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# LIFE IN THE UNIVERSE

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## **BREAKTHROUGH** INITIATIVES

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# BREAKTHROUGH INITIATIVES



BREAKTHROUGH  
INITIATIVES

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INITIATIVES

BREAKTHROUGH  
INITIATIVE



## Fundamental Questions

Is there other life in the universe?

Is there intelligent life elsewhere?

Can we travel between the stars?

# Breakthrough Prize

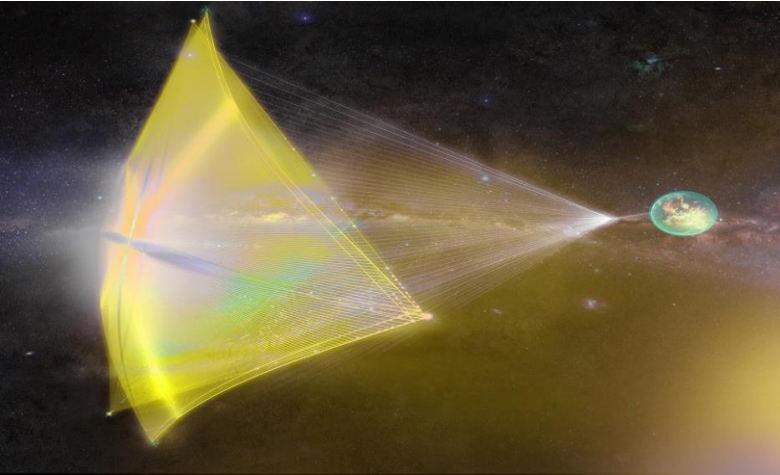
## WORLDS LARGEST PRIZES IN SCIENCE





BREAKTHROUGH  
STARSHOT

# BREAKTHROUGH STARSHOT

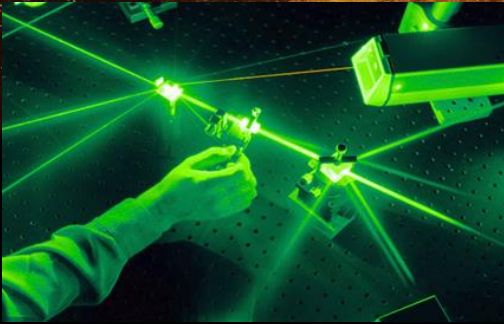


# Starshot Objectives

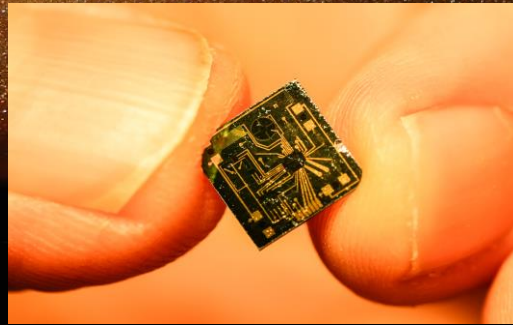
1. Determine if there are potentially life-bearing planets in the Alpha Centauri system
2. Take science data of star system focused on planets and beam data back to Earth
3. Launch within 30 years, at an affordable cost
4. Go FAST – 20% the speed of light

# Solution to go fast

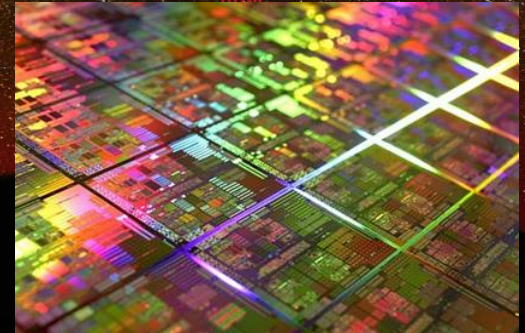
1. Lowest possible mass
2. Leave engine/fuel on Earth
3. Attach a chip to a sail
4. Laser beam is the wind



