ASTR/GEOL-2040: Search for life in the Universe: Lecture 38

- Breakthrough initiatives
- SETI, which frequency?
- Arecibo message, etc.

Axel Brandenburg
(Office hours: Mondays 2:30 – 3:30 in X590
and Wednesdays 11-12 in D230)

Breakthrough initiatives?

- Funded by Yuri Milner
  - PhD (Th Physics 1985) from Moscow SU
  - Lebedev Physical Institute
  - Since 1990 in US, 1999 internet investor
- 2012: Breakthrough Prize (Phys, Life, Math)
- 2015: Breakthrough Initiatives
  - Breakthrough Listen, Message, Starshot

1st step toward StarChip

IN QUEST TO REACH ALPHA CENTAURI, BREAKTHROUGH STARSHOT LAUNCHES WORLD'S SMALLEST SPACECRAFT

First Prototype 'Sprites' – Precursors to Eventual 'StarChip' Probes – Achieve Low Earth Orbit

San Francisco – July 26, 2017 – Breakthrough Starshot, a multi-faceted program to develop and launch practical interstellar space missions, successfully flew its first spacecraft – the smallest ever launched.

On June 23, a number of prototype **"Sprites"** – the world's smallest fully functional space probes, built on a single circuit board – achieved Low Earth Orbit, piggybacking on OHB System AG's 'Max Valier' and 'Venta' satellites. The 3.5-by-3.5 centimeter chips weigh just four grams but contain solar panels, computers, sensors, and radios. These vehicles are the next step of a revolution in spacecraft miniaturization that can contribute to the development of centimeter- and gram-scale **"StarChips"** envisioned by the Breakthrough Starshot project.

The **Sprite** is the brainchild of Breakthrough Starshot's Zac Manchester, whose 2011 Kickstarter campaign, "KickSat", raised the first funds to develop the concept. The **Sprites** were constructed by researchers at Cornell University and transported into space as secondary payloads by the Max Valier and Venta satellites, the latter built by the Bremen-based OHB System AG, whose generous assistance made the mission possible.

The **Sprites** remain attached to the satellites. Communications received from the mission show the **Sprite** system performing as designed. The spacecraft are in radio communication with ground stations in California and New York, as well as with amateur radio enthusiasts around the world. This mission is designed to test how well the Sprites' electronics perform in orbit, and demonstrates their novel radio communication architecture.

Nearby stars

Name	Travel time (yr)	Distance (ly)	Luminosity ($L_\odot$)
Proxima Centauri	20	4.2	-
α Centauri A	20	4.36	1.52
α Centauri B	20	4.36	0.50
Sirius A	68.90	8.58	24.20
Procyon A	154.06	11.44	6.94
Vega	167.39	25.02	50.05
Altair	176.67	16.69	10.70
Fomalhaut A	221.33	25.13	16.67
Denebola	325.56	35.78	14.66
Castor A	341.35	50.98	49.85
Epsilon Eridani	363.35	10.50	0.50

Breakthrough Initiatives

From Wikipedia, the free encyclopedia

Breakthrough Initiatives is a program founded in 2015 and funded by Yuri Milner to search for extraterrestrial intelligence over a span of at least 10 years. The program is divided into multiple projects. Breakthrough Listen will comprise an effort to search over 1,000,000 stars for artificial radio or laser signals. A parallel project called Breakthrough Message is an effort to create a message "representative of humanity and planet Earth".[1][2] The project Breakthrough Starshot aims to send a swarm of probes to the nearest star at about 20% the speed of light. The project Breakthrough Watch aims to identify and characterize Earth-sized, rocky planets around Alpha Centauri and other stars within 20 light years of Earth.[3]

[4][5] The announcement included an open letter co-signed by multiple scientists, including Hawking, expressing support for an intensified search for alien radio communications. During the public launch, Hawking said: "In an infinite Universe, there must be other life. There is no bigger question. It is time to commit to finding the answer."[6][7]

