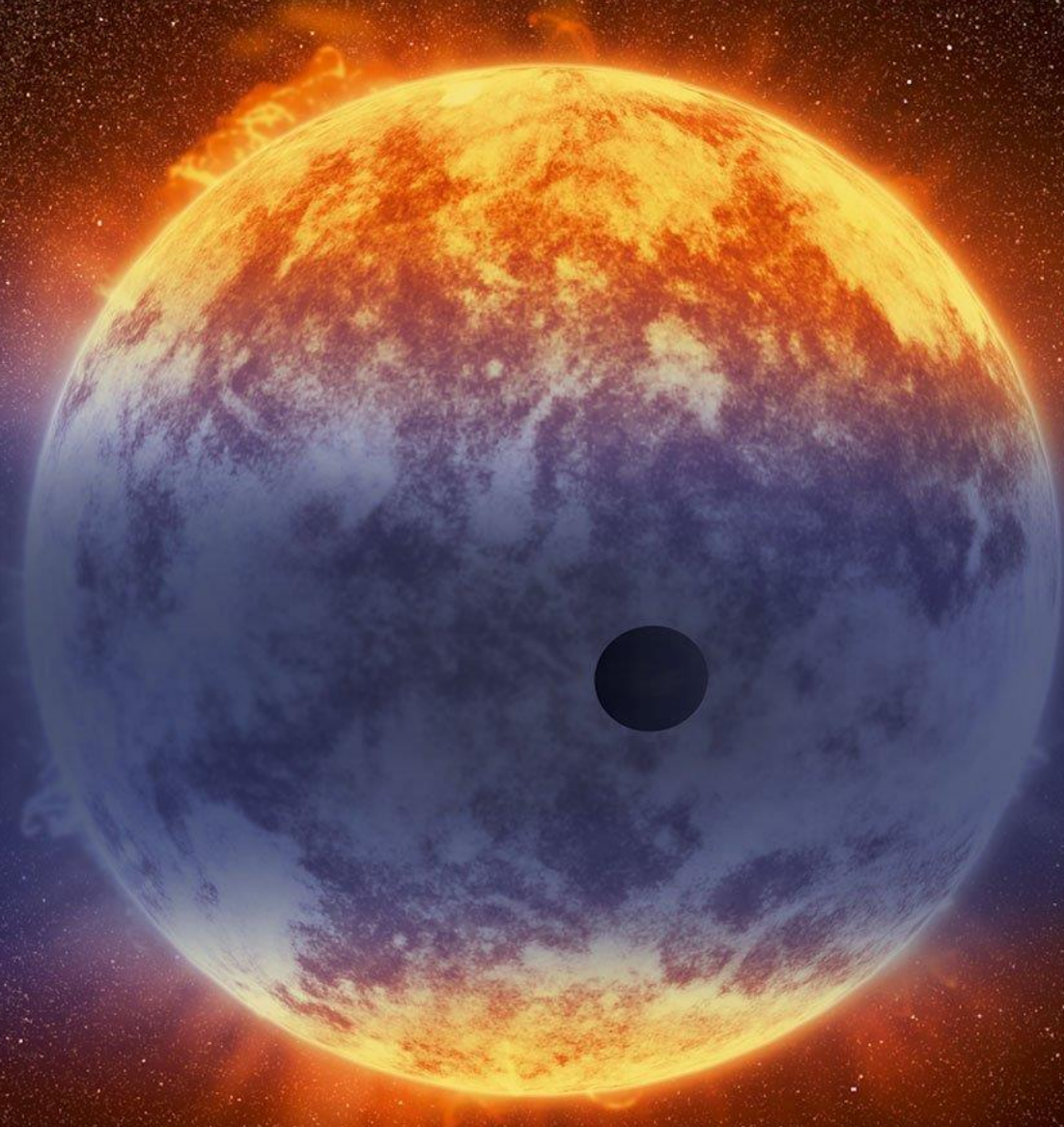


Exoplaneten

Wat zijn exoplaneten?

Waarom bestuderen we ze?

Hoe geraken we er?