**Photonics**

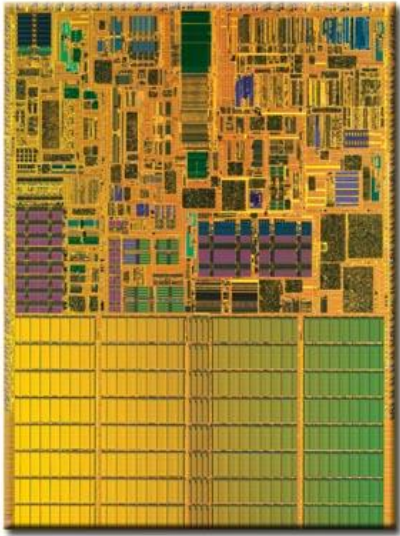


**StarChip - 0.22 gram**



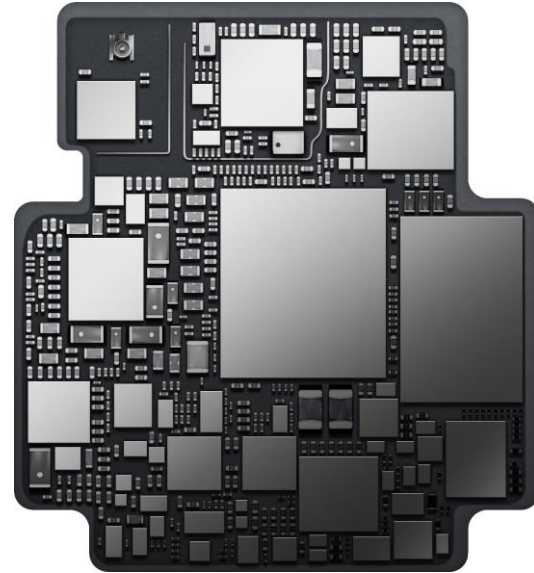
**Microelectronics**

## StarChip Size



← 15mm →

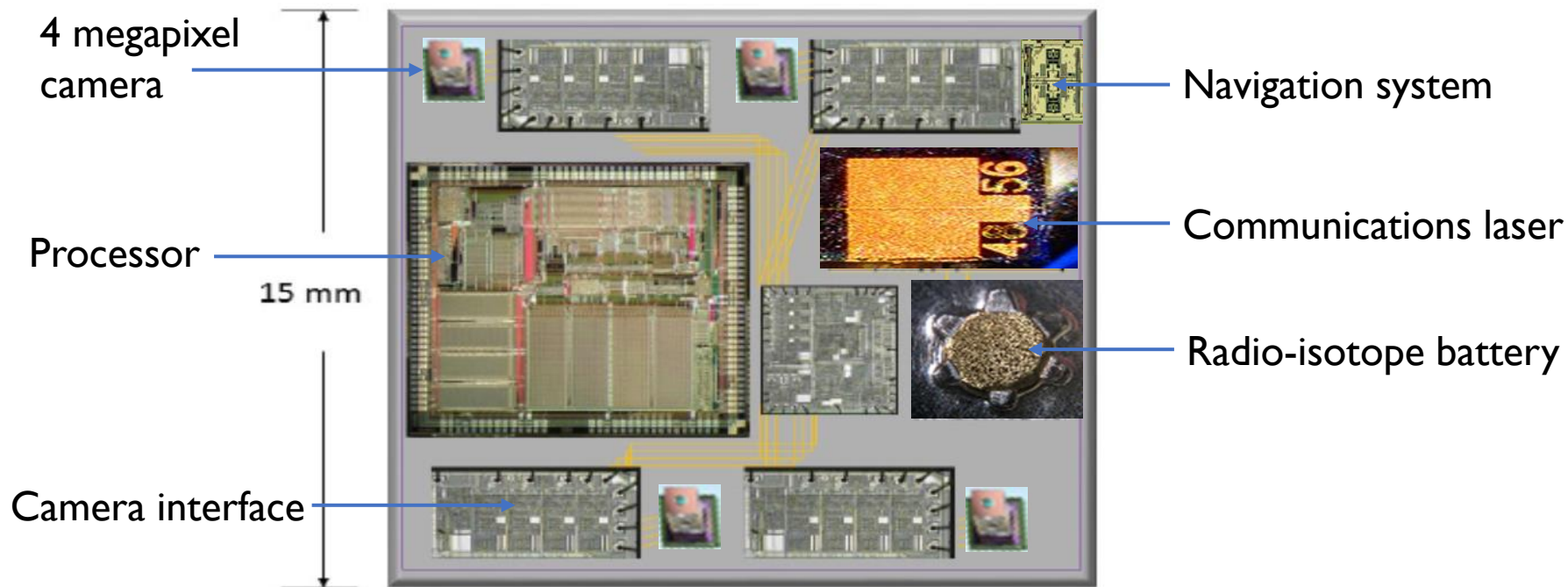
StarChip



← 25mm →

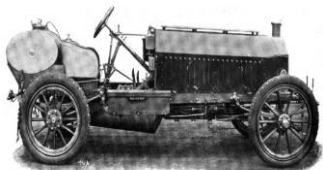
Apple Watch chip

# StarChip Componets



# Is there a Moore's law for speed?

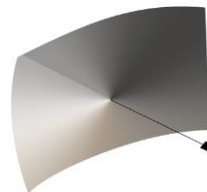
Helios 2  
1976



Helios 2  
1976

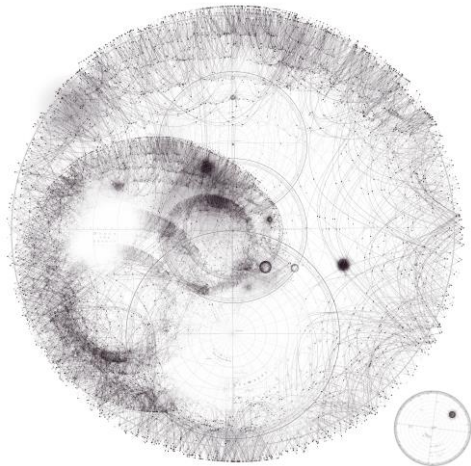


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1000 times faster within 100 years

1000 times faster within ? years



