

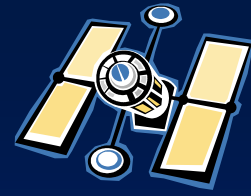
The Search for Extra-Terrestrial Intelligence (SETI)

Prepared for the Mid-Atlantic Antique Radio Club

August 2024

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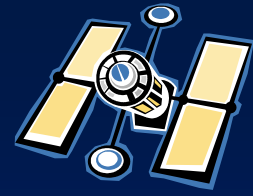




Topics

- SETI assumptions
- Possibilities for alien intelligences
- History of SETI from the 19th century to the present day
- SETI in the radio spectrum
- SETI trade space
- Discussion of signal “leakage”
- Intentional interstellar communications
- The Drake equation
- Where is everybody?
- The WOW! Signal
- SETI projects over the years
- What to do if a signal is found
- Should we advertise?
- Oumuamua
- Future SETI initiatives



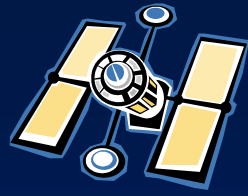


Assumptions

- The laws of physics are the same everywhere in the universe
- Our cosmological understanding of the universe is essentially correct, if incomplete
- Any technological civilization would use some form of electromagnetic radiation for communications
- We would recognize artificial signals if we saw them
- Alien intelligences would communicate on time scales similar to ours
 - Not much faster or slower



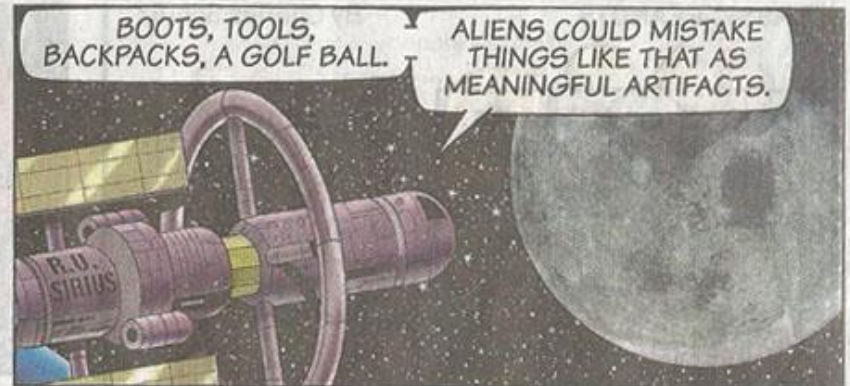
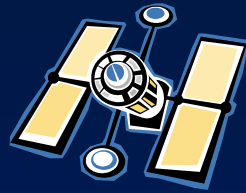
Possibilities for Alien Intelligences



- One extreme – aliens will be bipedal oxygen/carbon/water mammals
- Other extreme – aliens will be so different from us, that not only will we not recognize intelligence, we will not even recognize life
- Something in between



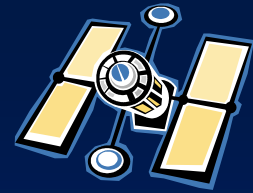
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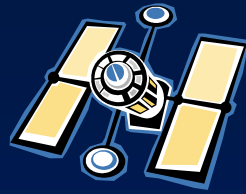


Short History of SETI

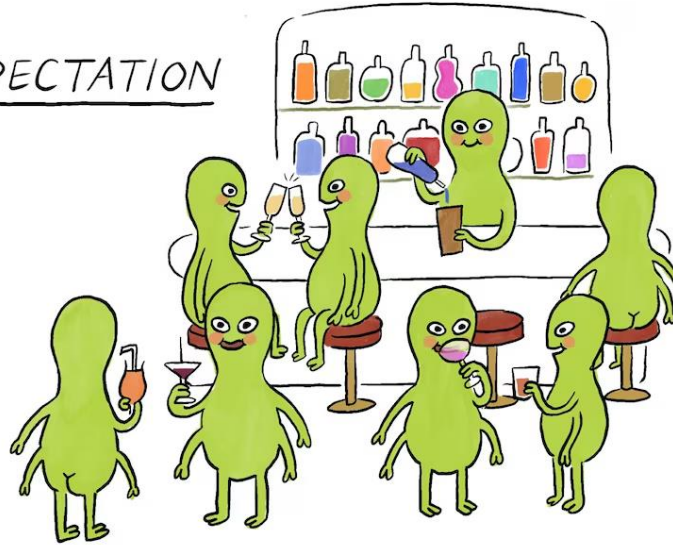
- SETI has been (mostly) a disciplined, scientific process
- SETI has been an “organized” activity since 1960
 - Sporadic funding from government and private sources
- SETI has produced *no* evidence of extra-terrestrial intelligence



