

# Esopianeti

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# Contenuti

- **Che cosa sono gli esopianeti, e dove si trovano?**
- **Perche' sono importanti?**
- **La prima scoperta**
- **Metodi di ricerca**
- **Lo zoo degli esopianeti**
- **Ricerche future**

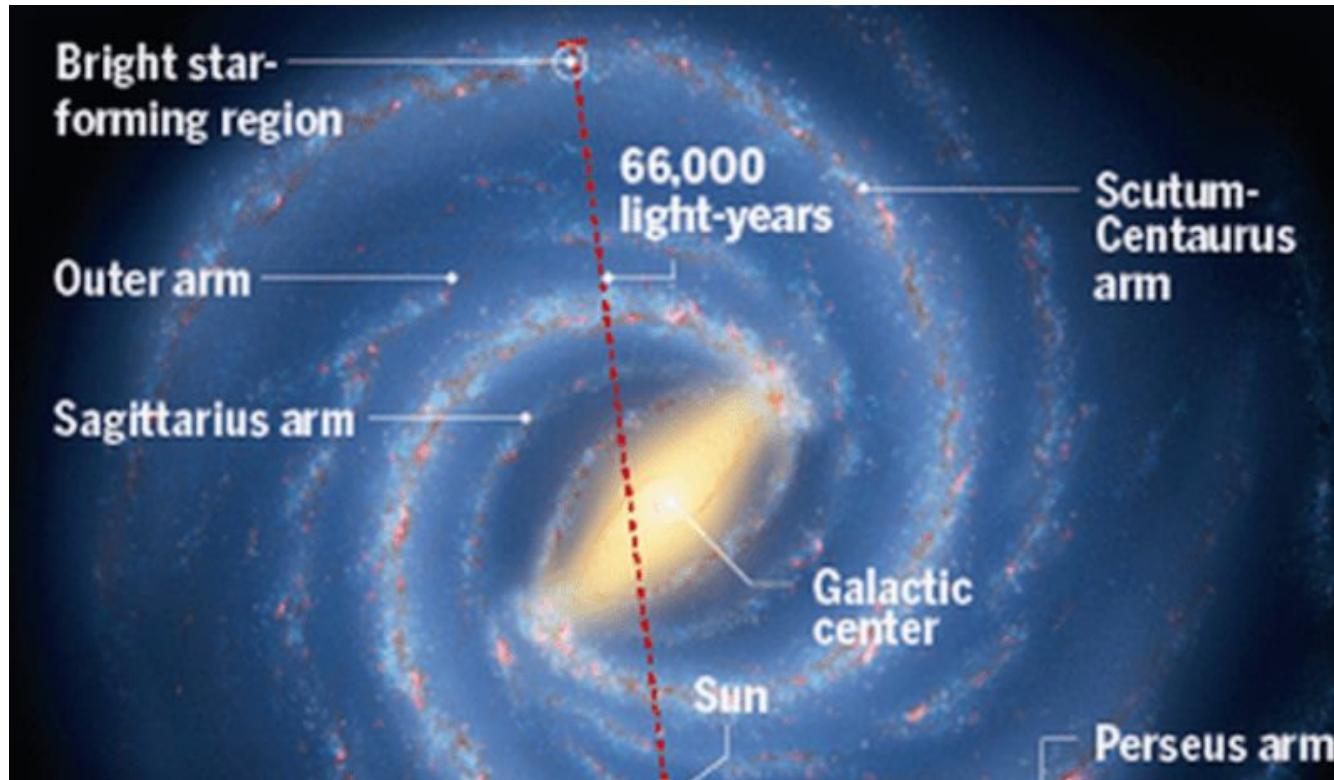
# Che cosa sono gli esopianeti, e dove si trovano?





# La Via Lattea: 400 miliardi di stelle

Un anno luce:  
un anno a  
300000 km/s,  
Un Parsec:  
3.2 anni luce,  
La Via Lattea  
misura piu' di  
70000 anni  
luce





# **Esopianeti: pianeti orbitanti intorno alle stelle nell'Universo**



# Perche' sono importanti?





# Siamo soli?



# Paradosso di Fermi

## MUSINGS ON THE PROBABILITY OF ALIEN LIFE EXISTING SOMEWHERE IN THE UNIVERSE:

THERE ARE TRILLIONS OF GALAXIES



IN THE OBSERVABLE UNIVERSE

OUR GALAXY ALONE HAS 400 BILLION!



YET STARS ARE OUTNUMBERED BY PLANETS...

AND LESS THAN 5,000 ARE KNOWN!



.. EACH WITH BILLIONS OF STARS



SURELY SOME OF THEM HARBOR LIFE

IN FACT: THERE MAY BE 2 PLANETS PER STAR



OF THEM, 20 BILLION ARE "EARTH-LIKE"

HOW CAN ANYONE EVER  
SAY WE ARE ALONE?



# Possibili soluzioni al paradosso di Fermi

## THE FERMI PARADOX

There are 400 billion stars in our galaxy, astronomers estimate that each has 1.6 planets on average, bringing the total number of planets within the range of 660 billion; The number of potentially habitable worlds differs according to the source, but most say the Milky Way may have over 60 billion habitable planets. As such, based on those numbers alone, it seems rather improbable that we are alone.

Therein lies Fermi's paradox: If other forms of intelligent life exist, why haven't we found any evidence yet? Here are ten possible solutions to the Fermi Paradox:

### DOWN THE RABBIT HOLE



We haven't found evidence of extraterrestrials because our reality is an elaborate illusion. As in, we are living in a computer simulation created by our alien overlords, who make all the rules.

### THEY ARE ALREADY HERE (A perk of being a wallflower)



It would be silly to presume that all life is similar to Earth's. Perhaps alien beings are so different, they would not register us even if they were under our noses. Conversely, they may be so similar, they are indistinguishable from humans, and can easily avoid detection.

### OUR WIRES ARE CROSSED



It's very possible that other intelligent life forms are actively sending transmissions into space, we simply don't use the same range of frequencies (radio waves, for instance), or perhaps everyone is listening and no one's talking.

### THEY LIVE IN UNLIKELY PLACES (We don't know where to look)



The search for life is largely conducted on other planets, but what if we are looking in the wrong place altogether? A very advanced civilization may not need to be anchored to a rocky world. In fact, some astronomers suggest that, because of energy demands, aliens might lurk on the edge of the galaxy, maybe even in supermassive black holes themselves.