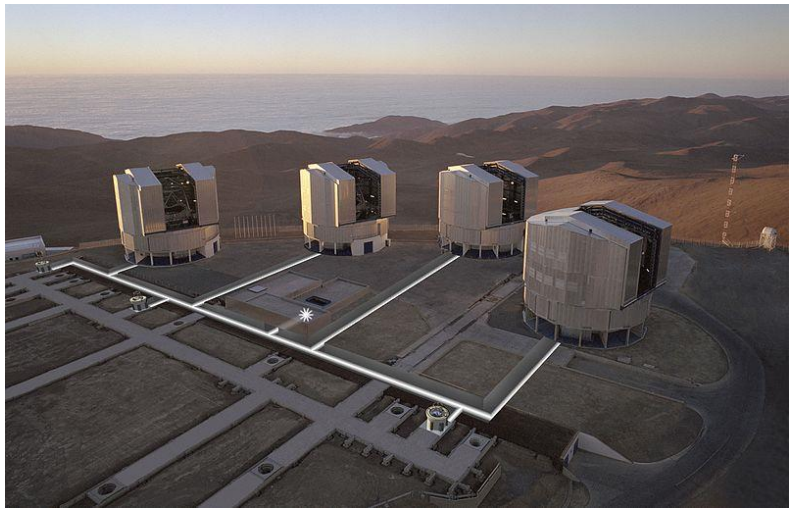
← exoplanets

Breakthrough support to ESA

- European Southern Observatory (ESA) collaboration with Breakthrough Initiatives
- VISIR upgrade
- VLT Imager & Spectrometer for mid IR
- Very Large

  Telescope

  4 x 8.2 m



Breakthrough Listen

- 100 M$ to SETI (2x NASA 1973-1993)
- 10 yr initiative, 1 – 10 GHz

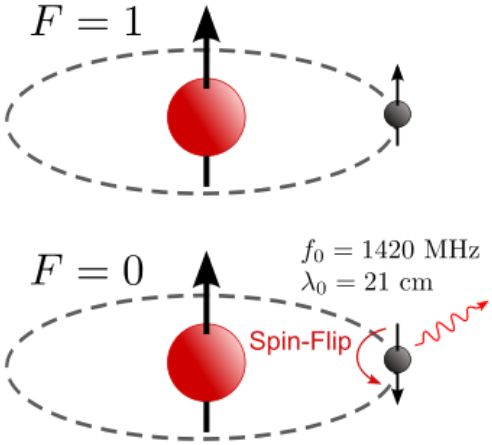
Early beginnings

- Pioneered by Guglielmo Marconi (1874-1937)
  - Made first transatlantic radio communication
  - 1920 picked up extraterrestrial source?
- Nikola Tesla (1856-1943)
  - Discovered whistler waves
- 1924 tried communication with Mars
  - Closest approach
  - US army joined the search