Hearing NASA's Mars rover has found signs of life



EXPECTATION



REALITY

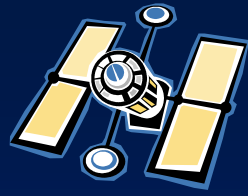
(A rock with millimeter-sized white splotches that may be signs of ancient microbial activity)



EDITH

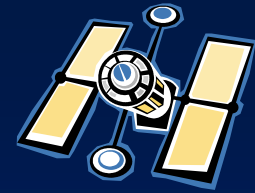


19th Century SETI



- Prominent astronomer Percival Lowell saw “canals” on Mars, speculated an advanced civilization lived there
- Tesla, Marconi, and others speculated about searching for intelligence in radio signals from space
 - Efforts provided nothing conclusive
- Tesla claimed he was communicating with Martians
 - They would not talk to anyone but him
 - Not very encouraging





Early 20th Century SETI

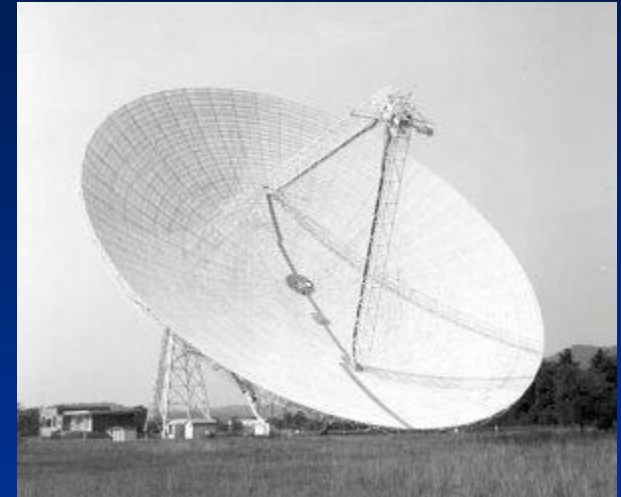
- August 21 - 23 1924, at Mars opposition, US Naval Observatory requested all radio transmitters in US to be quiet for five minutes on every hour
- A radio receiver designed by Charles Francis Jenkins (of scanning TV fame) was hoisted to 10,000 feet under a dirigible
- Potential alien messages were listened for
- Nothing heard



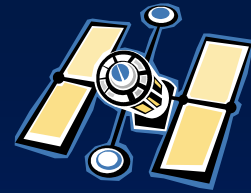


“Radio” SETI

- Radio SETI began in an organized manner in 1960
 - Frank Drake, Project *Ozma*
 - Green Bank WV radio telescope
 - 1420 MHz frequency
 - Rest frequency of neutral hydrogen
 - Universe-wide physical constant
 - Reserved frequency for radio astronomy – no terrestrial emissions allowed