# THE SEARCH FOR LIFE IN THE UNIVERSE: **ALPHA CENTAURI**

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## **BREAKTHROUGH INITIATIVES**







Alpha Centauri A



Sun



Alpha Centauri B



Proxima Centauri

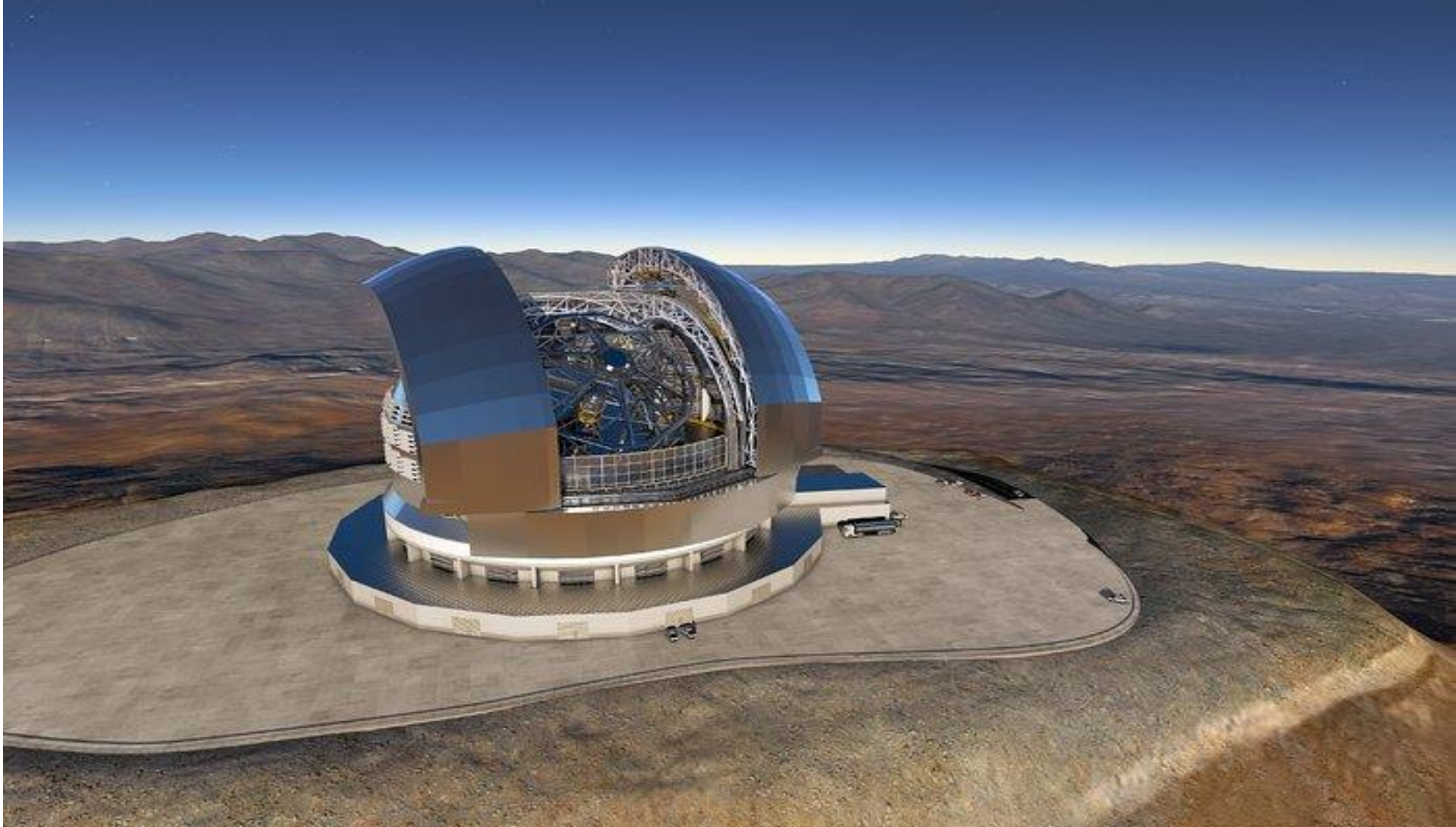
A composite image of Earth from space at night. The bottom half shows the Earth's horizon with a blue glow and numerous yellow and orange city lights. The top half shows a dark, star-filled sky with the Milky Way galaxy visible as a bright, blueish-white band of light. The text "BREAKTHROUGH WATCH" is centered in the middle of the image.