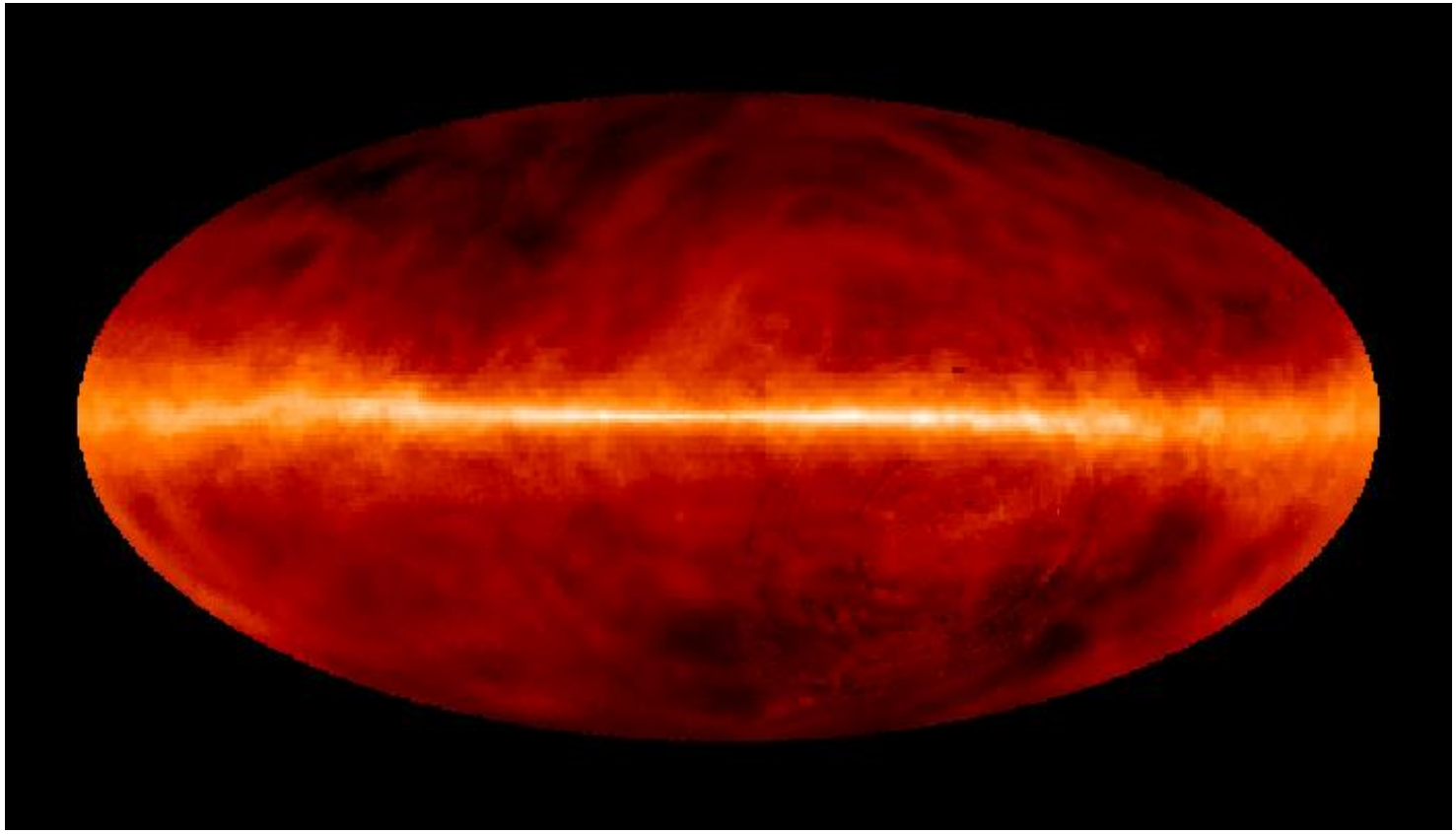
Searching - SETI

- Search for Extraterrestrial Intelligence
- What frequency?
- Radio!
- Astronomers: mapping galaxy in 21 cm

Neutral hydrogen



- Cause by spin flip of electron
- 21 cm line penetrates dust etc



Searching - SETI

- Search for Extraterrestrial Intelligence
- What frequency?
- Radio!
- Astronomers: mapping galaxy in 21 cm
- = 3e8/0.21 Hz = 1.42e9 Hz = 1420 MHz
- Doppler shift: blurred → 1419 … 1421 MHz
- Maybe not use the same frequency → which?

SEARCHING FOR INTERSTELLAR COMMUNICATIONS

By GIUSEPPE COCCONI* and PHILIP MORRISON†
Cornell University, Ithaca, New York

NO theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation ; (2) origin of life ; (3) evolution of societies possessing advanced scientific capabilities. In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation. The lifetime of such societies is not known ; but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time. It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us.

* Now on leave at CERN, Geneva.

† Now on leave at the Imperial College of Science and Technology, London, S.W.7.

To the beings of such a society, our Sun must appear as a likely site for the evolution of a new society. It is highly probable that for a long time they will have been expecting the development of science near the Sun. We shall assume that long ago they established a channel of communication that would one day become known to us, and that they look forward patiently to the answering signals from the Sun which would make known to them that a new society has entered the community of intelligence. What sort of a channel would it be ?

The Optimum Channel

Interstellar communication across the galactic plasma without dispersion in direction and flight-time is practical, so far as we know, only with electromagnetic waves.

Since the object of those who operate the source is to find a newly evolved society, we may presume that the channel used will be one that places a minimum burden of frequency and angular discrimi-

Radio most favored

in planetary atmospheres. The band-widths which seem physically possible in the near-visible or gamma-ray domains demand either very great power at the source or very complicated techniques. The wide radio-band from, say, 1 Mc. to 10^4 Mc./s., remains as the rational choice.

