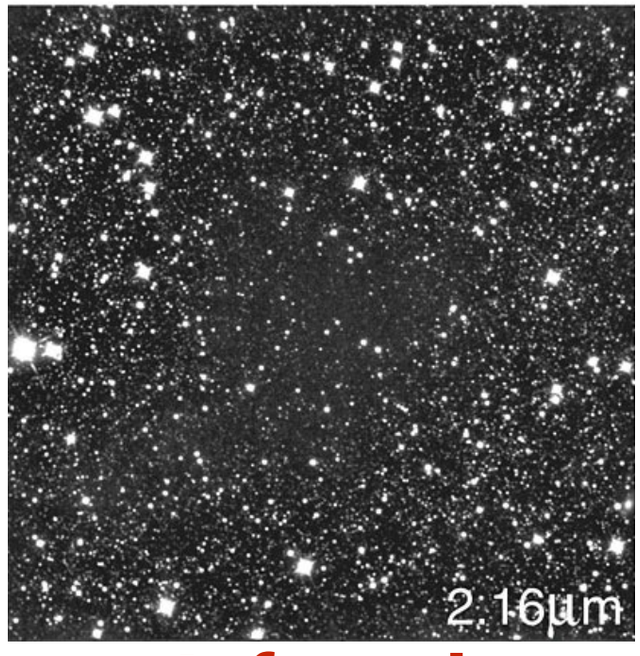
Issues with visible light!

- The visible portion of the electromagnetic spectrum has **trouble passing through interstellar dust.**

- **Far more energy** is needed to produce strong visible light signals than radio signals.

Optical





Infrared

How would interstellar optical communication work?

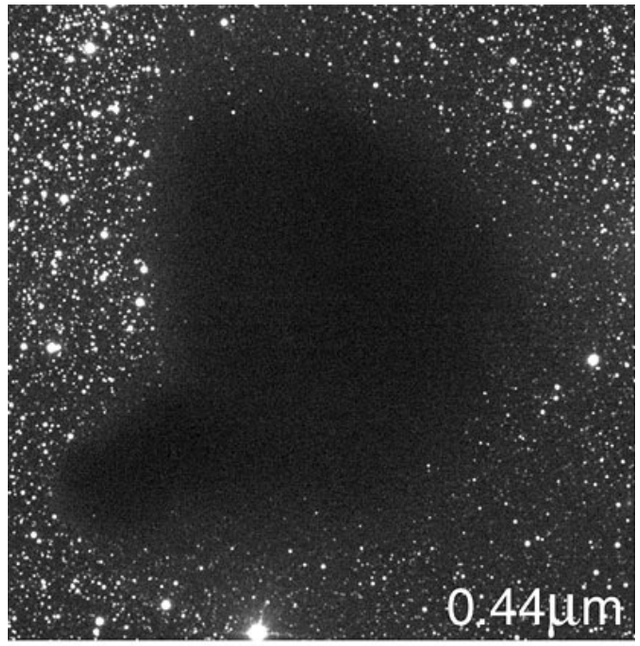
- The visible portion of the electromagnetic spectrum has trouble passing through interstellar dust.

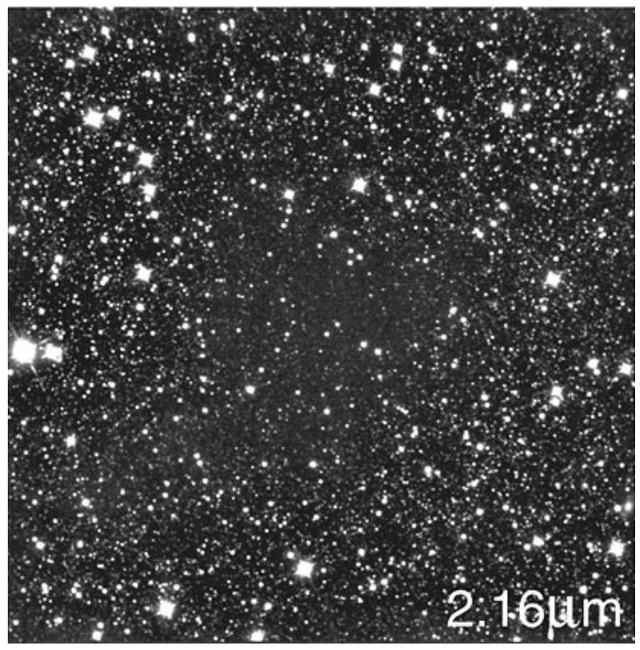
- Far more energy is needed to produce strong visible light signals than radio signals.