### EARTH IS A FISHBOWL (Which makes us the fish)



In this scenario, alien civilizations know we exist, they simply watch our development from afar to let us evolve without influence, ultimately forging our own path.

### THEY USE TECH TO SPY



Regardless of how technologically advanced a civilization may be, space exploration will always be long and fraught. Instead of sending massive ships to explore the galaxy, aliens might dispatch self-replicating nanobots, like von Neumann probes, to do the work for them.

### DESTROY OR BE DESTROYED



In Darwin's theory of evolution, a tenet says the strongest species survives. A similar tactic may be employed by alien beings: perhaps they stay silent, hoping that hostile species aren't alerted, or they strike before others destroy them first.

### WE ARE THE ALIENS



Perhaps aeons ago, some alien race visited Earth. After seeing all the earmarks of a habitable world, the creatures sowed the seeds of life with their own genetic material, before going along their merry way. We, in a sense, are their experiment.

### SPACE IS TOO VAST (& Signals take too long)

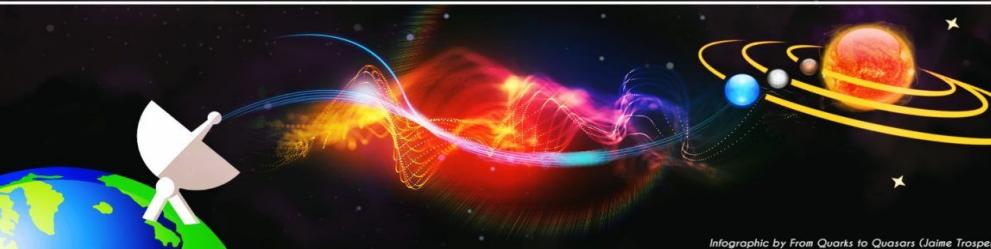


Space, simply put, is incredibly large. So large, if we beamed a transmission to the closest star, it would take 4 years to reach the system. Say intelligent life did pick up one of our signals, it might take years, if not decades, to get a response.

### LIFE IS EXTREMELY RARE



Perhaps, in the search for extraterrestrial intelligence, the simplest solution is the correct one. We haven't encountered signs of life either because it doesn't exist, or it's exceedingly rare. The prerequisites for complex life are nearly impossible to replicate in their entirety elsewhere.





# Equazione di Drake

$$N = R_* \cdot f_P \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

$N$  = number of civilizations with which humans could communicate

$R_*$  = mean rate of star formation

$f_P$  = fraction of stars that have planets

$n_e$  = mean number of planets that could support life per star with planets

$f_l$  = fraction of life-supporting planets that develop life

$f_i$  = fraction of planets with life where life develops intelligence

$f_c$  = fraction of intelligent civilizations that develop communication

$L$  = mean length of time that civilizations can communicate



# Equazione di Drake

$$N = R_* \cdot f_P \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

**Sconosciuto**

$N$  = number of civilizations with which humans could communicate

**Misurato**

$R_*$  = mean rate of star formation

**Misurato**

$f_P$  = fraction of stars that have planets

**Misura in atto**

$n_e$  = mean number of planets that could support life per star with planets

**Sconosciuto**

$f_l$  = fraction of life-supporting planets that develop life

**Sconosciuto**

$f_i$  = fraction of planets with life where life develops intelligence

**Sconosciuto**

$f_c$  = fraction of intelligent civilizations that develop communication

**Sconosciuto**

$L$  = mean length of time that civilizations can communicate



# Astrobiologia: il mistero della formazione della vita nell’Universo



# Molecole trovate nello spazio.

2 atomi	3 atomi	4 atomi	5 atomi	6 atomi	7 atomi	8 atomi	9 atomi
H <sub>2</sub>	C <sub>3</sub>	c-C <sub>3</sub> H	C <sub>5</sub>	C <sub>5</sub> H	C <sub>6</sub> H	CH <sub>3</sub> C <sub>3</sub> N	CH <sub>3</sub> C <sub>4</sub> H
AlF	C <sub>2</sub> H	l-C <sub>3</sub> H	C <sub>4</sub> H	l-H <sub>2</sub> C <sub>4</sub>	CH <sub>2</sub> CHCN	HCOOCH <sub>3</sub>	CH <sub>3</sub> CH <sub>2</sub> CN
AlCl	C <sub>2</sub> O	C <sub>3</sub> N	C <sub>4</sub> Si	C <sub>2</sub> H <sub>4</sub>	CH <sub>3</sub> C <sub>2</sub> H	CH <sub>3</sub> COOH?	CH <sub>3</sub> CH <sub>2</sub> OH
C <sub>2</sub>	C <sub>2</sub> S	C <sub>3</sub> O	l-C <sub>3</sub> H <sub>2</sub>	CH <sub>3</sub> CN	HC <sub>5</sub> N	C <sub>7</sub> H	HC <sub>7</sub> N
CH	CH <sub>2</sub>	C <sub>3</sub> S	c-C <sub>3</sub> H <sub>2</sub>	CH <sub>3</sub> NC	HCOCH <sub>3</sub>	H <sub>2</sub> C <sub>6</sub>	CH <sub>3</sub> CH <sub>2</sub> OH
CH <sup>+</sup>	HCN	C <sub>2</sub> H <sub>2</sub>	CH <sub>2</sub> CN	CH <sub>3</sub> OH	NH <sub>2</sub> CH <sub>3</sub>	CH <sub>2</sub> OHCHO	C <sub>8</sub> H
CN	HCN?	CH <sub>2</sub> D <sup>+</sup> ?	CH <sub>4</sub>	CH <sub>3</sub> SH	c-C <sub>2</sub> H <sub>4</sub> O	CH <sub>2</sub> CHO	Glicolaldeide
CO	Acido cianidrico	HCCN	HC <sub>3</sub> N	HCONH <sub>2</sub>	NH <sub>2</sub> CHO		
CO <sup>+</sup>	HCS	HCNH <sup>+</sup>	HC <sub>3</sub> NC	HC <sub>3</sub> NH <sub>+</sub>			
CP	HOC <sup>+</sup>	HNCO	HCOOH	HC <sub>2</sub> CHO			
CSi	H <sub>2</sub> O	HNCS	H <sub>2</sub> CN	NH <sub>2</sub> CHO			
HCl	H <sub>2</sub> S	HOCO <sup>+</sup>	H <sub>2</sub> CO	C <sub>5</sub> N			
KCl	HNC	H <sub>2</sub> CO	H <sub>2</sub> NCO				
NH	HNO	H <sub>2</sub> CN	HNC <sub>3</sub>	CH <sub>3</sub> C <sub>5</sub> N?			
NO	MgCN	H <sub>2</sub> CS	SiH <sub>4</sub>	(CH <sub>3</sub> ) <sub>2</sub> CO			
NS	MgNC	H <sub>3</sub> O <sup>+</sup>	H <sub>2</sub> COH <sup>+</sup>	NH <sub>2</sub> CH <sub>2</sub> COOH?			
NaCl	N <sub>2</sub> H <sup>+</sup>	NH <sub>3</sub>					
OH	N <sub>2</sub> O	SiC <sub>3</sub>					
PN	NaCN	CH <sub>3</sub>					
SO	OCS						
SO <sup>+</sup>	SO <sub>2</sub>						
SiN	c-SiC <sub>2</sub>						
SiO	CO <sub>2</sub>						
SiS	NH <sub>2</sub>						
CS	H <sub>3</sub> <sup>+</sup>						
HF	SiCN						
SH	AINC						
FeO?	H <sub>2</sub> D <sup>+</sup>						