At what frequency shall we look ? A long spectrum search for a weak signal of unknown frequency is difficult. But, just in the most favoured radio region there lies a unique, objective standard of frequency, which must be known to every observer in the universe : the outstanding radio emission line at 1,420 Mc./s. ($\lambda = 21$ cm.) of neutral hydrogen. It is reasonable to expect that sensitive receivers for this frequency will be made at an early stage of the development of radio-astronomy. That would be the expectation of the operators of the assumed source, and the present state of terrestrial instruments indeed justifies the expectation. Therefore we think it most promising to search in the neighbourhood of 1,420 Mc./s.

How & where to look?

- Pulsed (not too slow/fast)
- ε Eridani

settings should cover the frequency range F using an integration time of minutes or hours.

Nature of the Signal and Possible Sources

No guesswork here is as good as finding the signal. We expect that the signal will be pulse-modulated with a speed not very fast or very slow compared to a second, on grounds of band-width and of rotations. A message is likely to continue for a time measured in years, since no answer can return in any event for some ten years. It will then repeat, from the beginning. Possibly it will contain different types of signals alternating throughout the years. For indisputable identification as an artificial signal, one signal might contain, for example, a sequence of small prime numbers of pulses, or simple arithmetical sums.

The first effort should be devoted to examining the closest likely stars. Among the stars within 15 light years, seven have luminosity and lifetime similar to those of our Sun. Four of these lie in the directions of low background. They are τ Ceti, 0_2 Eridani, ε Eridani, and ε Indi. All these happen to have southern declinations. Three others, α Centauri, 70 Ophiucus and 61 Cygni, lie near the galactic plane and therefore stand against higher backgrounds. There are about a hundred stars of the appropriate luminosity among the stars of known spectral type within some fifty light years. All main-sequence dwarfs between perhaps $G0$ and $K2$ with visual magnitudes less than about $+6$ are candidates.

The reader may seek to consign these speculations wholly to the domain of science-fiction. We submit, rather, that the foregoing line of argument demonstrates that the presence of interstellar signals is entirely consistent with all we now know, and that if signals are present the means of detecting them is now at hand. Few will deny the profound importance, practical and philosophical, which the detection of interstellar communications would have. We therefore feel that a discriminating search for signals deserves a considerable effort. The probability of success is difficult to estimate ; but if we never search, the chance of success is zero.

DIRECT CONTACT AMONG GALACTIC CIVILIZATIONS BY RELATIVISTIC INTERSTELLAR SPACEFLIGHT*

CARL SAGAN†
Department of Genetics, Stanford University Medical Centre,
Palo Alto, California

(*Received* 16 *December* 1962)

Abstract—An estimate of the number of advanced technical civilizations on planets of other stars depends on our knowledge of the rate of star formation; the frequency of favorably situated planets; the probabilities of the origins of life, of intelligence and of technical civilization; and the lifetimes of technical civilizations. These parameters are poorly known. The estimates of the present paper lead to $\sim 10^6$ extant advanced technical civilizations in our Galaxy. The most probable distance to the nearest such community is then several hundred light years.

The multiplication of the preceding factors gives

$$N = 10 \times 1 \times 1 \times 1 \times 10^{-1} \times 10^{-1} \times L = 10^{-1}L.$$

L is the mean lifetime in years of a technical civilization possessing both the interest and the capability for interstellar communication. For the evaluation of L there is—fortunately for us, but unfortunately for the discussion—not even one known terrestrial example. The present technical civilization on Earth has reached the communicative phase (in the sense of high-gain directional antennas for the reception of extraterrestrial radio signals) only within the last few years. There is a sober possibility that L for Earth will be measured in decades. It is also possible that international political differences will be permanently settled, and that L may be measured in geological time. It is conceivable that, on other worlds, the resolution of national conflicts and the establishment of planetary governments are accomplished before weapons of mass destruction become available. We can imagine two extreme alternatives for the evaluation of L: (a) a technical civilization destroys

Sagan's idea

- Different by π
- e.g. (1420/π) MHz and/or (1420π) MHz
- Why not add and/or subtract?

A. Too small a difference

B. Too large a difference

C. None of the above

Sagan's idea

- Different by π
- e.g. (1420/π) MHz and/or (1420π) MHz
- Why not add and/or subtract?

A. Too small a difference

B. Too large a difference

C. None of the above

Eavesdropping instead?

- Choice made for us: limited number of targets (neighborhood)
- Weak signal, if not directed toward us
- Perhaps additional clues: e.g., look for systems with outer Jupiters
- Why?