- Even with dust, signals can travel up to a **few thousand light-years**. Also **infrared**!

- Visible light is energy cost-effective if sent in a **concentrated beam** (laser?!)

Optical





Infrared

So far we've only discussed communications signals

But that's not all we could possibly detect! What about alien technology?

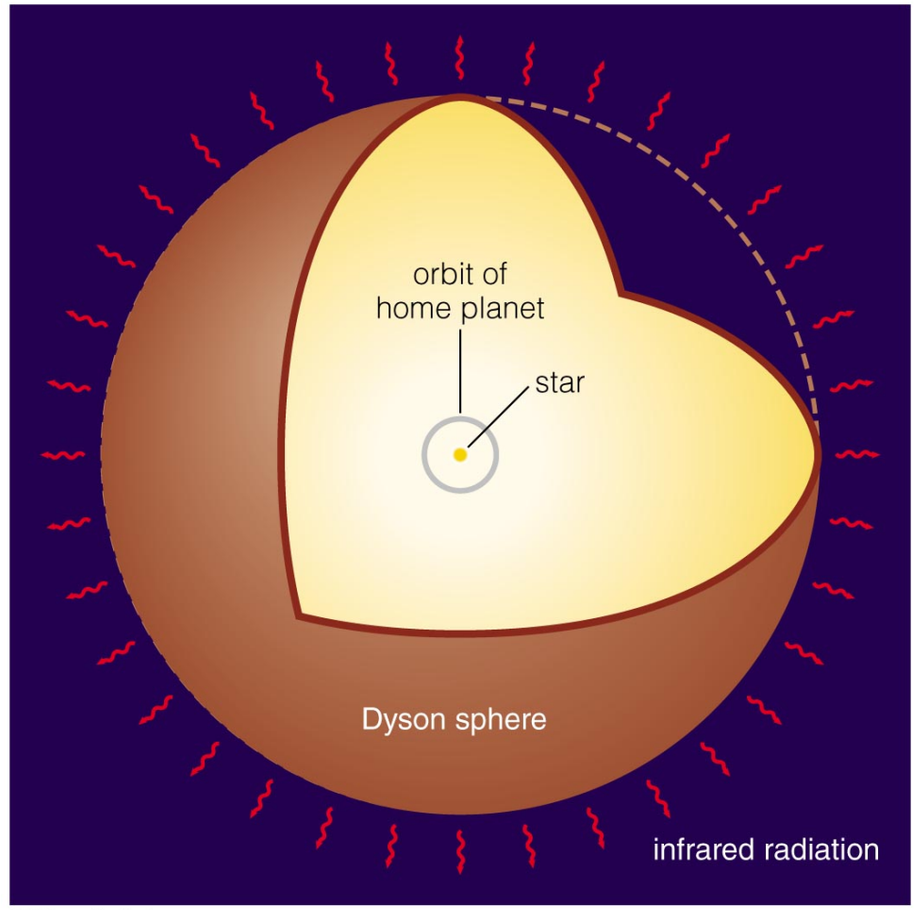
Astroengineering: Dyson Spheres or Swarms