BREAKTHROUGH  
WATCH











# Toliman Proposed Program

BREAKTHROUGH  
INITIATIVES

## ► Toliboy (\$1,000K-Class)

- Target Super Earths around Alpha Centuri and 61 Cygni
- 9 cm F20 telescope, LEO mission
- Launch 2019, mission length one year

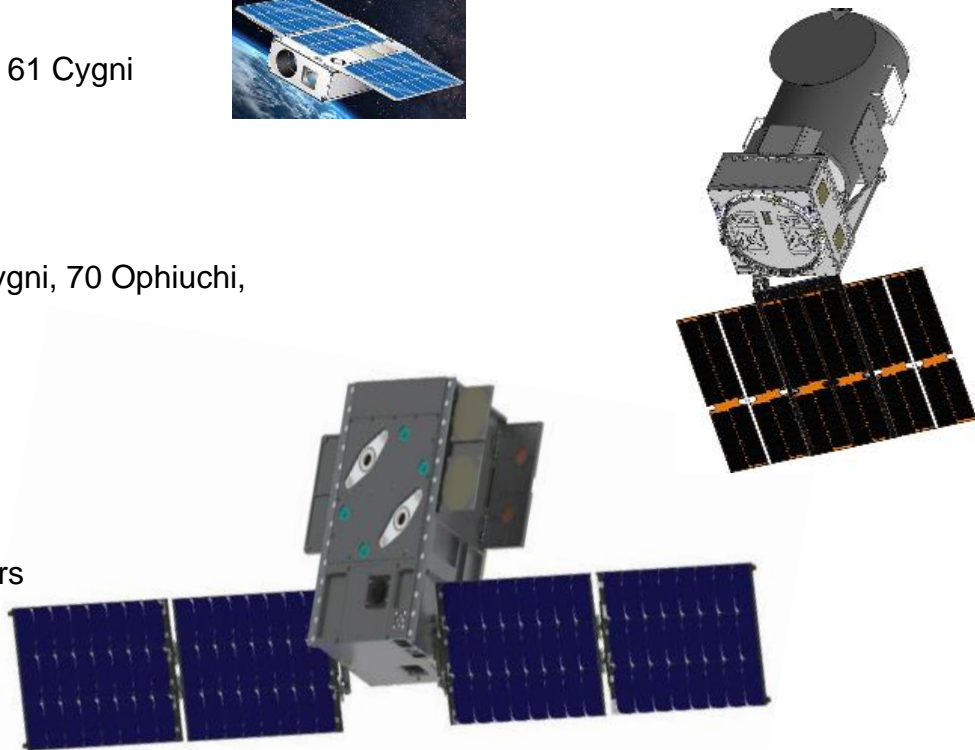


## ► Toliman (\$10,000K-Class)

- Target Earth size planets, Alpha Centuri, 61 Cygni, 70 Ophiuchi, 36 Ophiuchi, Rho-Eridani, Xi Ursae Majoris
- 30 cm F20 telescope, GEO mission
- Launch 2021, mission length: three years
- Possible Partners ASI, JAXA, NASA