Eavesdropping instead?

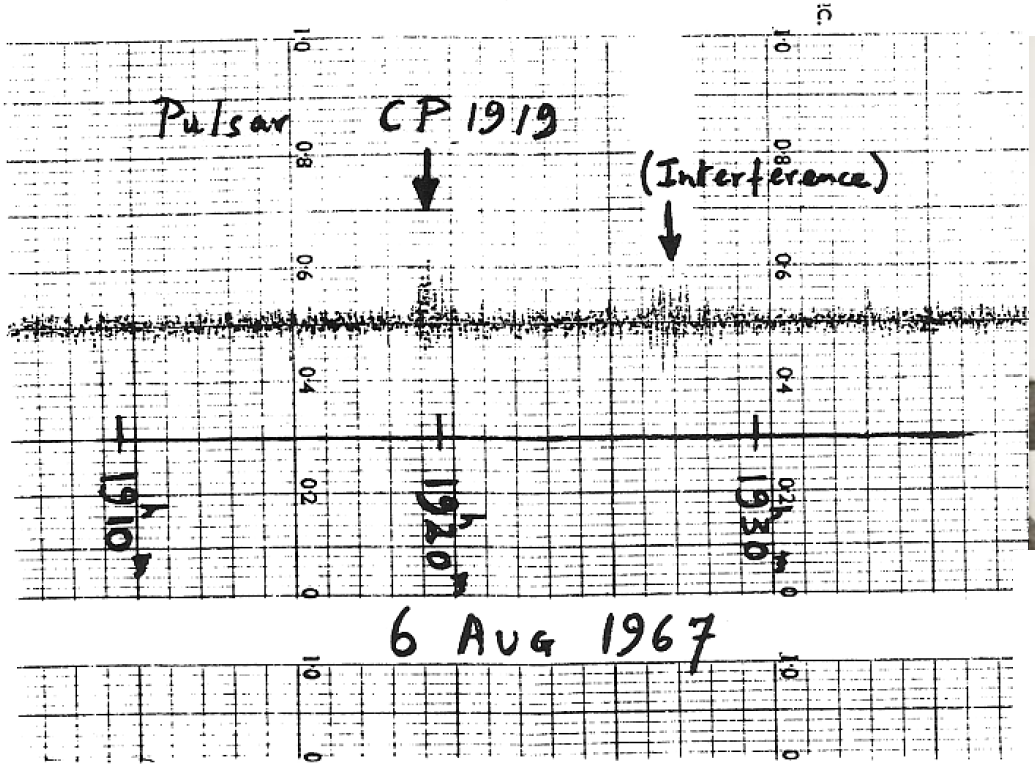
- Choice made for us
- Limited number of targets
- Weak signal if not directed toward us
- Look for systems with outer Jupiters
- Why?

Would protect us from some of the bombardments by comets etc

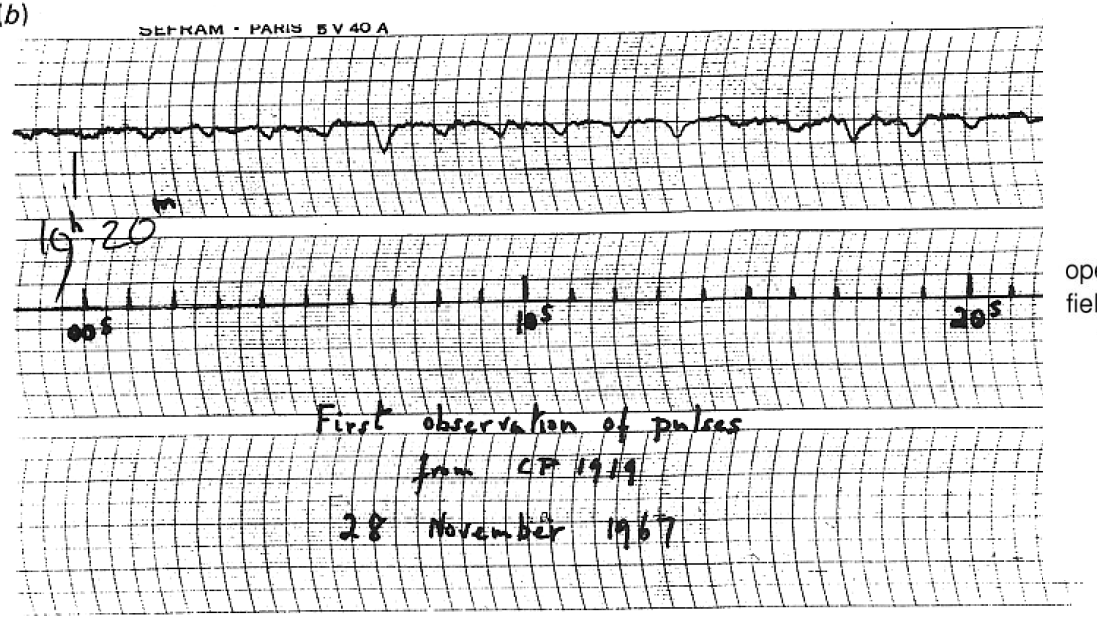
‘Little Green Men’ SETI signal in 1967 focus of new scientific paper