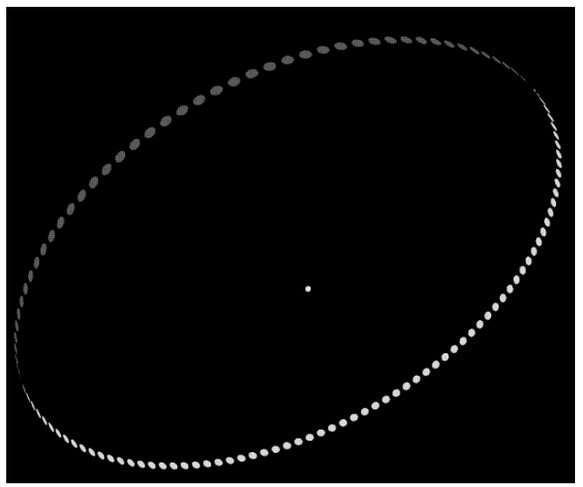
- As a civilization advances it needs more energy! Next: **all stellar energy!**

- Construct a **Dyson Sphere**: basically a sphere of solar panels encasing a star.

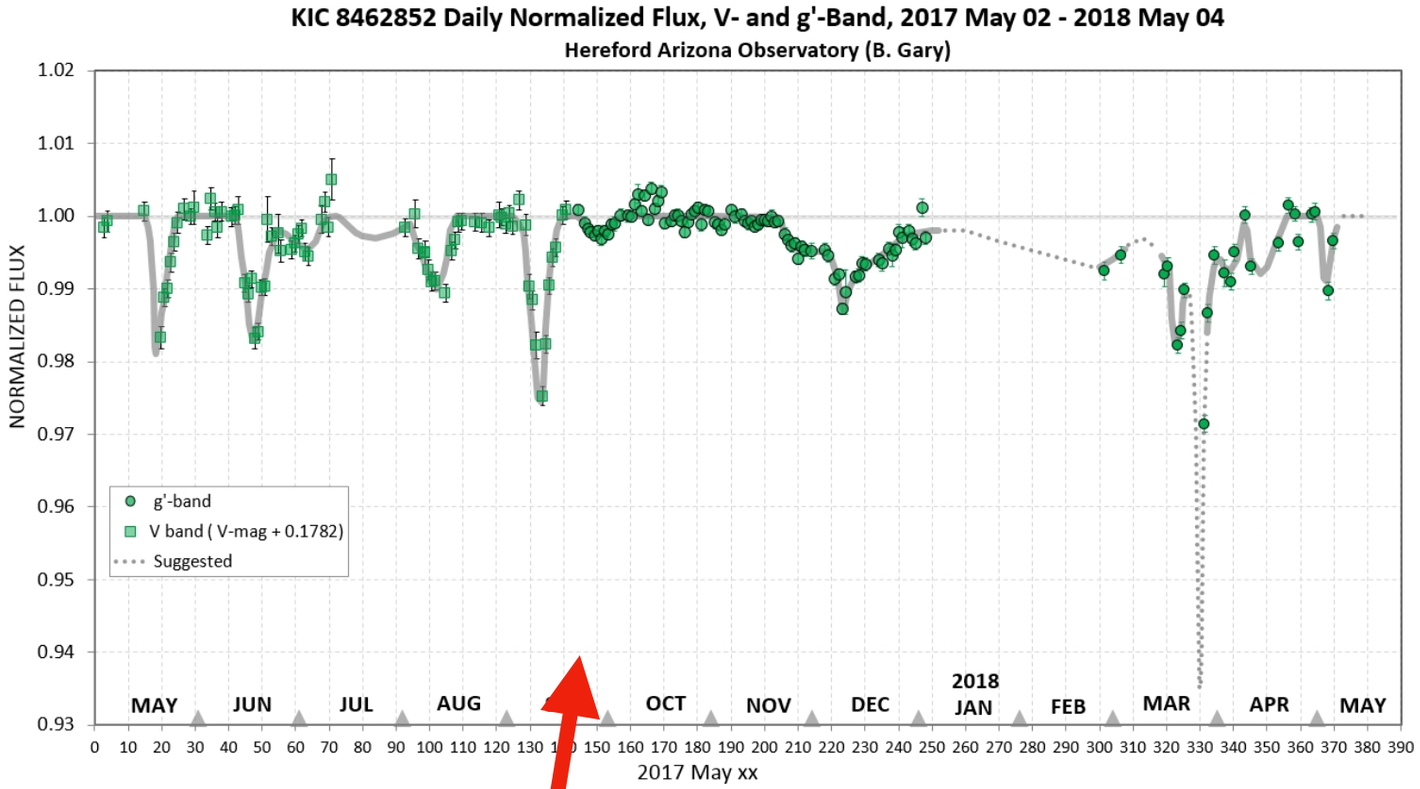
- A sphere is actually not stable, so would probably be a **Dyson Swarm** – a collection of orbiting solar panels.