Formamide

Glicina

Acido acetico

10 atomi

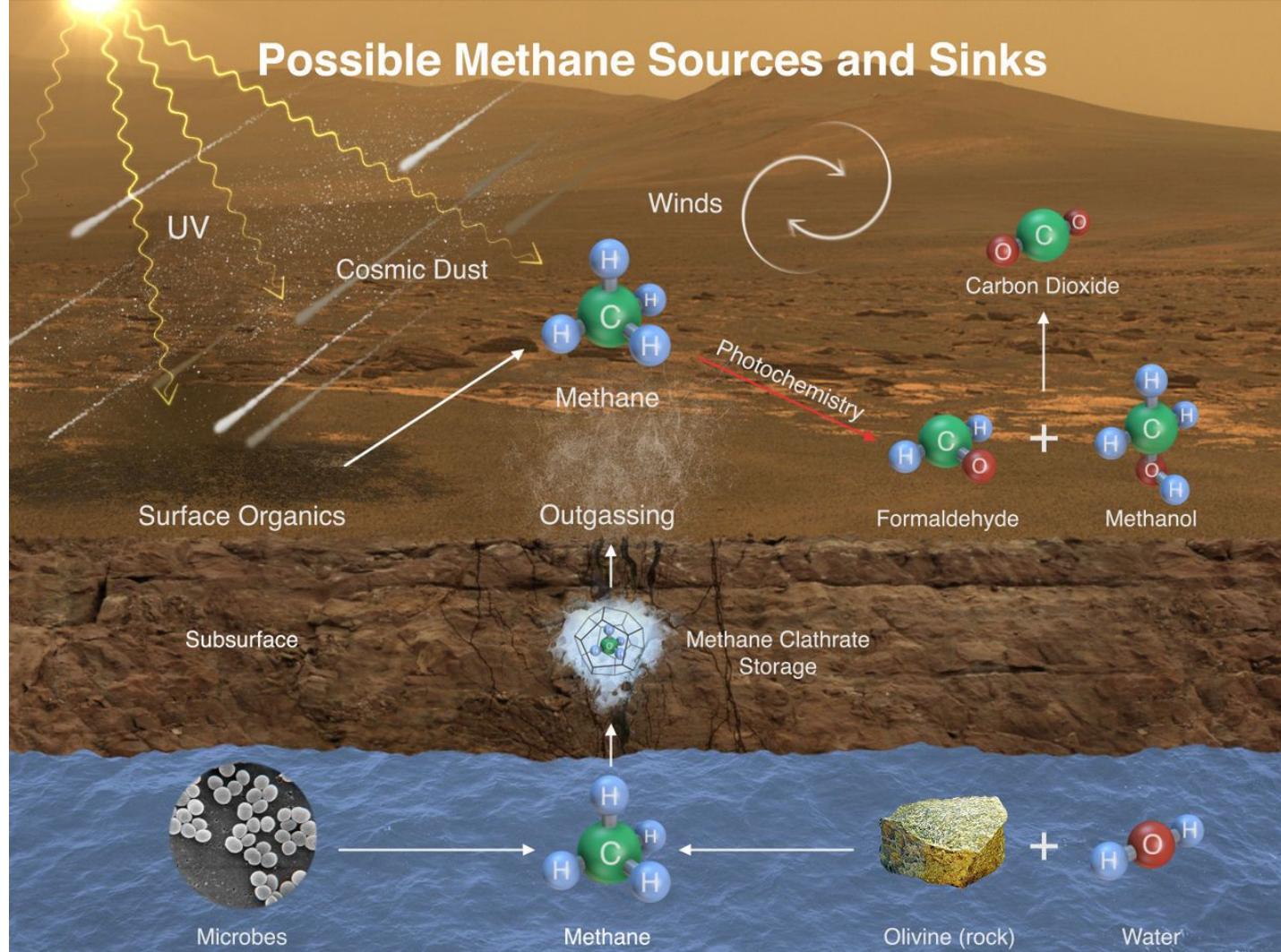
11 atomi

12 o più atomi

Fullereni

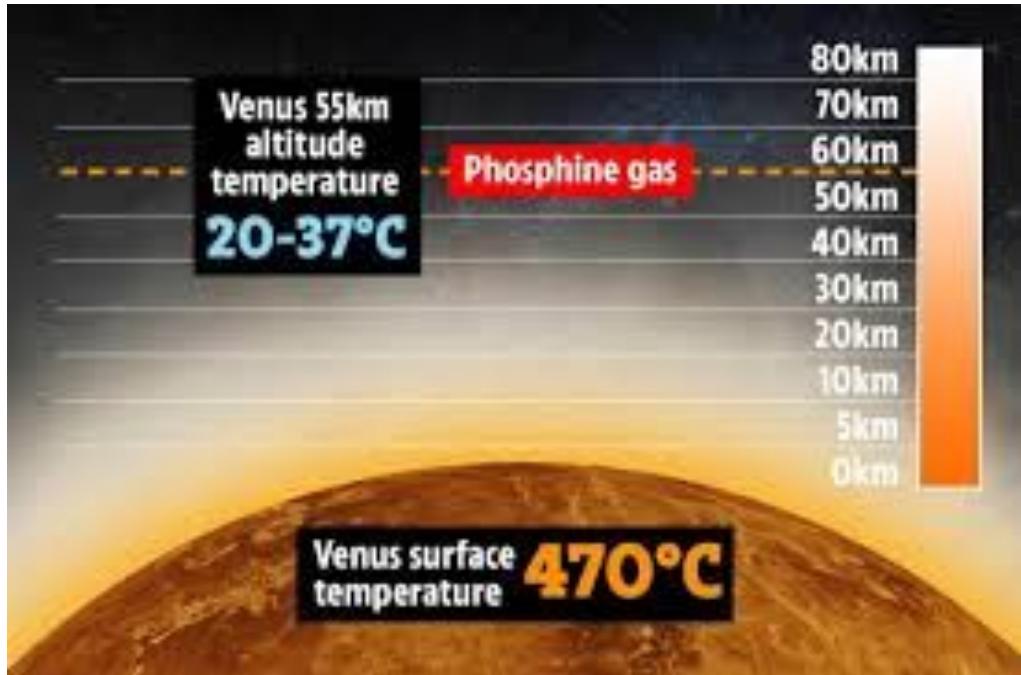
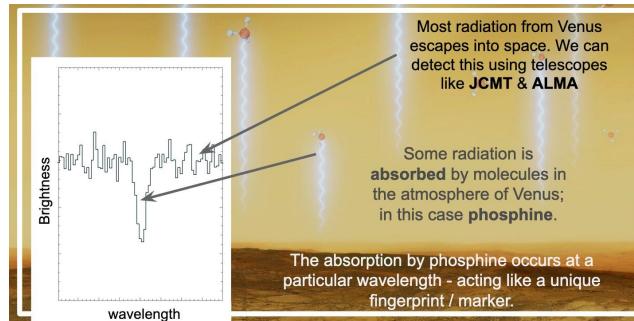
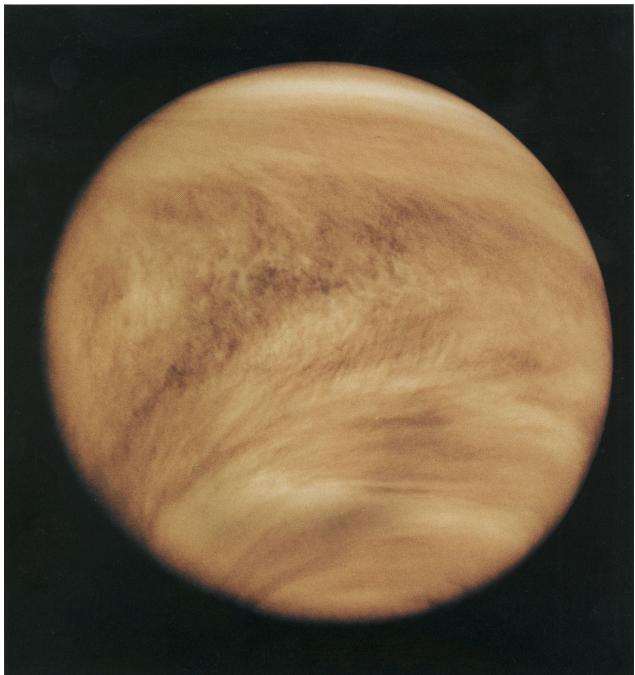
Idrocarburi  
Policiclici  
Aromatici

# Possible Methane Sources and Sinks



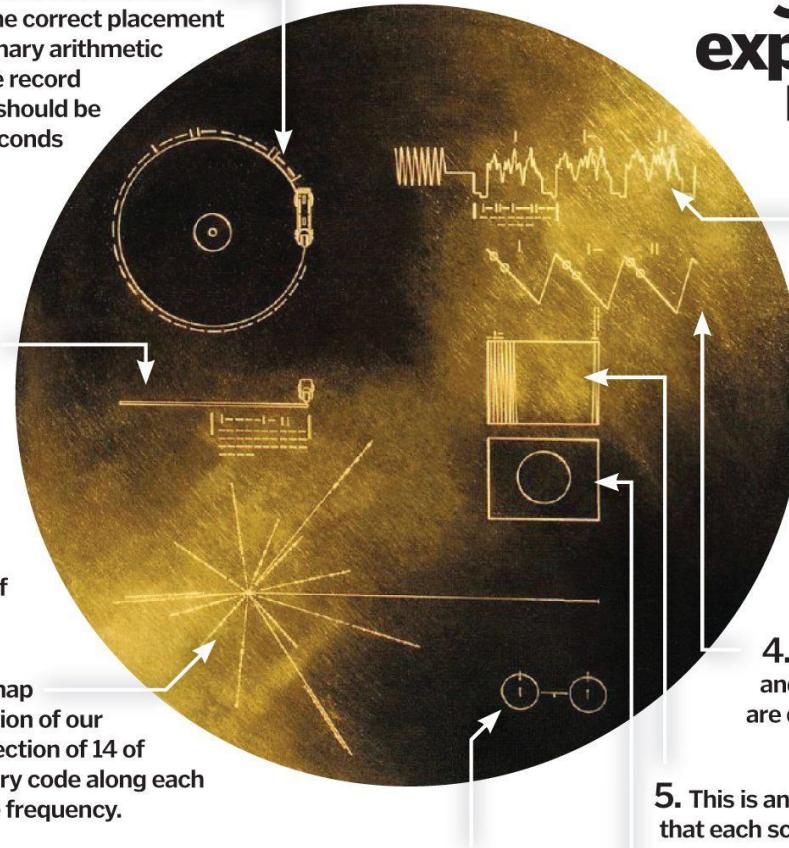


# Vita su Venere?



# Symbols explain the record's use

1. This overhead illustration of the record shows the correct placement of the stylus. Binary arithmetic surrounding the record explains that it should be played at 3.6 seconds per rotation.



2. A side-view of record and stylus has binary arithmetic below it to show that the record has about an hour of play time.

7. This pulsar map shows the location of our Sun and the direction of 14 of its pulsars. Binary code along each pulsar gives the frequency.