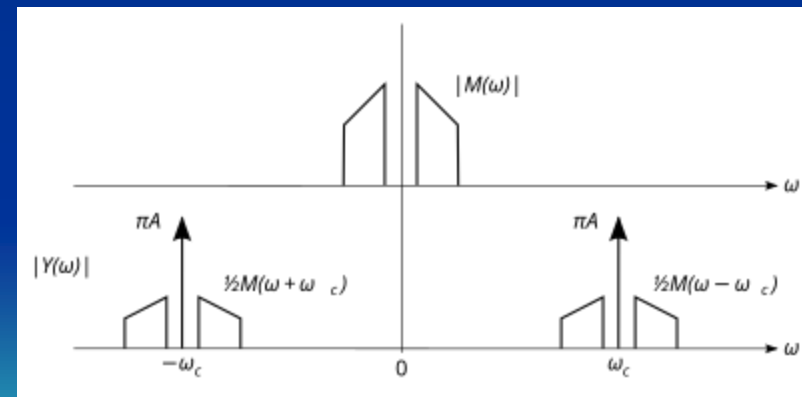


– Nothing found



Why Radio?

- In 1960, that's all we knew how to do
- We use radio, so speculation is other civilizations do also
- Modulated radio signals do not appear naturally (as far as we know), so a modulated signal (one carrying information) would stand out
 - Narrow band
 - Sharp rise and falloff in frequency
 - Symmetrical, repeatable
 - Sidebands





SETI Trade Space

- Wavelength (radio, IR, visible, UV, x-rays, gamma rays)
- Maybe not even EM (neutrinos, other particle beams, some technology of which we have no inkling?)
- Laser?
- Lots of sky to search



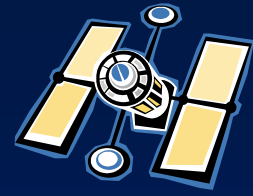


Possibilities for Signals

- Leakage – we have been “leaking” EM radiation into space for 125 years
 - Book/movie “Contact”
- Broadcast signals – “We don’t know if anyone is out there, here we are, come visit”
 - We have tried this, occasionally
- Tight-beamed signals – “We know you are there and listening, let’s be friends”



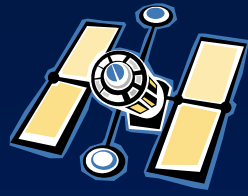
Would We Hear Leakage?



- Let's say Proxima Centauri (nearest star to Earth) had a technological civilization like ours
- Would we be able to detect their equivalent of “I Love Lucy” TV broadcast?
- Short answer from calculating S/N for biggest antennas and best receivers on Earth – no, the signal would be too far down in the noise



What About Intentional Communications?



- Situation is very different for intentional communications between star systems 4.25 light years apart
- Current (Earth) technology, using commercial broadcast high power amplifiers and existing very large antennas could make low data rate communications possible
- So if SETI ever finds a modulated signal, it will probably be something sent our way intentionally