## ► Toliman Follow On (\$100,000K-Class)

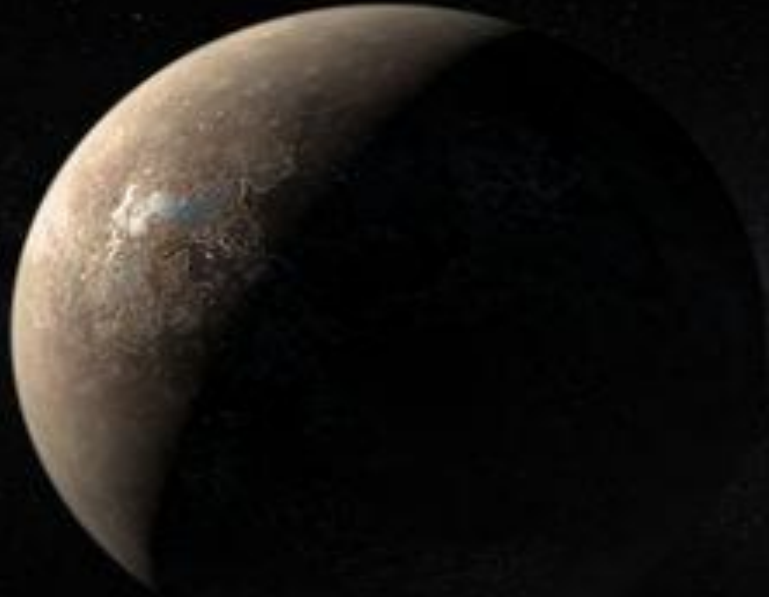
- Target Earths size planets within 15 Light Years
- 100 cm class Chronograph telescope, GEO
- Launch 2025, mission length: five years
- Possible partners ESA, ASI, JAXA, NASA



2019 CONFERENCE,  
APRIL 11-12, University  
of California, Berkeley

“Panspermia”

- Migration of Life in the Universe
- Search for Extraterrestrial Genomes
- Emigration of Earth Life



# PANSPERMIA: LIFE FROM SPACE



Orbit of a comet  
within solar system

Path of 'Oumuamua  
(1I/2017 U1)