Jana Bosschaerts

Educatieve master Wetenschappen (Fysica & Sterrenkunde)

Overzicht

- Definitie en classificatie
 - Gasreuzen
 - Neptunus-achtige
 - Super aardes
 - Rotsachtige
- Zoektocht
 - Naar leven
 - De tools
- Vervoer

Overzicht

- **Definitie en classificatie**
 - **Gasreuzen**
 - **Neptunus-achtige**
 - **Super aardes**
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- Vervoer

Definitie

- Exoplaneet = planeten buiten het zonnestelsel
 - Rond ster
 - Solitaire planeten



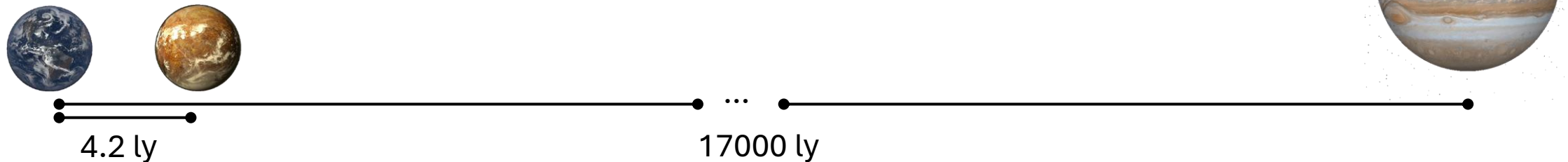
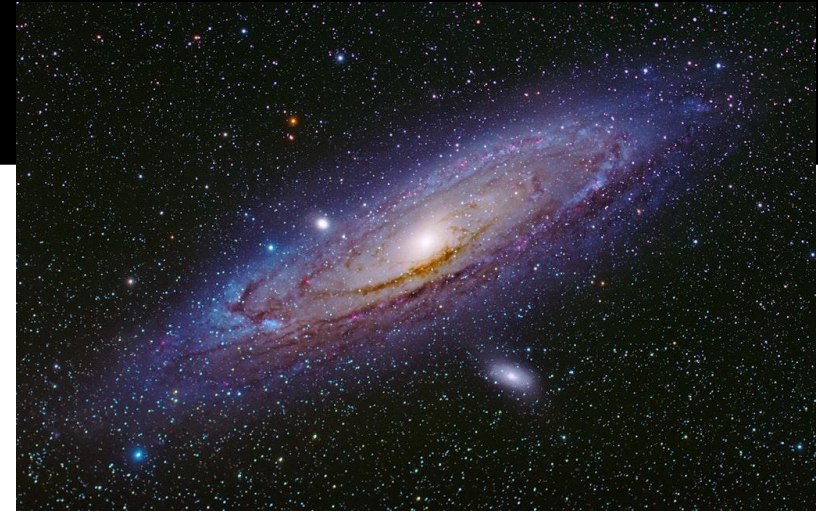
4,2 ly