Reception Problems

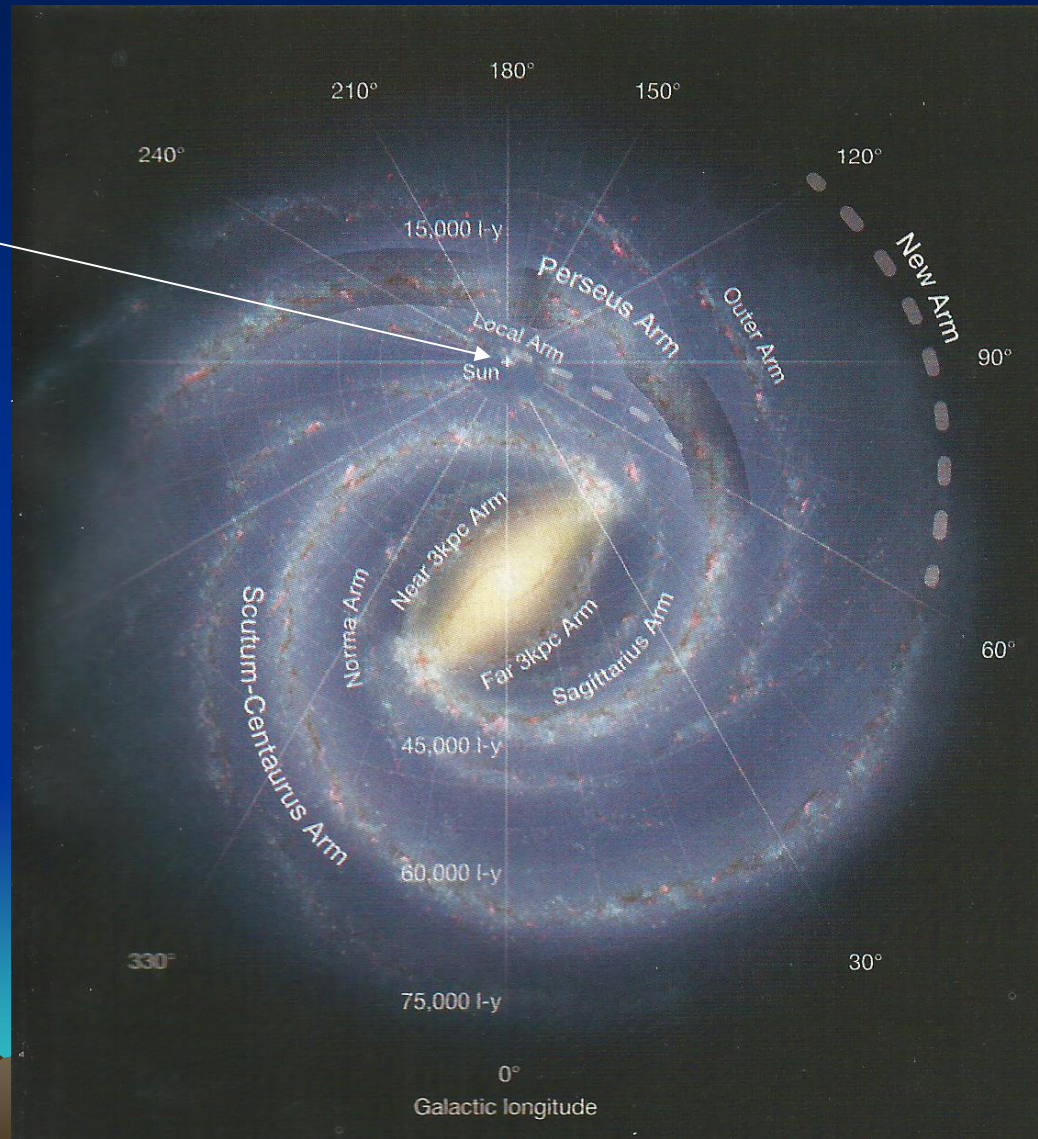
- Time delay – Proxima Centauri 4.5 light years, E-Eridani 11 LY, Tau Ceti 14 LY, etc.
 - Long wait for an answer
- Signal strength decreases $1/r^2$
- Interstellar dust absorbs EM radiation





Scale of the Problem

You are here

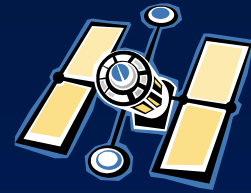




Drake Equation

- N is the number of civilizations in our galaxy with which communication might be possible
- $N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$
- R is average rate of star formation
- f_p is fraction of those stars that might have planets
- n_e is average number of planets that can potentially support life per star that has planets
- f_l is fraction of planets that could support life that develop life
- f_i is fraction of planets with life that develop civilizations
- f_c is fraction of civilizations that develop a technology detectable at inter stellar distances
- L is length of time for which such civilizations release detectable signals into space

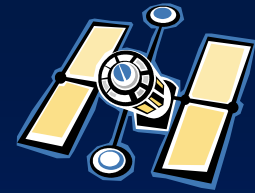




Drake Equation

- Drake equation is entirely *made up*
 - No physical basis
 - More a tool for discussion than actual engineering
- When Drake equation was written (early 1960s), values for most factors were wild guesses
- Subsequent science has placed bounds on some of the numbers
- For “reasonable” values for which professional scientists have no violent objections, N is quite large (on the order of a million possible intelligent civilizations in our galaxy)
 - 100 to 400 billion stars in our galaxy
- Then, as Enrico Fermi famously asked, “Where is everybody?”





“Where is Everybody?”