- But how we would detect them…?

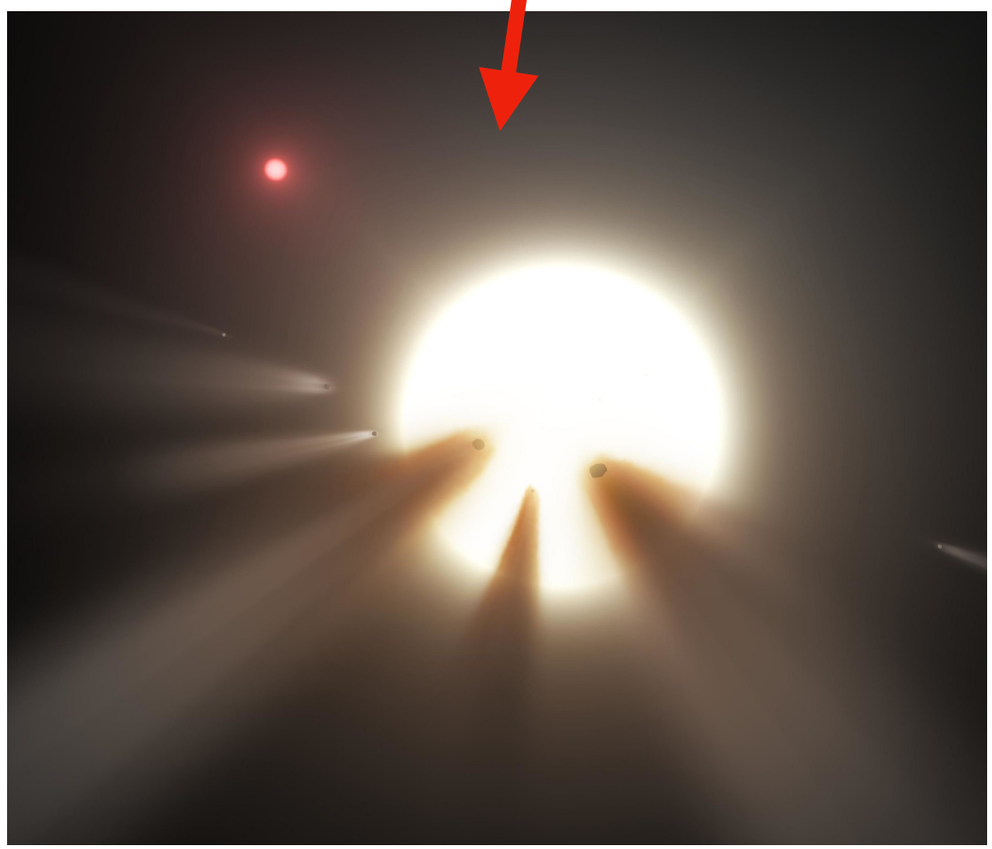




Detecting Dyson structures: Transits and waste heat!



This system is almost certainly from dust around the star



Maybe would see the structures transit!
Would be unlike planetary transits.

Also, there would be waste heat, so they would emit in the infrared.

Lastly, can we find alien artifacts in space?

- This is hypothetically likely if the alien civilizations are **significantly more advanced** than us!

- ETI may have **left artifacts** on other solar system bodies or in orbit around the sun, or past spacecraft?