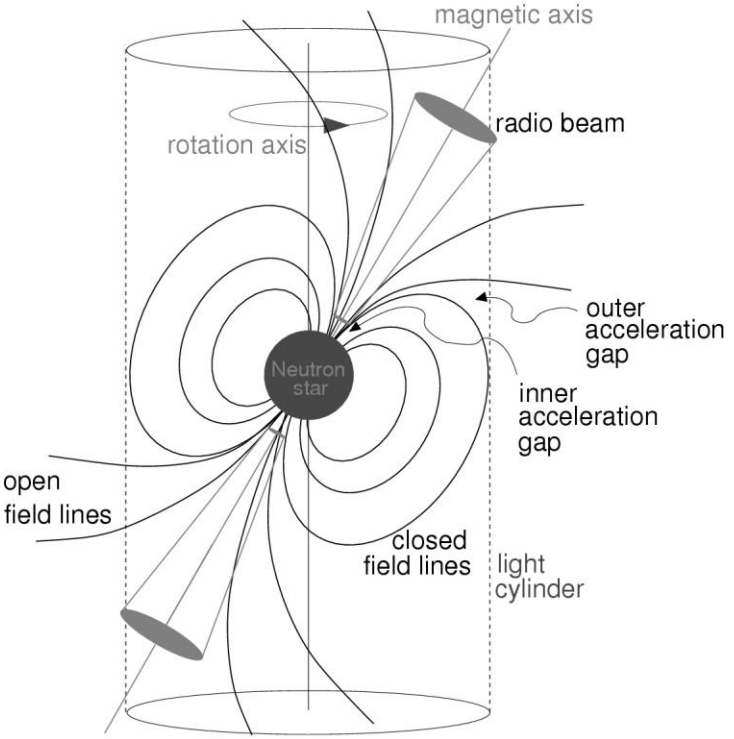
Posted by: Alejandro Rojas March 8, 2013 0

(a)


Pulsar CP 1919
(Interference)
19h10m
19h20m
19h30m
6 Aug 1967

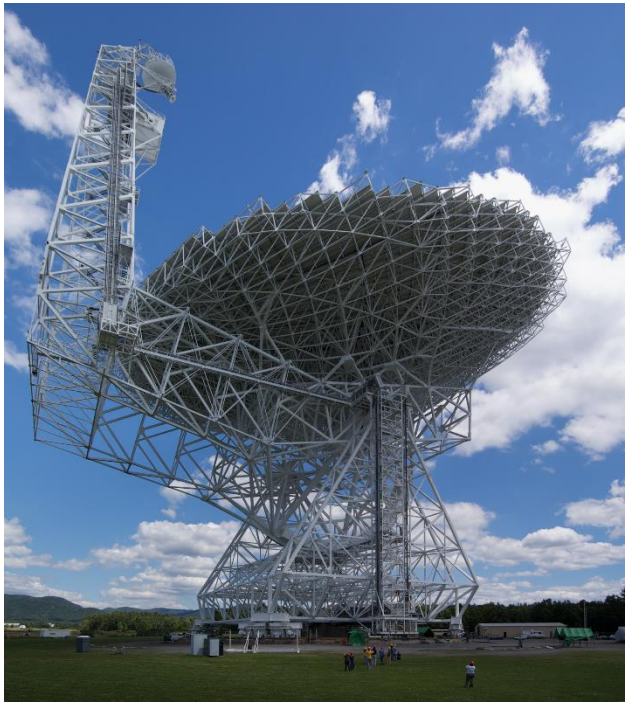
(b)