- We have no way of knowing
- Maybe we are truly alone
 - I consider this to be unlikely, the universe is way too big, and we have only examined a tiny local sliver of our unremarkable galaxy
- Maybe civilizations evolve, but don't last long enough to communicate or travel between stars





“Where is Everybody?”

- The Universe is ~ 14.5 billion years old
- There has been “intelligent” life on Earth for 300,000 – 500,000 years
 - 2% - 3% of the age of the universe
- There has been “technological” life on Earth for ~150 years
 - Don’t know how long this will last



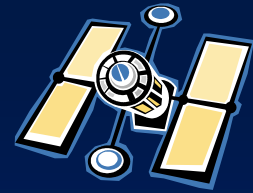
Plenty of time for other civilizations to arise and subsequently die of old age



“Where is Everybody?”

- Science fiction provides guesses
 - Maybe there really is no one there
 - Maybe we are being quarantined, or ignored
 - Maybe we are an experiment by a higher civilization, a glorified petri dish
 - Maybe other civilizations use communications that are impossible for us to notice
 - Maybe they are calling, but we are not smart enough to answer
 - Maybe, maybe, maybe.....





“Where is Everybody?”

- More guesses
 - Maybe nobody cares
 - Maybe aliens are here and are quietly observing
 - Maybe we are so far out in the boondocks that the myriad civilizations near the galactic center have not noticed us
 - Maybe all the other technological civilizations have died out, or turned inwards
 - The universe is 100 million times as old as our technological civilization
 - Maybe, maybe, maybe.....





The Wow! Signal

- Narrowband signal received on August 15, 1977 by Ohio State University radio telescope
 - Unmodulated CW signal near 1420 MHz
 - Astronomer doing data reduction noticed the signal and wrote “Wow!” in the margin of the printout
 - Has not been detected since



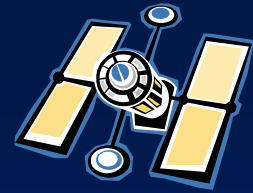
SETI Projects Over the Years



- Frank Drake made sporadic searches around 1420 MHz using a radio telescope during 1960s
- Soviet astronomers made sporadic searches using omni antennas during 1960s
- Big Ear (found the Wow! signal) begun by Ohio State University in 1950s for \$71,000



SETI Projects Over the Years



- NASA funded SETI study 1971 – 1981
 - NASA pulled out due to sticker shock
 - \$10 billion, then. NASA total 2019 budget was \$22 billion
- Various US Planetary Society efforts
 - Suitcase SETI, Sentinel, 1981 - 1985
 - META, 1985 until today
 - BETA, 1995 – 1999. Antenna destroyed by wind storm.



SETI Projects Over the Years



- SETI piggybacked on NASA Microwave Observing Program (MOP) in 1991
 - NASA funding pulled by Congress in 1992
 - Private funding continued as Project Phoenix until 2004.
- Many on-going (sporadic) radio searches at various radio telescopes around the world

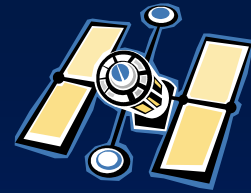


SETI Projects Over the Years



- SERENDIP analyzes radio telescope science data looking for artificial signals
 - High tech
 - Low cost
- UCLA students are conducting targeted listening on promising star systems





Allen Telescope Array

- Funded by late Paul Allen
 - Planned 350 6.1-meter radio dishes
 - Operational with a partial array
 - High tech
 - Solid funding
- Also does science





Breakthrough Listen

- \$100 million of private funding began 2015
- Thousands of hours of dedicated listening at Green Bank (northern hemisphere sky) and Parkes (southern)
- Automated Planet Finder at Lick Observatory is looking for laser signals
- Collaborating with Transiting Exoplanet Survey Satellite (TESS) to look for other technosignatures



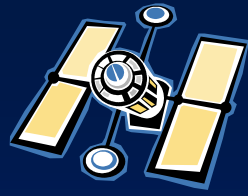
FAST



- Chinese Five Hundred Meter Aperture Spherical Telescope has SETI as one of its core science missions
 - As yet no results