- Would assume the ETI was **capable of interstellar travel** to some degree.

Monolith from 2001: A Space Odyssey

Instapoll #3:

Which of the following kinds of signal do we currently have the best chance of detecting with current technology?

A. a signal used for communication between a civilization's home world and another star system

B. a signal used for communication between a civilization's home world and another planet in its own planetary system

C. an intentional signal beacon

D. a signal used for local communication in the world where the intelligent beings exist

Instapoll #4:

We mostly think of using radio signals for interstellar communication rather than visible light signals because:

A. Radio signals are the only form of light that can carry information.

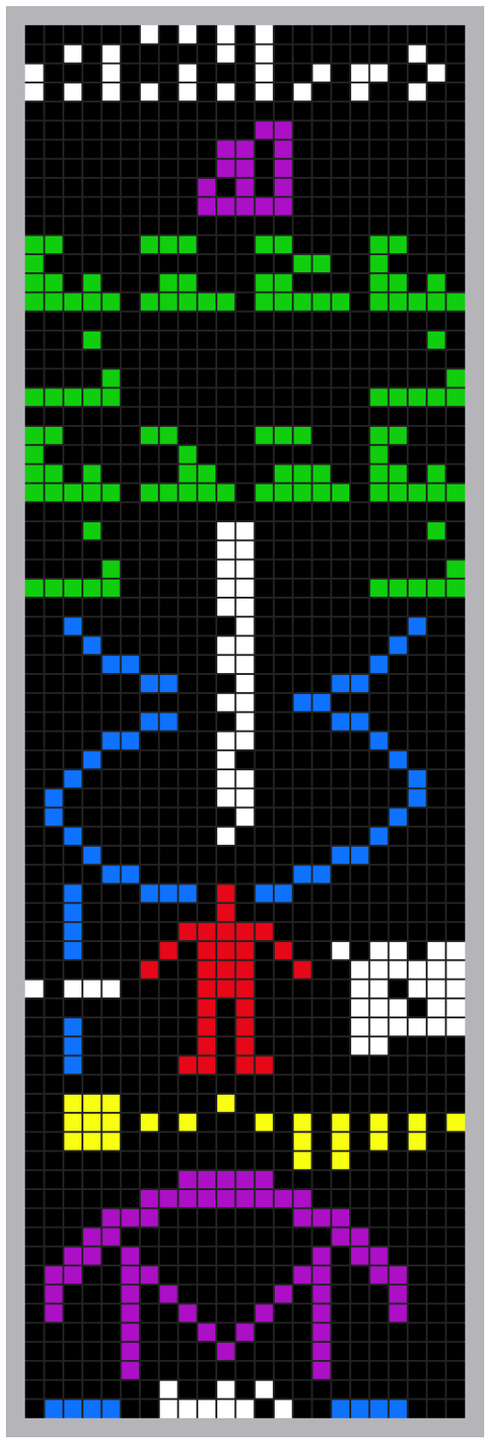
B. Visible light cannot pass as easily through the large amount of dust between stars in our galaxy.