Definitie

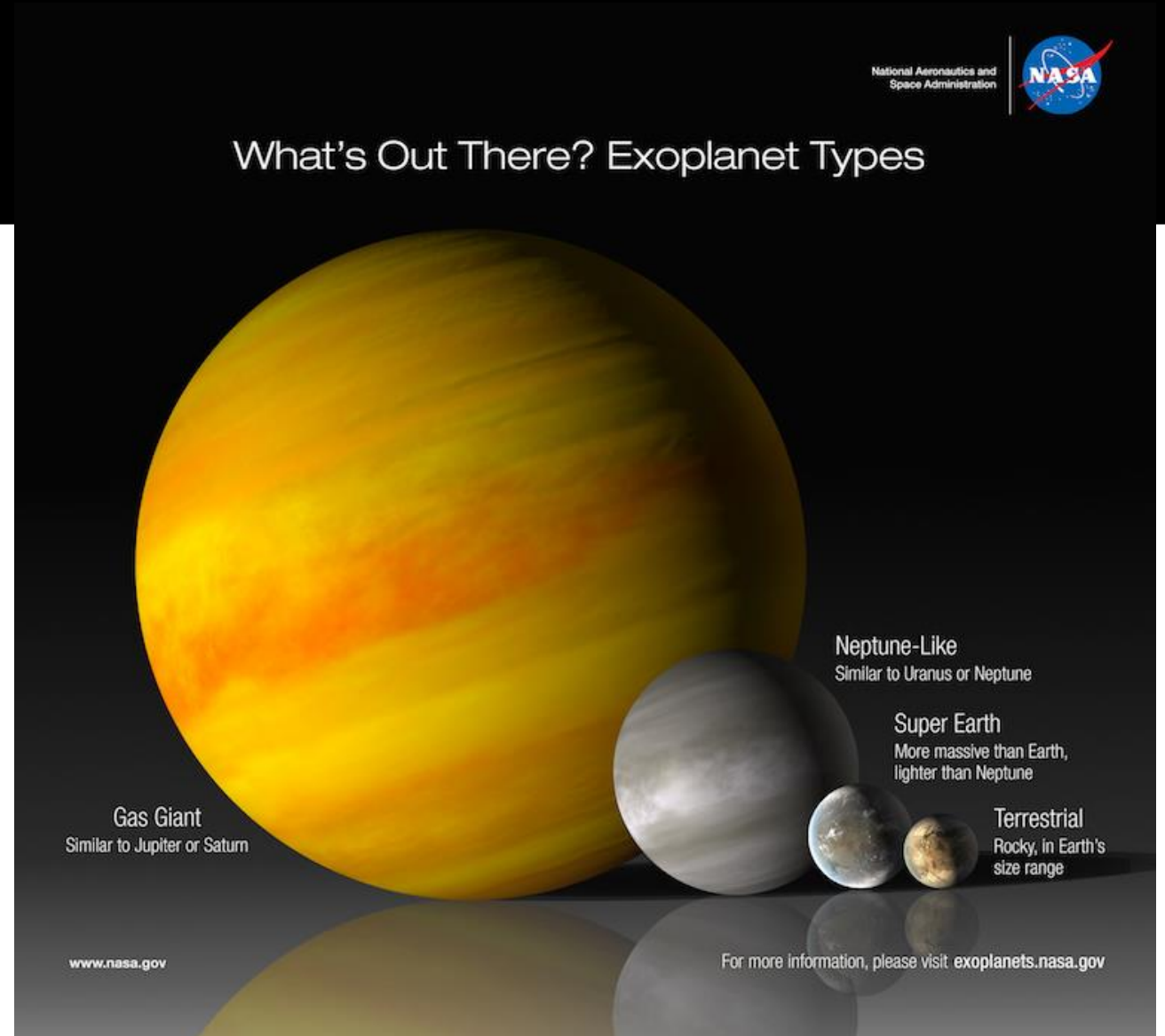
- Exoplaneet = planeten buiten het zonnestelsel
 - Rond ster
 - Solitaire planeten