SEFRAM - PARIS 5 V 40 A
19h.20m
00s
10s
20s
First observation of pulses
from CP 1919
28 November 1967


magnetic axis
radio beam
rotation axis
outer
acceleration
gap
Neutron
star
inner
acceleration
gap
open
field lines
closed
field lines
light
cylinder

Breakthrough message

- 1 M$ to study the ethics of sending messages

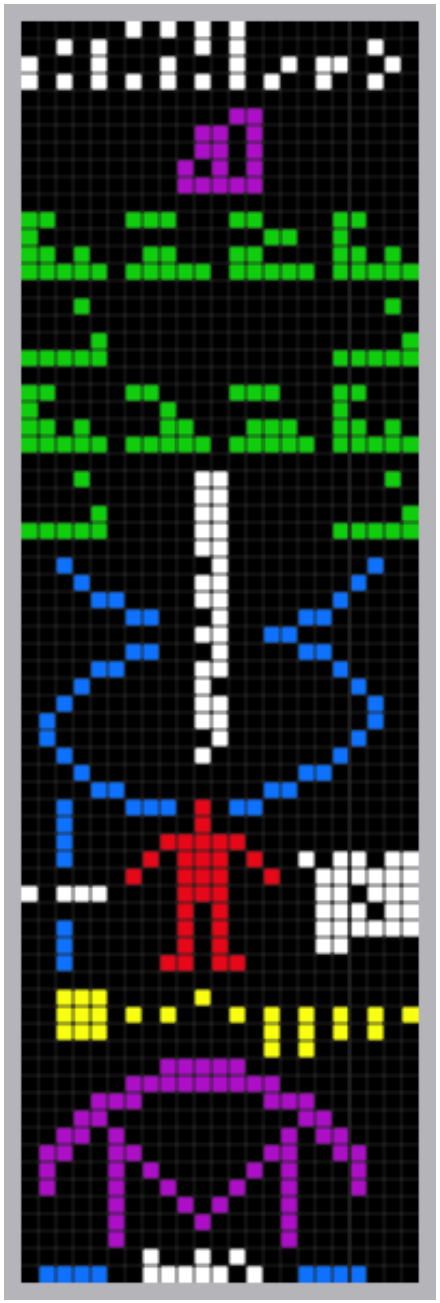


Breakthrough Message [edit]