C. It takes more energy to generate visible light signals than radio signals.

D. All of the above

E. Both B & C

Today's Activity:
A message from ET intelligence



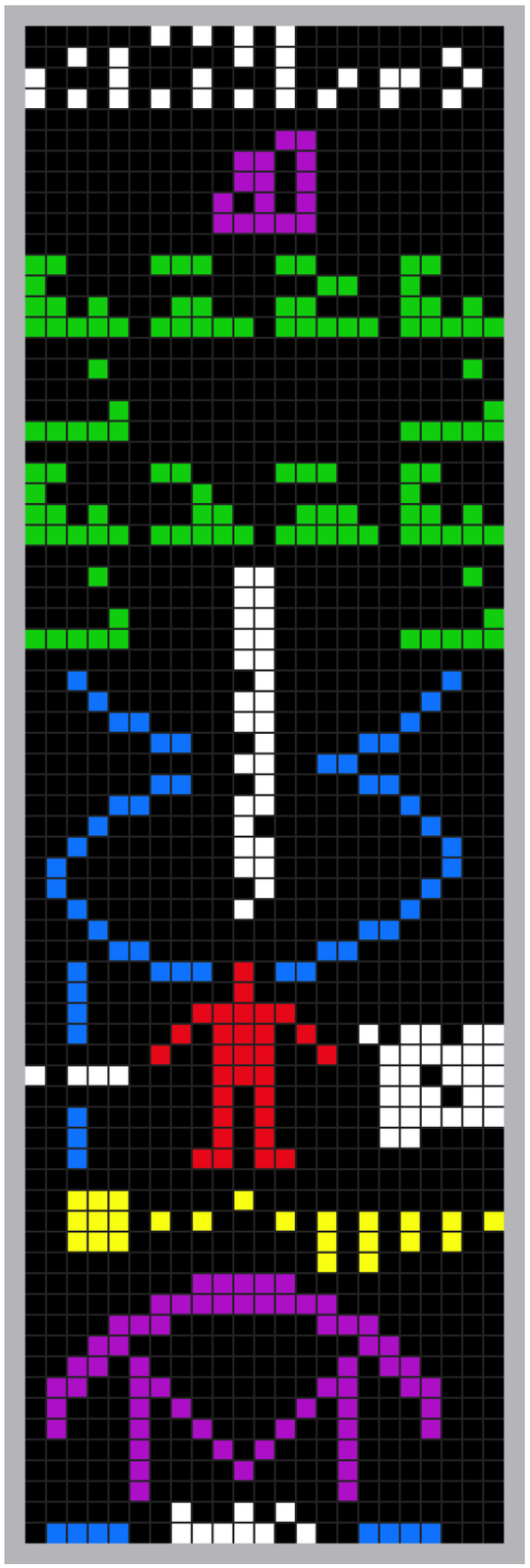
- You are an alien on a distant world and have just discovered an **unnatural radio signal** and have extracted information from it.

- It is now your job to **decipher what information** the message is trying to give you.

- Complete the first page before looking at the second page!

- You also will consider what type of **message you might send back**, and what its content will be!

Activity discussion



Numbers 1-10 in binary

Elements that make up DNA (H, C, N, O, P)