SETI@home



- UC Berkeley project
- Distributed SERENDIP data packets to volunteers for signal processing
- Processed data then returned to Berkeley for subsequent human examination
- A victim of its own success, SETI@home has so much processed data that it has suspended volunteer processing while the human team takes a few years to catch up



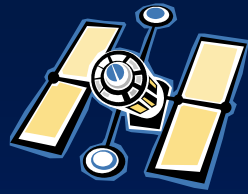


Other SETI

- SETI Net
- SETI League
- Project Argus
- Optical experiments
- Search for extra-terrestrial artifacts
 - Space probes?
- Technosignatures
 - Not just signals
 - Pollution?



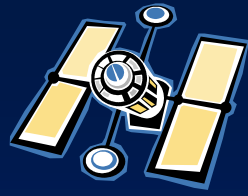
What is the Protocol if a Signal is Found?



- The International Academy of Astronautics (NGO) has a permanent study group considering this question
- No international consensus
- Keep it secret? (Doubtful this can be done)
- Announce it to the world?
- Inform world leaders only?



Should We Advertise?



- Should we send messages to the cosmos, “Hey, here we are?”
- We already have
 - Voyagers
 - Various transmissions from radio telescopes
- Lots of smart people (including Stephen Hawking) have said we should be hiding, as best we can
- Even benign, altruistic contact with an alien civilization could have serious unpleasant social consequences