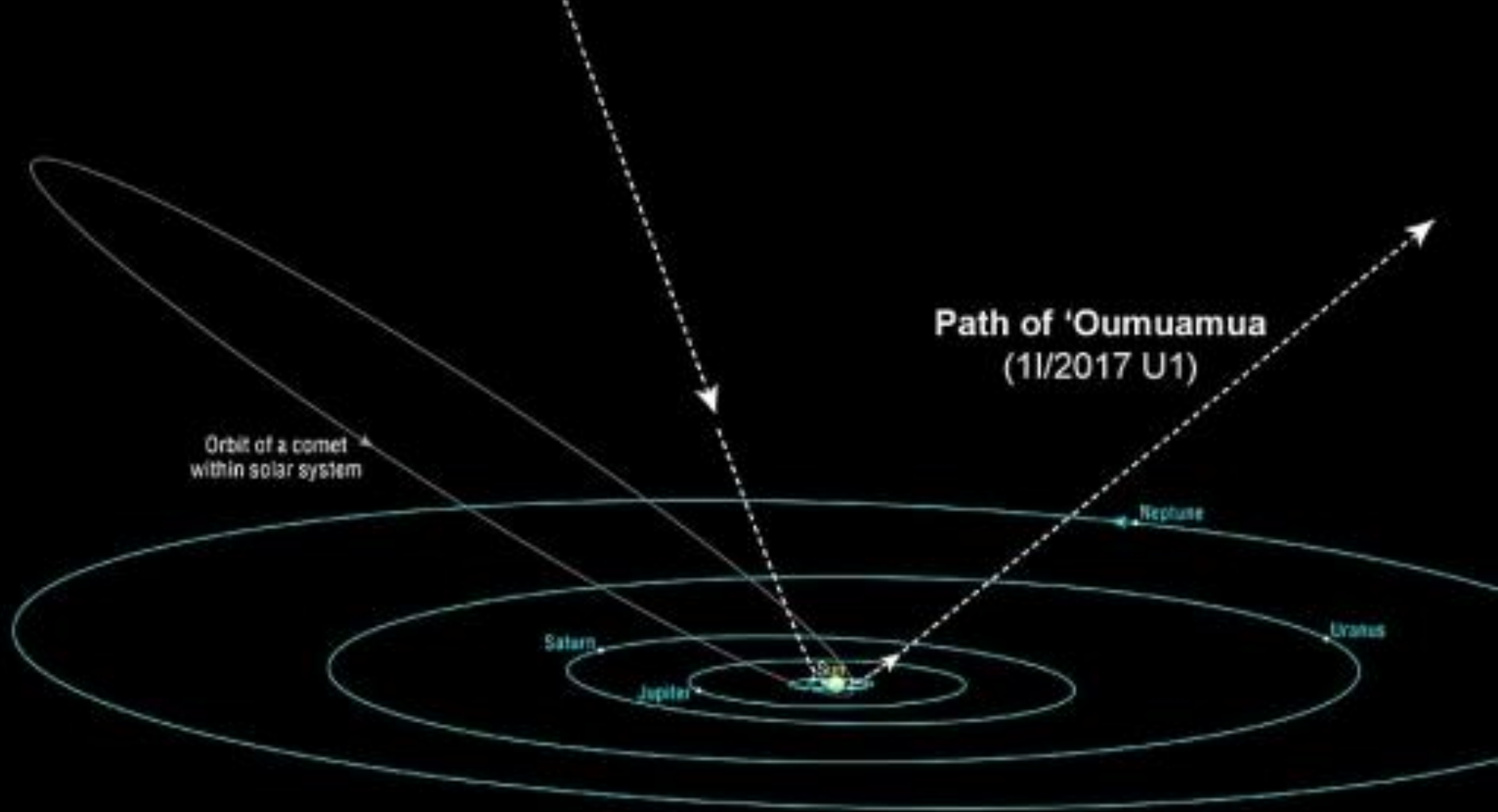
Saturn

Jupiter

Sun

Neptune

Uranus





'Oumuamua is a lightsail, floating in interstellar space as a debris from an advanced technological equipment

a fully operational probe sent *intentionally* to Earth

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Abstract  
We report on the discovery of a new interstellar object, 1I/2017 U1, which is the first of its kind. It is a small, elongated body, about 1 km in size, that passed within 0.2 AU of Earth on October 7, 2017. Its orbit is highly eccentric and its velocity is about 26 km/s, which is consistent with an interstellar origin. We discuss the possibility that 1I/2017 U1 is a natural object, but also consider the possibility that it is an artificial object, such as a lightsail or a probe. We conclude that the object is most likely a natural object, but that the possibility of an artificial origin cannot be ruled out.

1. Introduction  
The discovery of 1I/2017 U1 is a landmark event in the history of astronomy. It is the first interstellar object to be discovered, and its discovery has opened up new questions about the nature of the universe. In this paper, we report on the discovery of 1I/2017 U1 and discuss the possibility that it is an artificial object.

2. Discovery of 1I/2017 U1  
1I/2017 U1 was discovered on October 7, 2017, by the Pan-STARRS1 telescope at Haleakala Observatory. It was initially identified as a new comet, but its orbit was found to be highly eccentric, which is inconsistent with a cometary origin. Further observations revealed that the object was elongated and had a high velocity, which is consistent with an interstellar origin.

3. Properties of 1I/2017 U1  
1I/2017 U1 is a small, elongated body, about 1 km in size. It has a highly eccentric orbit, with a perihelion distance of about 0.2 AU. Its velocity is about 26 km/s, which is consistent with an interstellar origin. The object's surface is dark and featureless, which is consistent with a natural object, but it could also be an artificial object.

4. Discussion  
The discovery of 1I/2017 U1 has opened up new questions about the nature of the universe. It is the first interstellar object to be discovered, and its discovery has opened up new questions about the nature of the universe. In this paper, we report on the discovery of 1I/2017 U1 and discuss the possibility that it is an artificial object.

5. Conclusion  
The discovery of 1I/2017 U1 is a landmark event in the history of astronomy. It is the first interstellar object to be discovered, and its discovery has opened up new questions about the nature of the universe. In this paper, we report on the discovery of 1I/2017 U1 and discuss the possibility that it is an artificial object.