- Melkweg 100 000 ly



Classificatie

- > 5000 exoplaneten



Classificatie: Gasreuzen

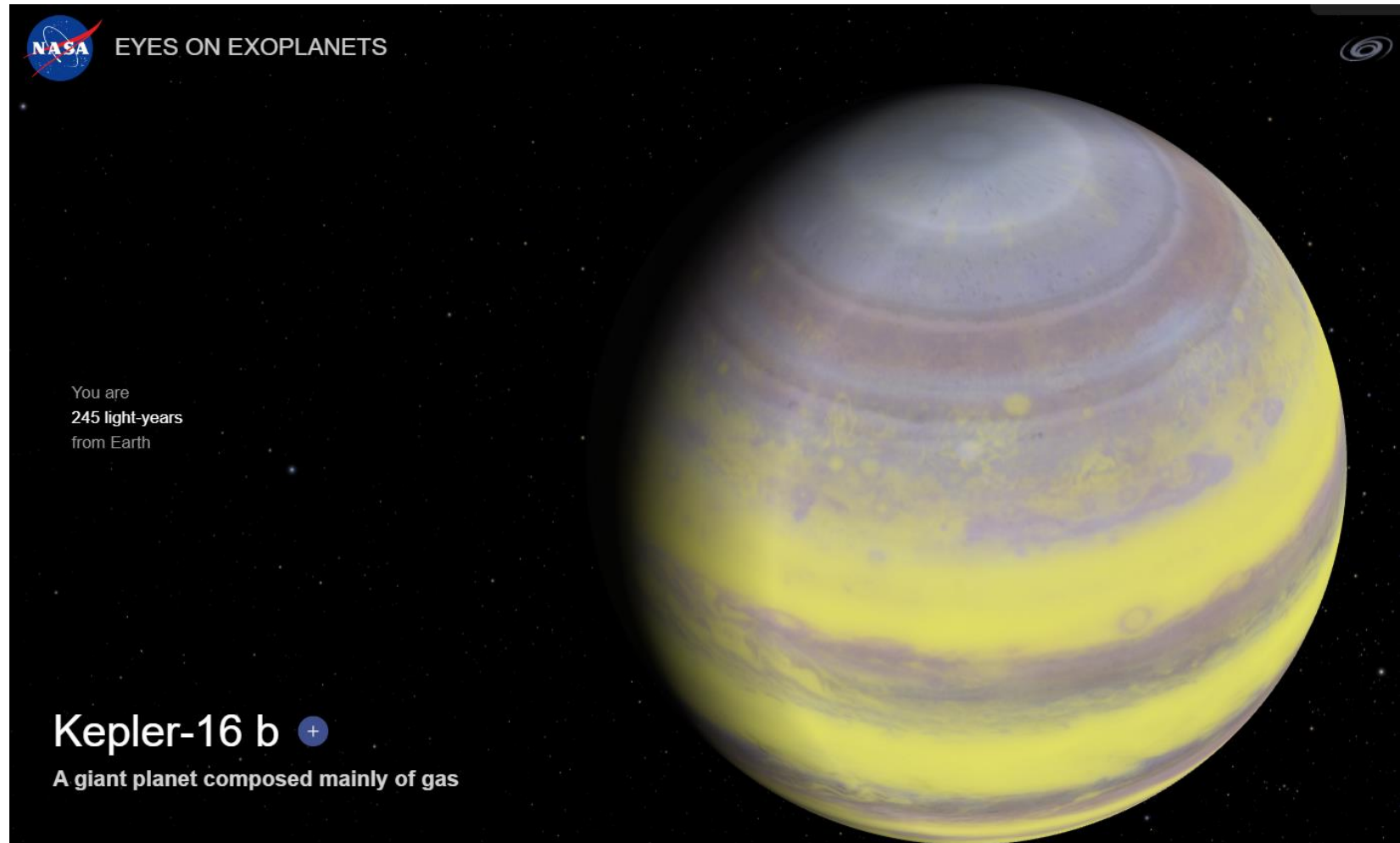
- He, H
- Grootte \geq Jupiter

- Hot Jupiters
 - A. Dicht bij ster ontstaan
 - B. Gemigreerd naar binnen in vroege jaren
 - C. Gemigreerd naar binnen in late jaren