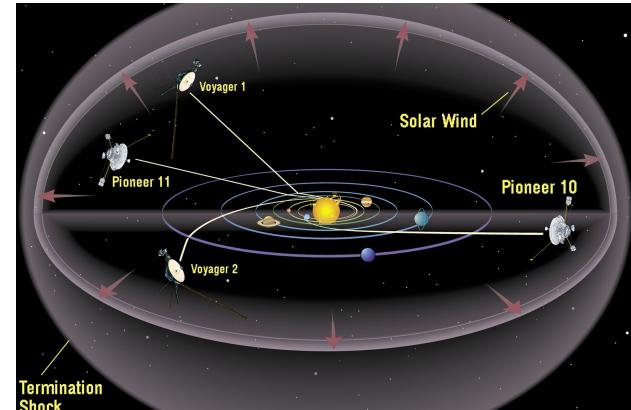
8. This illustration shows the two lowest states of the hydrogen atom. The vertical lines and dots show the spin moments of each atom's proton and electron. The connecting line and '1' show that the transition from one state to another is to be used as the timescale for all pictures on the cover as well as on the record.

3. This diagram and the three below explain the images on the record. The wavelengths illustrate how pictures are constructed of analogue video signals, with binary arithmetic showing that each scan lasts eight milliseconds.

4. Picture lines one, two and three show that they are drawn vertically with a staggered interlace.

5. This is an image frame showing that each scan is vertical and each image contains 512 lines.

6. If the pictures are rendered correctly, the first image on the record should match this image.

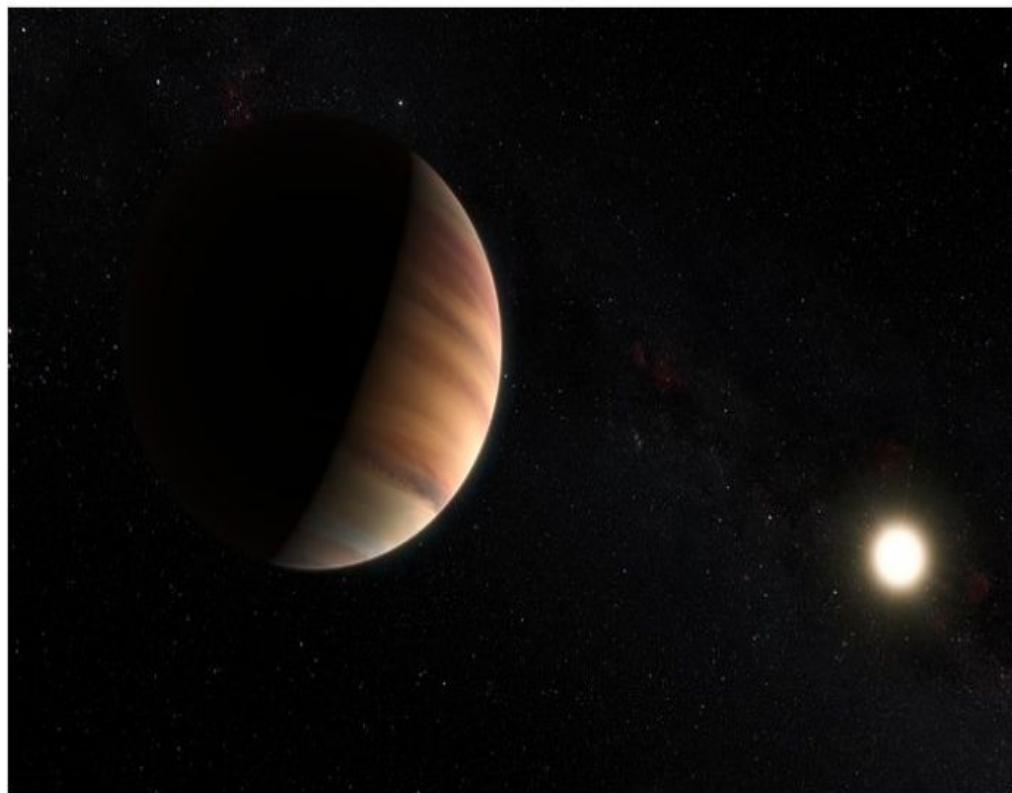
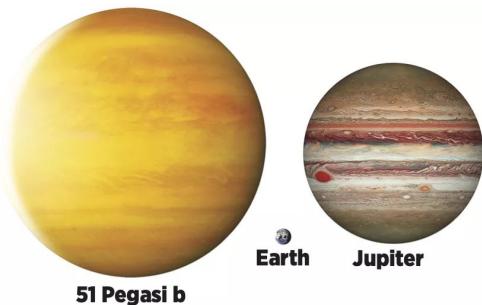
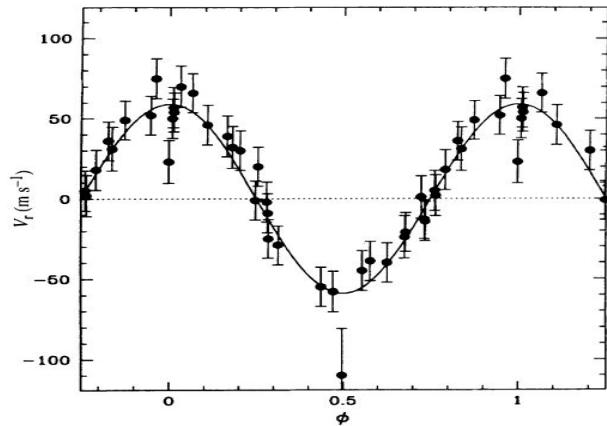


# Il Primo Esopianeta



# Artist's impression of the exoplanet 51 Pegas b

## Il primo Esopianeta



This artist's view shows the hot Jupiter exoplanet 51 Pegas b, sometimes referred to as Bellerophon, which orbits a star about 50 light-years from Earth in the northern constellation of Pegasus (The Winged Horse). This was the first exoplanet around a normal star to be found in 1995. Twenty years later this object was also the first exoplanet to be directly detected spectroscopically in visible light.