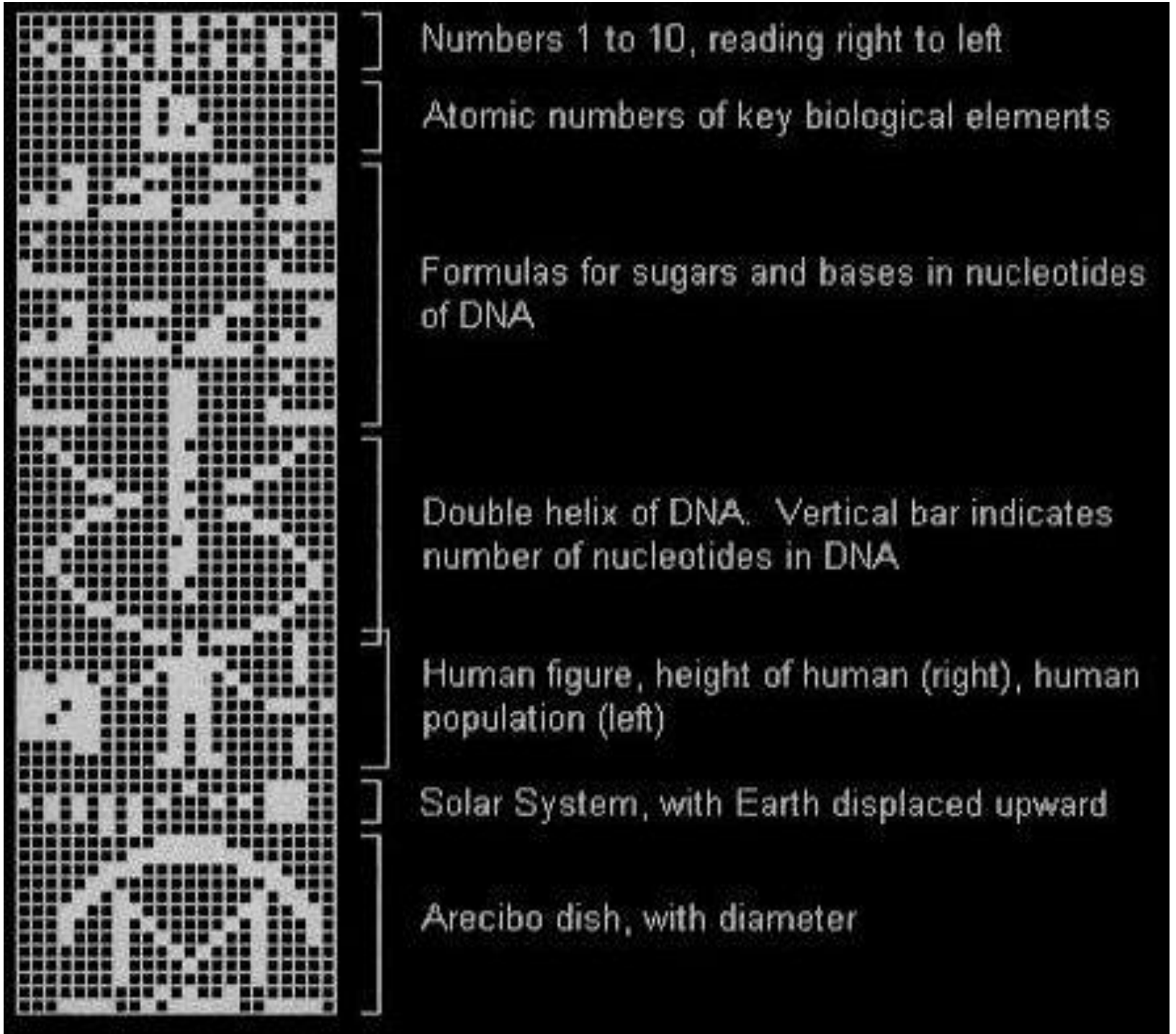
The *Breakthrough Message* program is to study the ethics of sending messages into deep space.[27] It also launched an open competition with a US$1 million prize pool, to design a digital message that could be transmitted from Earth to an extraterrestrial civilization. The message should be "representative of humanity and planet Earth". The program pledges "not to transmit any message until there has been a global debate at high levels of science and politics on the risks and rewards of contacting advanced civilizations".[28]

1974 Arecibo message

- Easy decoding?
- Image 1679 = 23 x 73
- Frequency 2380 MHz
- Wavelength 12.6 cm




M13


Numbers 1 to 10, reading right to left
Atomic numbers of key biological elements
Formulas for sugars and bases in nucleotides of DNA
Double helix of DNA. Vertical bar indicates number of nucleotides in DNA
Human figure, height of human (right), human population (left)
Solar System, with Earth displaced upward
Arecibo dish, with diameter

Decoding the signal

- 0001
- 0110
- 0111
- 1111

Some of Drakes colleagues
Solved some of the riddles,
But nobody solved all of them

5 B	6 C	7 N	8 O	9 F
13 Al	14 Si	15 P	16 S	17 Cl

Decoding the signal

- 0001 = 1
- 0010 = 2
- 0011 = 3
- 0100 = 4
- 0101 = 5
- 0110 = 6
- 0111 = 7
- 1000 = 8
- 1001 = 9
- 1010 = 10
- 1011 = 11
- 1100 = 12
- 1101 = 13
- 1110 = 14
- 1111 = 15

Current surveys

		Channels		MHz			
SETI	6x42m	450M	1 Hz	1390-1720	70 MW		
UCB	305 m	168M	.6 Hz	1370-1470	1 MW		
SETI Italia	32 m	24M	.6 Hz	1400, 2800, 6400, 22400	30 MW		

Optical SETI

- Possible w/o radio
  - Planting trees etc (comm w/ Mars)
  - Installing mirrors
- High powered lasers!
- Passive SETI
- UV, X-rays, ….

Next

- Wow signal
- Fermi paradox
- Spreading colonies
- Other applications of astrobiology
  - Artificial life, BS pp. 233 – 238