Classificatie: Gasreuzen

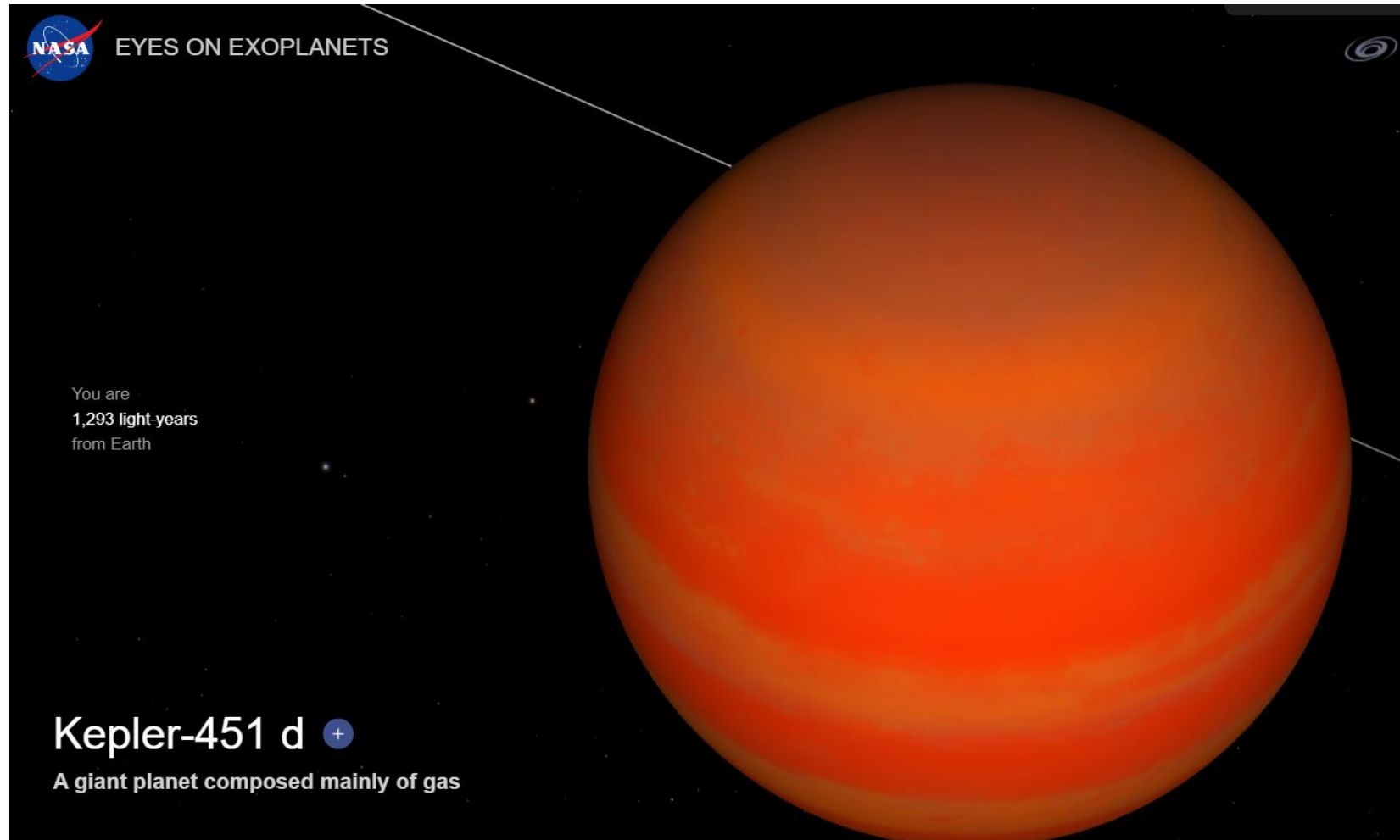
Kepler-16b

- Dubbel stersysteem



Classificatie: Gasreuzen

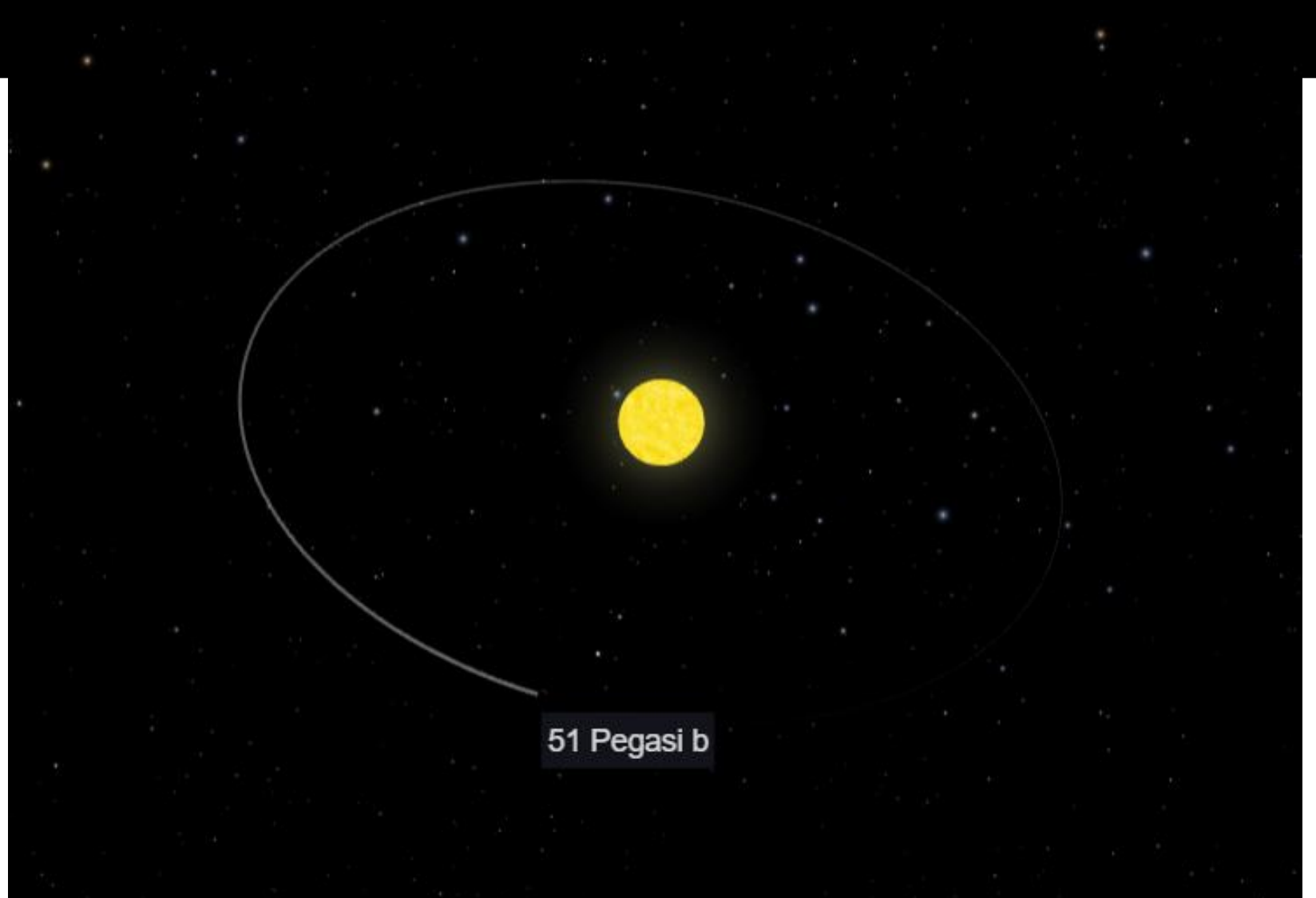
Kepler-451d



Classificatie: Gasreuzen

51 Pegasi b

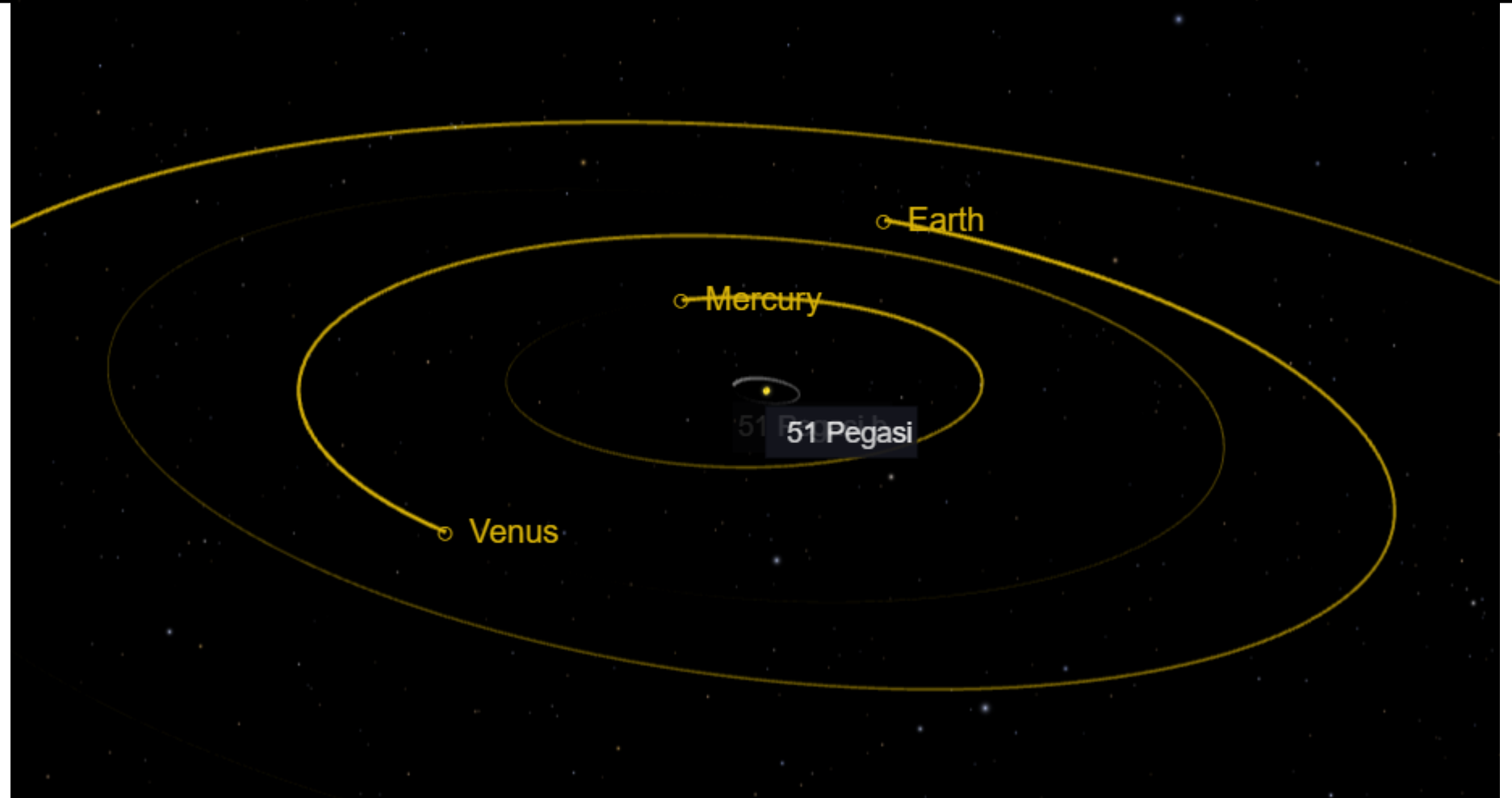