Credit: ESO/M. Kornmesser/Nick Risinger ([skysurvey.org](http://skysurvey.org))

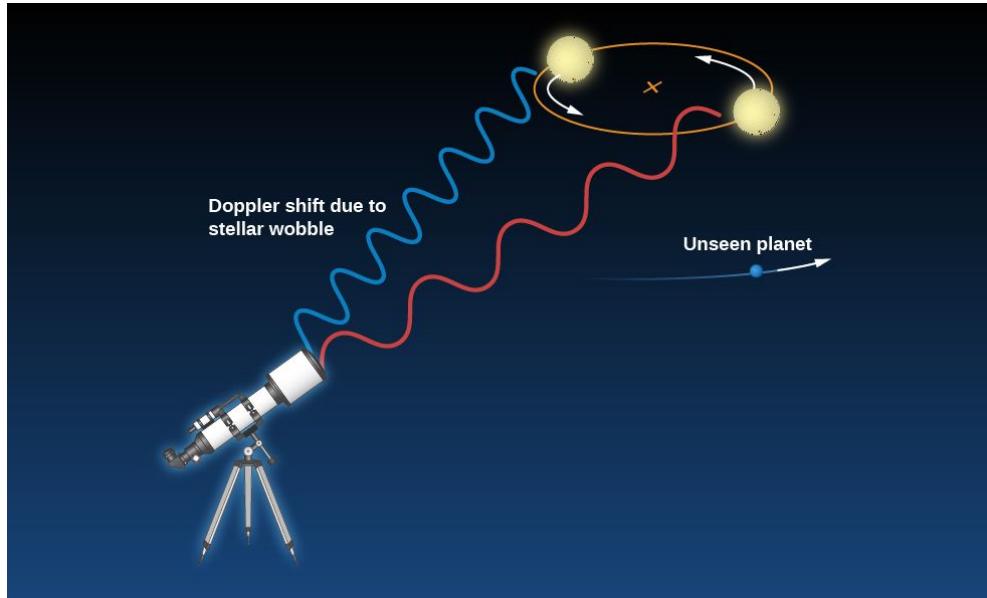
# Metodi di Ricerca





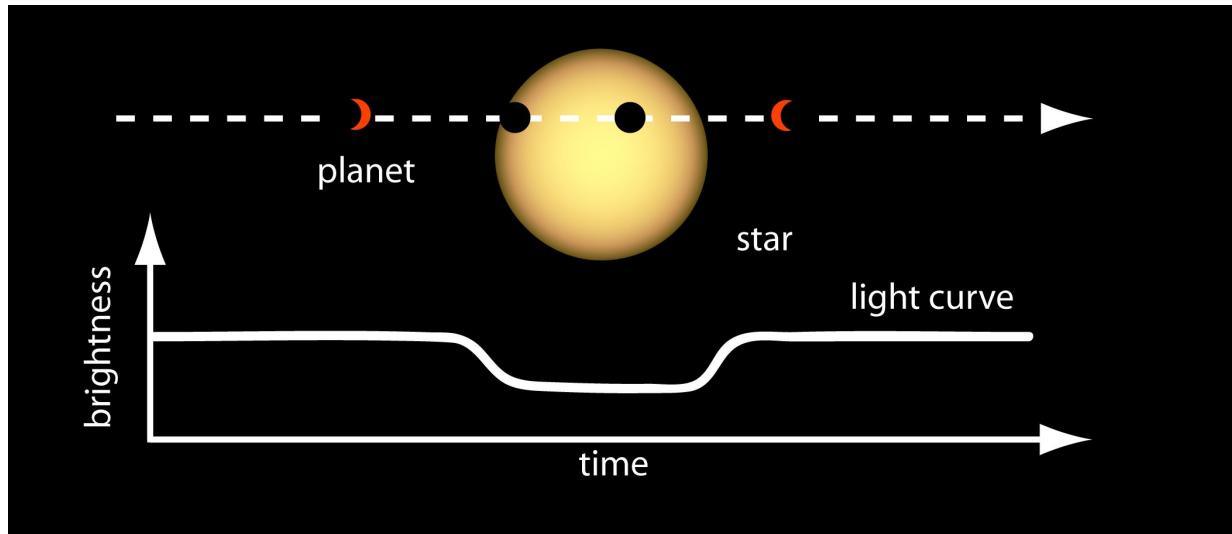
# Stelle Erranti

WOBBLING STARS HINT  
AT EXOPLANET  
PRESENCE





# Eclissi Parziale della Luce Stellare



TRANSITING PLANET CAUSES DIP IN STELLAR LIGHT

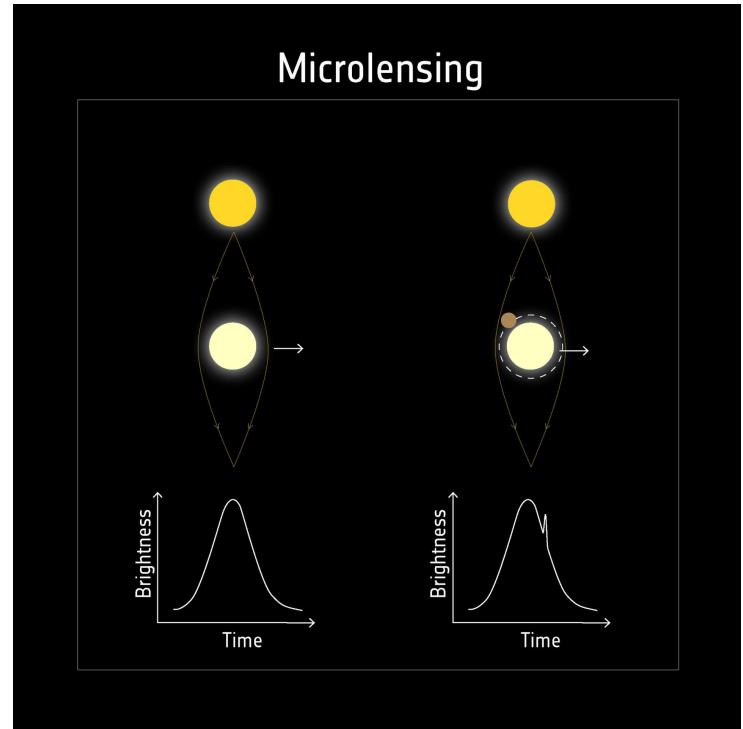


# Effetto Lente Gravitazionale

GRAVITATIONAL

MICROLENSING - CHANCE ALIGNMENT

REVEALS PLANET



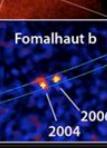
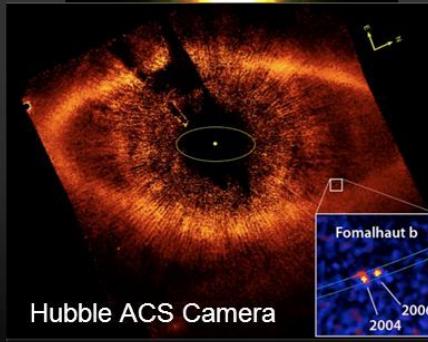


# Osservazione Diretta

## Detecting Transiting Exoplanets

### Direct Imaging Method

- For a handful of nearby stars, planets have been directly imaged.
- Complementary method to the others: better for more distant planets, can get orbit and hence true mass (but have to see it move over time—may take a few years).
- More sensitive for larger planets.
- Can image proto-planetary disk, as for Fomalhaut.