# Directed panspermia

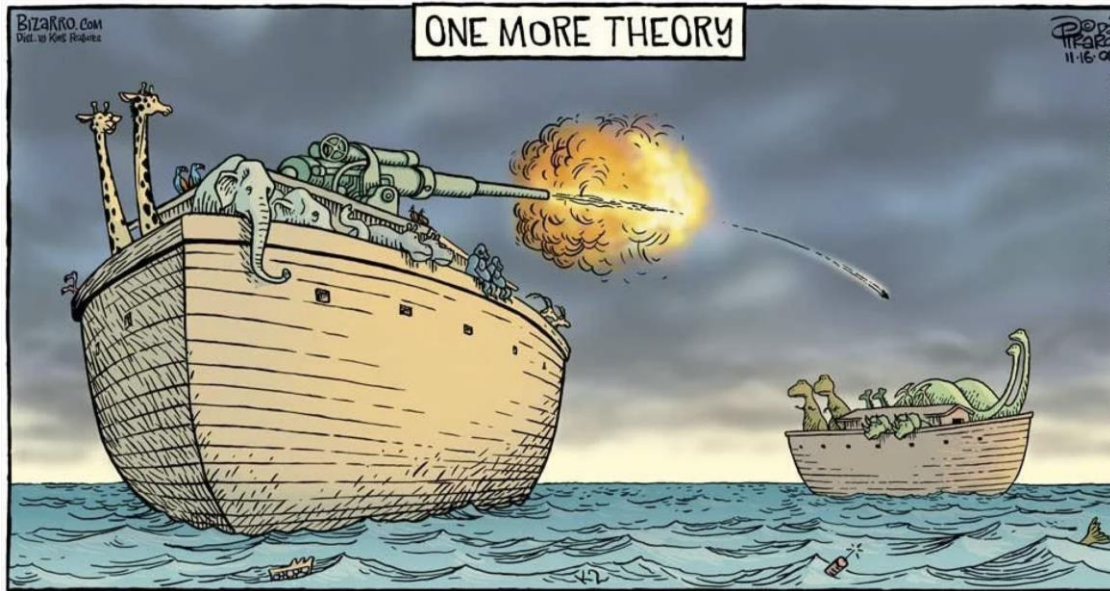
- Proposed by the late Nobel prize winner Professor Francis Crick, OM FRS, along with British chemist Leslie Orgel in 1973
- the intentional spreading of the seeds of life to other planets by an advanced extraterrestrial civilization, or the intentional spreading of the seeds of life from Earth to other planets by humans



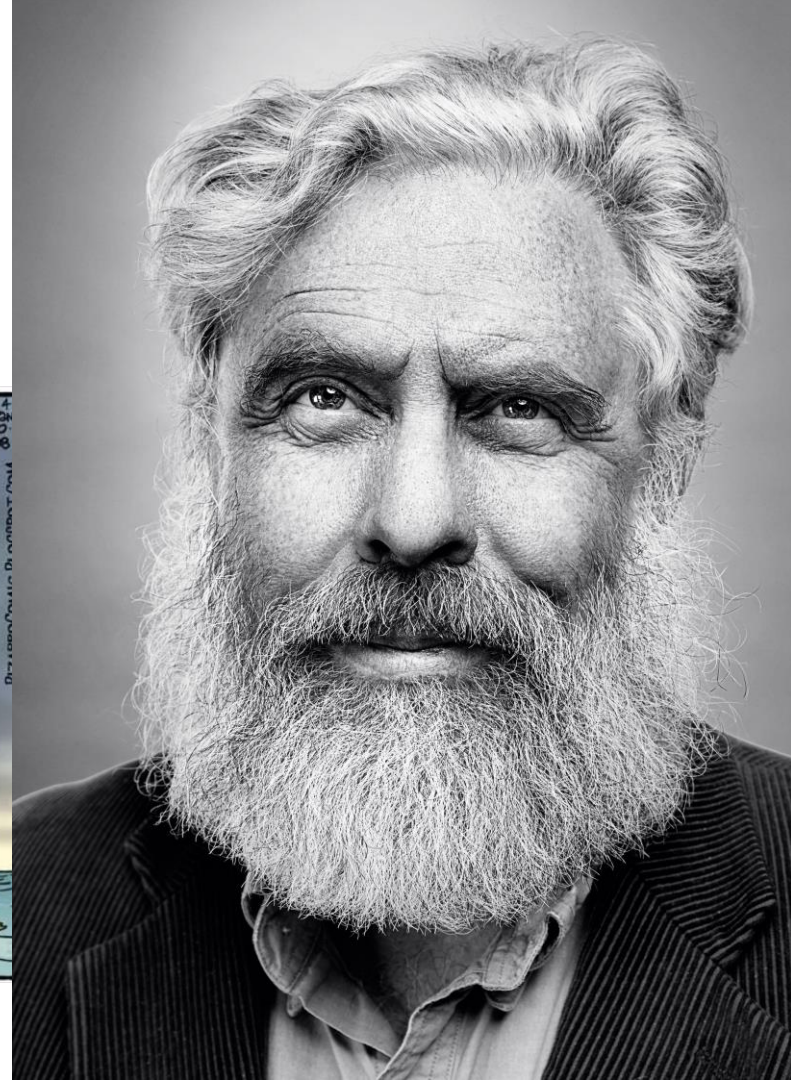
# DIRECTED PANSPERMIA – POSSIBLE WITH BREAKTHROUGH STARSHOT TECHNOLOGY IN THIS CENTURY?