Nucleotides, using the above elemental code

DNA double helix, vertical bar is number of nucleotides

Average height, a human, world population

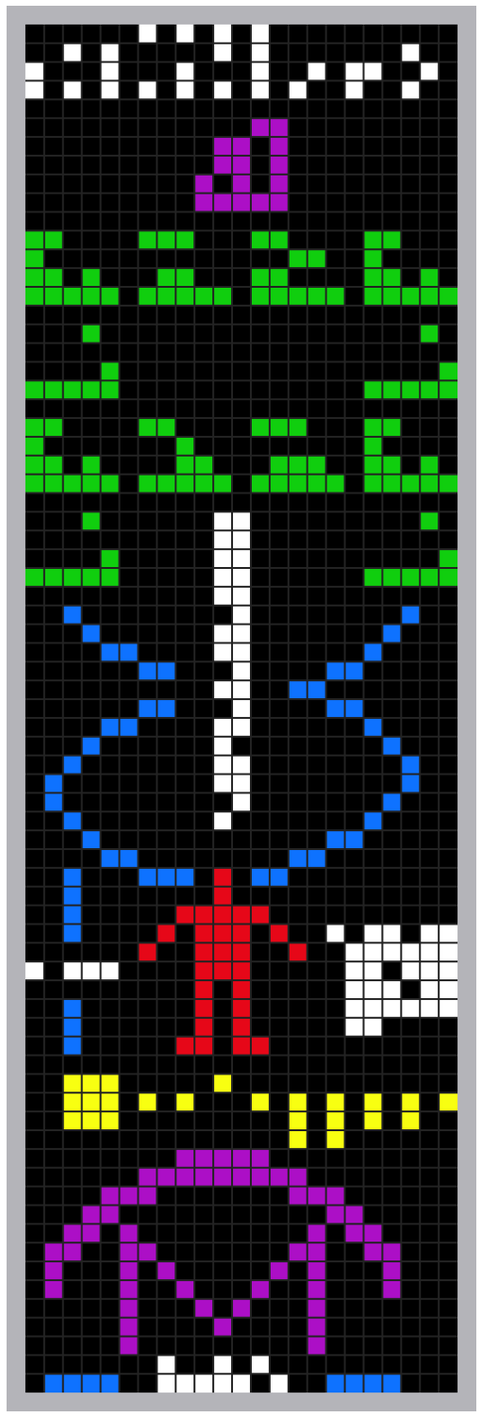
The solar system

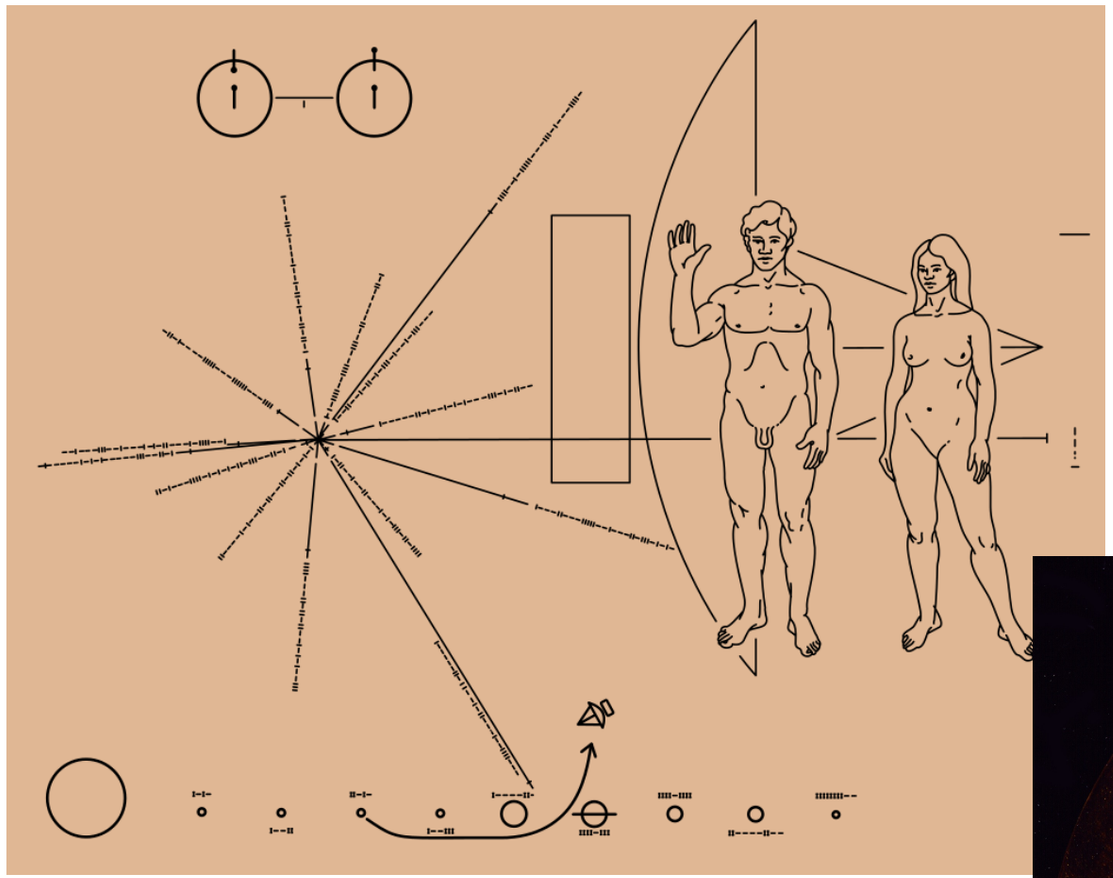
The Arecibo telescope dish, bottom is diameter

Activity discussion

- Was this a good message? In terms of content?
- Was it easy to decipher? Would it be clear to ETI?
- Are there any better ways to send information? What else would we want to include?
- Is sending messages to space (active SETI) a good idea?