# Lo Zoo degli Esopianeti





# Lo Zoo Esoplanetario

EXOPLANET GJ 1214B

FIRST EVAPORATING PLANET

TRAPPIST-1 PLANETS

<http://exoplanet.eu/catalog/>

# Potentially Habitable Exoplanets

Ranked by the Earth Similarity Index (ESI)



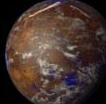
[0.85]  
Proxima Cen b



[0.85]  
TRAPPIST-1 e



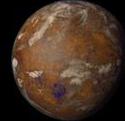
[0.84]  
GJ 667 C c



[0.84]  
Kepler-442 b



[0.77]  
GJ 667 C f\*



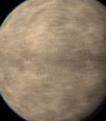
[0.73]  
Kepler-1229 b



[0.68]  
TRAPPIST-1 f



[0.68]  
LHS 1140 b



[0.67]  
Kapteyn b\*



[0.67]  
Kepler-62 f



[0.61]  
Kepler-186 f



[0.60]  
GJ 667 C e\*



[0.58]  
TRAPPIST-1 g



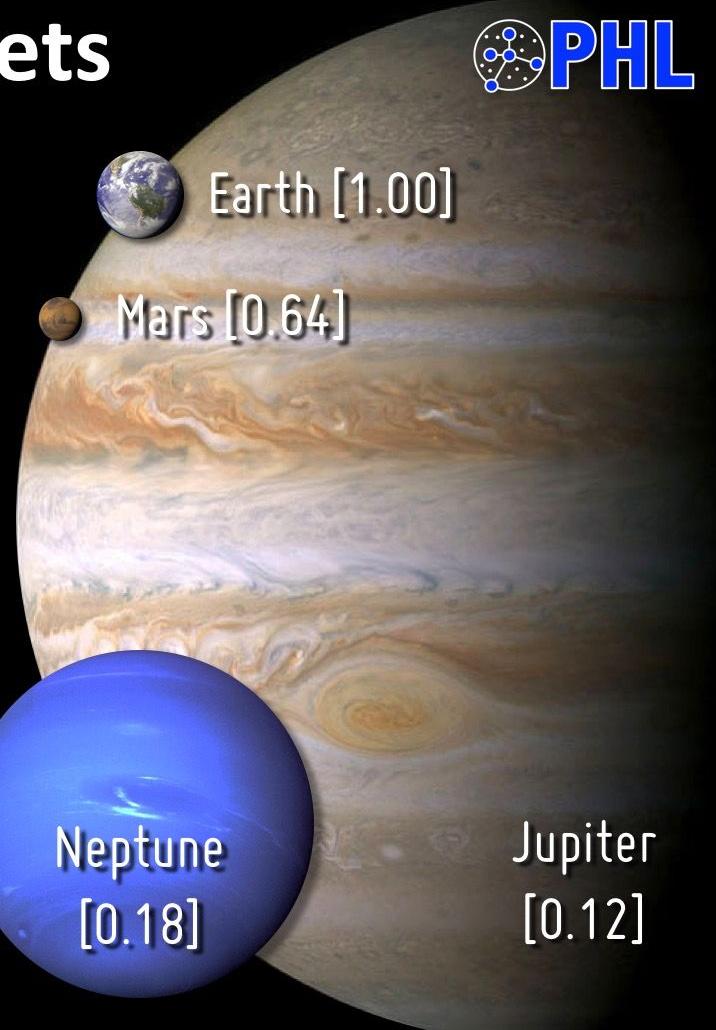
Earth [1.00]



Mars [0.64]



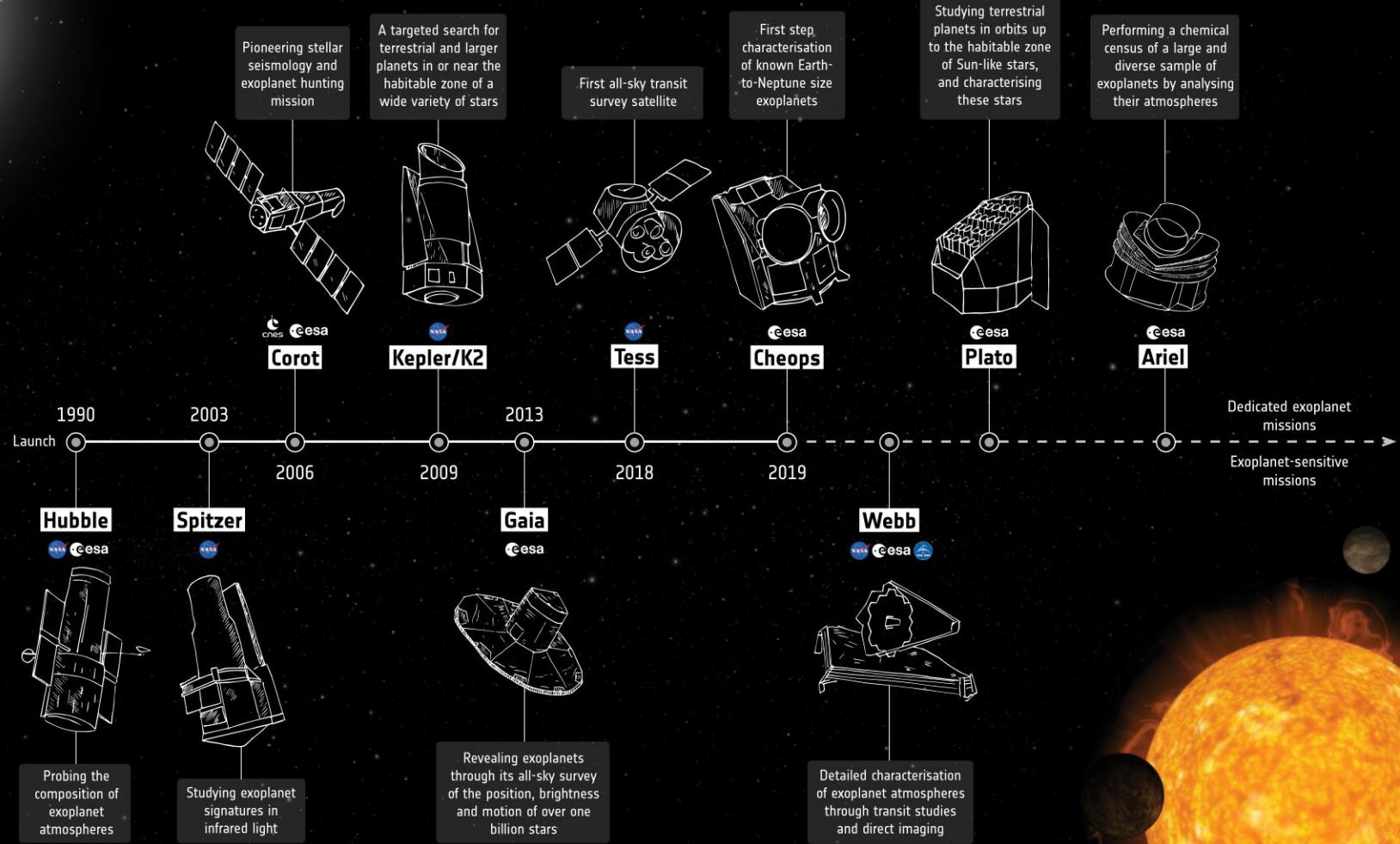
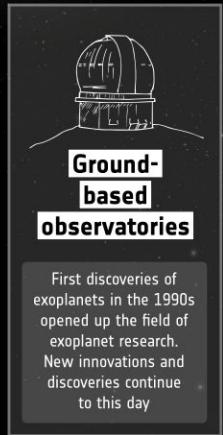
Neptune  
[0.18]