**21st Century Panspermia Ark:**  $1e7$  species +  $8e9$  people =  $3e-4$  g

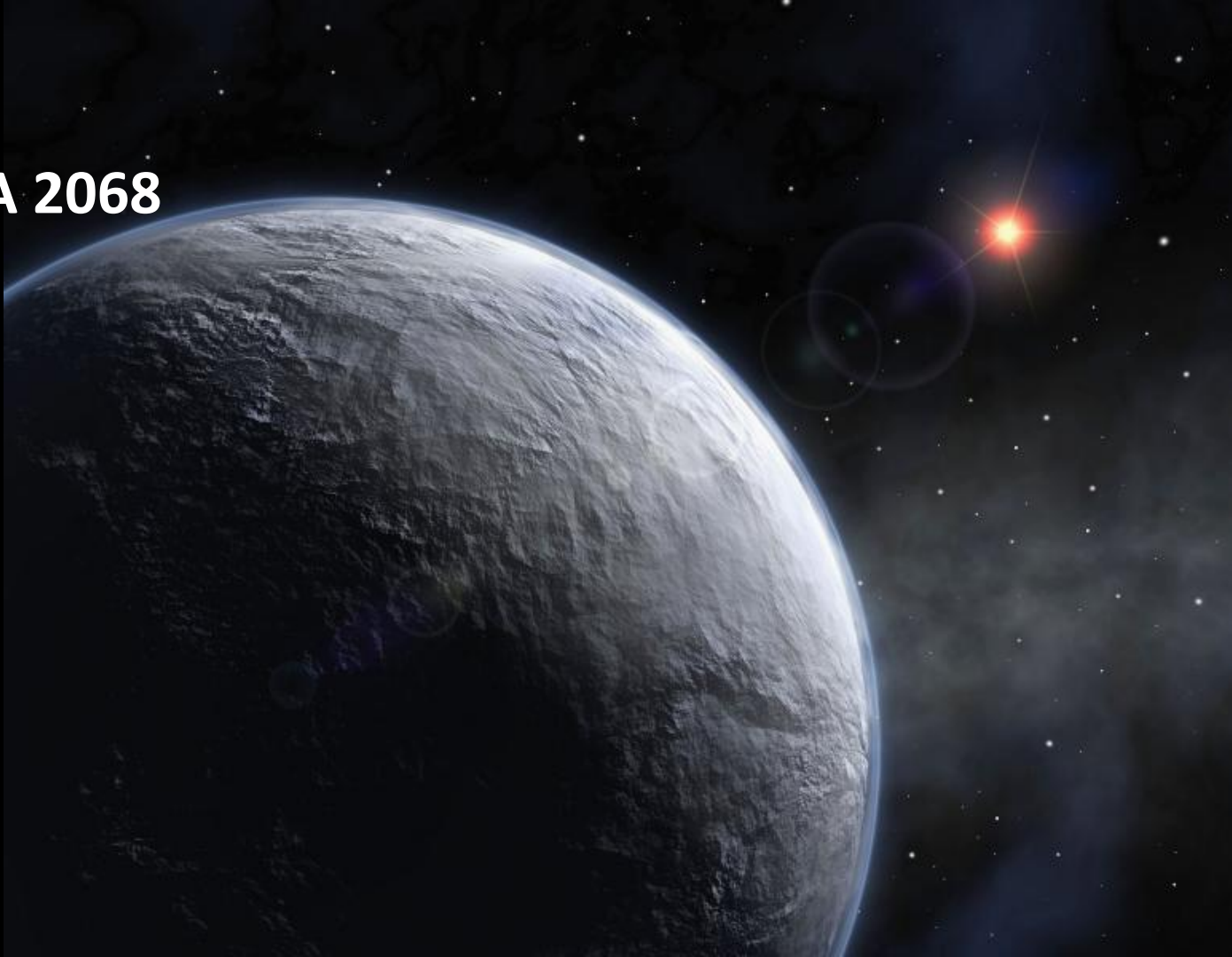
**Previous Ark:**  $3e3$  species + 8 people =  $2.4e10$  g



18 factors of ten ... some assembly required



**CIRCA 2068**



**CIRCA 3000?**