Well have we actually sent messages to outer space?

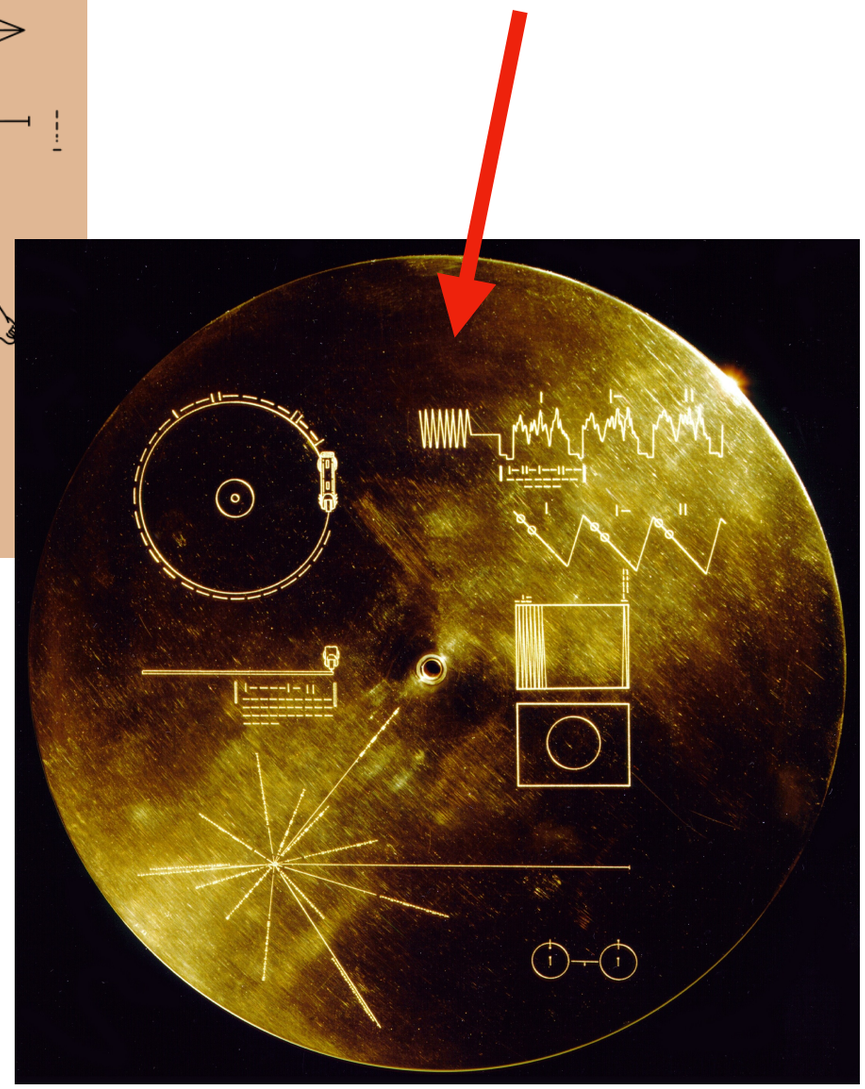




Pioneer plaque

Arecibo message

Voyager golden record



What do we do if we actually detect a signal from an extraterrestrial civilization?!

What are the actual policies in place for a SETI signal?

- **No official policies have been adopted** by governments, but there are SETI protocols in place in case of signal detection.

- If a signal is detected, first other astronomers and SETI scientists would be alerted to observe and confirm the signal.

- If a signal is confirmed, it would **immediately be announced** to the public and no response would be made.

- This discovery could potentially have huge impacts on the world, and we need to treat the aftermath carefully!

Instapoll #5:

Do you believe that aliens have landed on Earth?

A. Yes!

B. No!