Jupiter  
[0.12]

# Ricerche Future





# Contenuti

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- Li raggiungeremo mai?

# Interstellar challenges

## Time

- Wait 50 principle: If a mission will take more than 50 years maybe it should not be started, as future developments could enable faster travel and a future ship might be able to overtake and older mission making it obsolete and useless.
- If time is long for astronauts, how can we send them to another star?

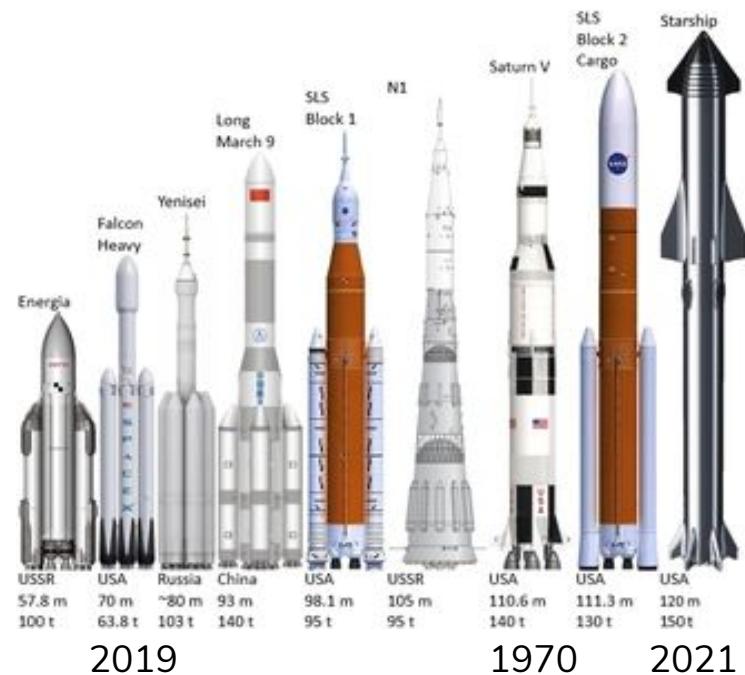
- Time Dilation
- Suspended animation
- Embryo colonization
- Generation ship
- Extended lifespan
- Mind uploading

## • Communications

- Obviously  $\times 2$  speed of light, so, 8 years to send a message and receive an answer from Alpha Centauri, the closest star

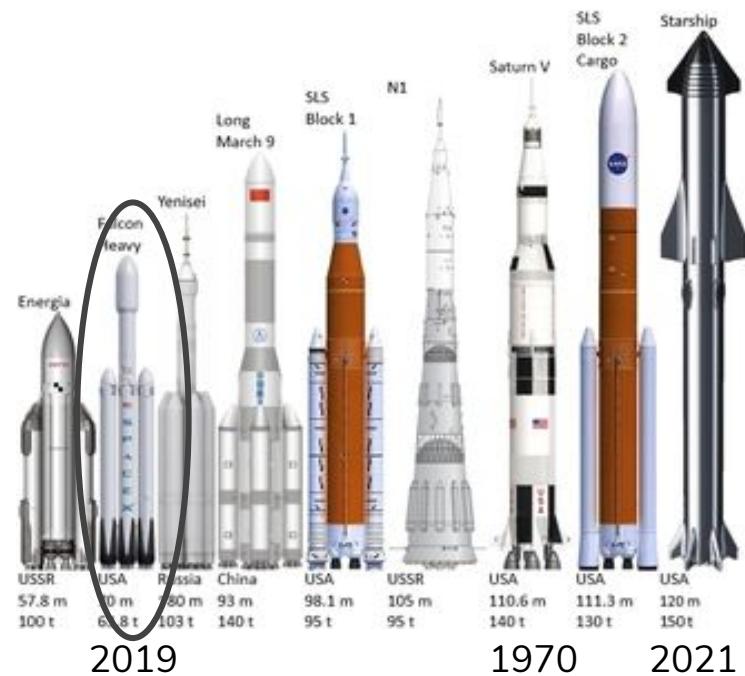


# Ma...come Fermi...il dato e', negli ultimi 120 anni...persone dalla Terra a Marte....





# Ma...come Fermi...il dato e', negli ultimi 120 anni...persone dalla Terra a Marte...





# Ma...come Fermi...il dato e', negli ultimi 120 anni...persone dalla Terra a Marte...