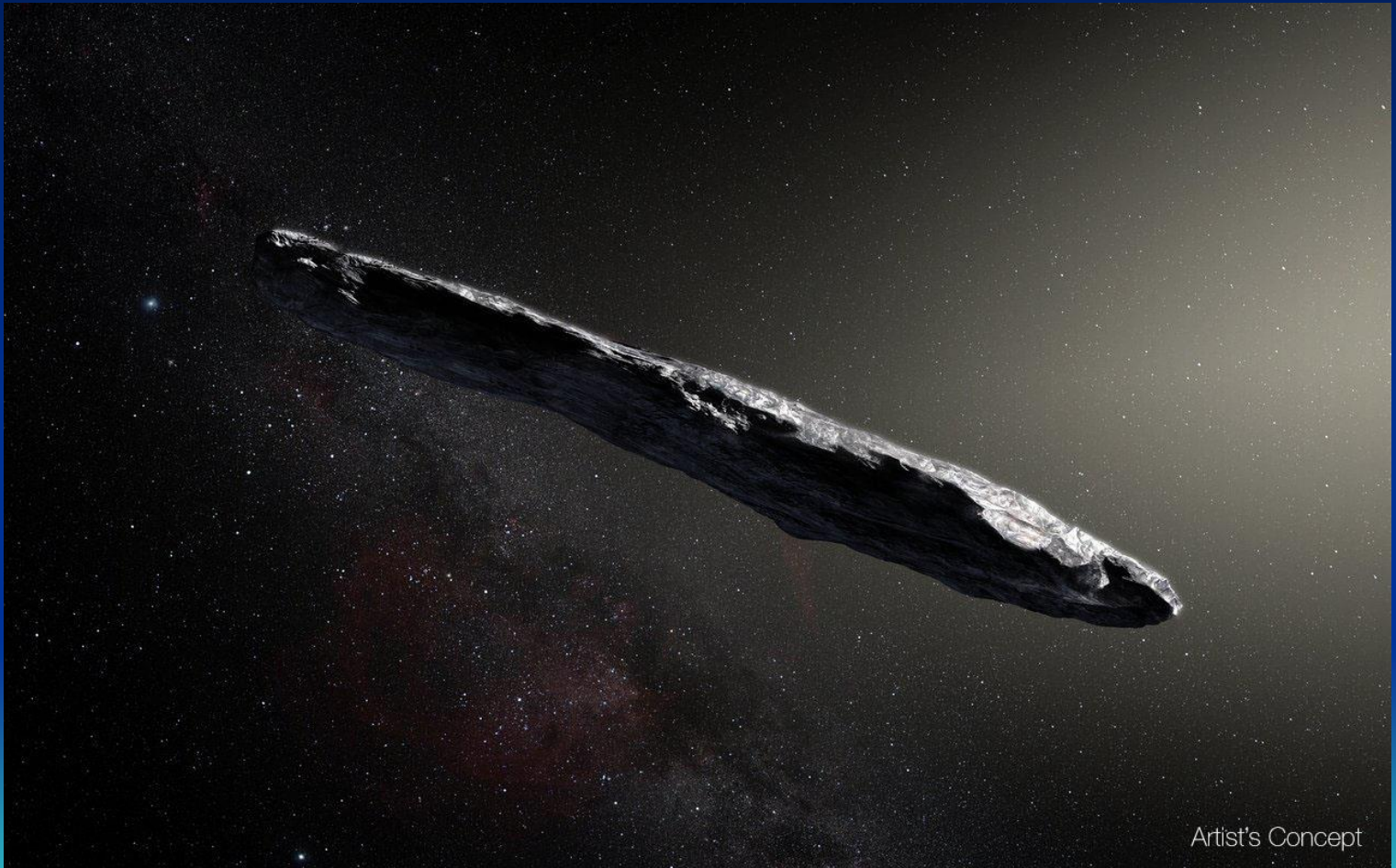


How to Advertise

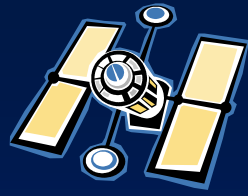
- I would not use radio, but a laser
 - Much higher gain, longer range
- Simple signal, maybe counting out the first 20 prime numbers
 - 1, (2), 3, 5, 7, 11, etc.
- Laser (coherent) light not found in nature
- Hard to mistake this for a natural signal



Was Oumuamua an Alien Artifact?



Was Oumuamua an Alien Artifact?



- Clearly originated outside our solar system
 - Hyperbolic orbit
- Exhibited dynamical behavior not usually seen in comets or asteroids
 - But not unprecedented
- Obvious parallels with “Rendezvous with Rama”
- Nevertheless, nothing suggests Oumuamua was anything but a natural object

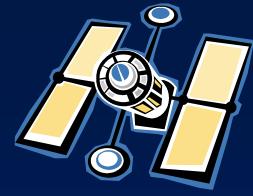




We Have Plans.....

-to send a fast probe to another star system
- Breakthrough Starshot wants to send laser-propelled mini sats to Alpha Centauri
 - 20 years enroute
 - Sail through the Alpha Centauri system at 100 million miles/hour and report back on what they see
- Stay tuned
- <https://breakthroughinitiatives.org/initiative/3>





Breakthrough Starshot

- At 100 million mi/hr, a probe would transit our entire solar system in 56 hours
 - Based on orbit of Neptune
 - Not much time to look around and report back
- Starshot's launch laser would be visible to the target solar system as an obviously artificial signal





Late Breaking

NASA has \$10 million in its budget “to search for technosignatures, such as radio transmissions, in order to meet the NASA objective to search for life’s origin, evolution, distribution, and future in the universe.”

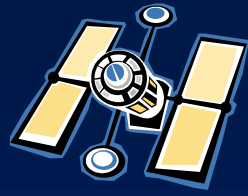




Summary

- Tonight we have taken a brief look at SETI
- Much more to study
- SETI has been sporadic, unorganized, lacking in direction
 - Lack of funding, lack of dedicated assets, and the “giggle factor”
- Hard to get money to look for something when you can't articulate what you are looking for





Summary

- Nevertheless, there is some serious money (government and private) being expended on SETI initiatives
- I hope this presentation encourages you to think about the problem





References

- Wikipedia article on SETI (although not authoritative) is an excellent pointer to dozens of SETI articles
- The importance of continents, oceans and plate tectonics for the evolution of complex life: implications for finding extraterrestrial civilizations

– <https://www.nature.com/articles/s41598-024-54700-x>



Questions?



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