- De eerste!
- 50 ly
- Periode:
4 dagen



Classificatie: Gasreuzen

51 Pegasi b

- De eerste!
- 50 ly
- Periode:
4 dagen



Classificatie: Neptunus-achtige

- Vaste kernen: gesteente en metaal
 - Dichte atmosferen: H en He
 - Grootte en massa \approx Neptunus, Uranus
 - Voorbij de sneeuwlijn
-
- Hot Neptunes?

Classificatie: Neptunus-achtige

- Hot Neptunes?
 - Voorbij de sneeuwlijn
-
- 1 AU = 149 597 871 km
 - 1 mijl = 1.609344 km



Jupiter

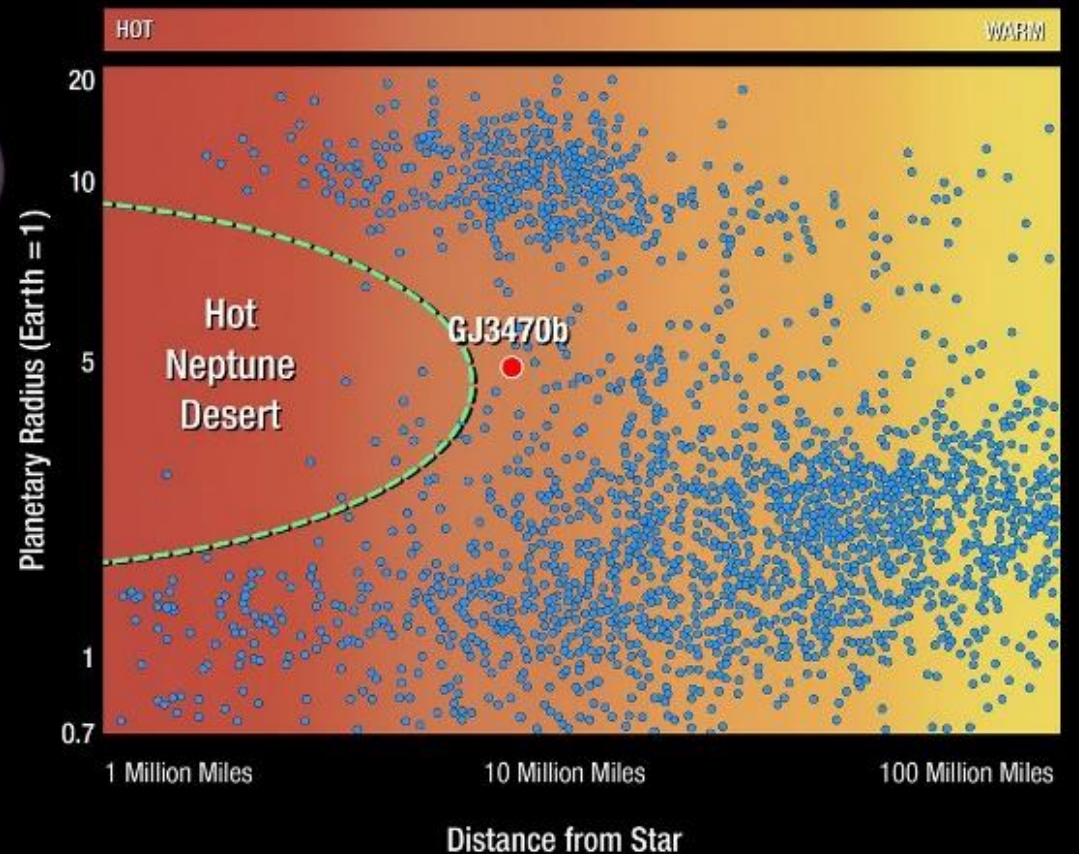


Neptune



Earth

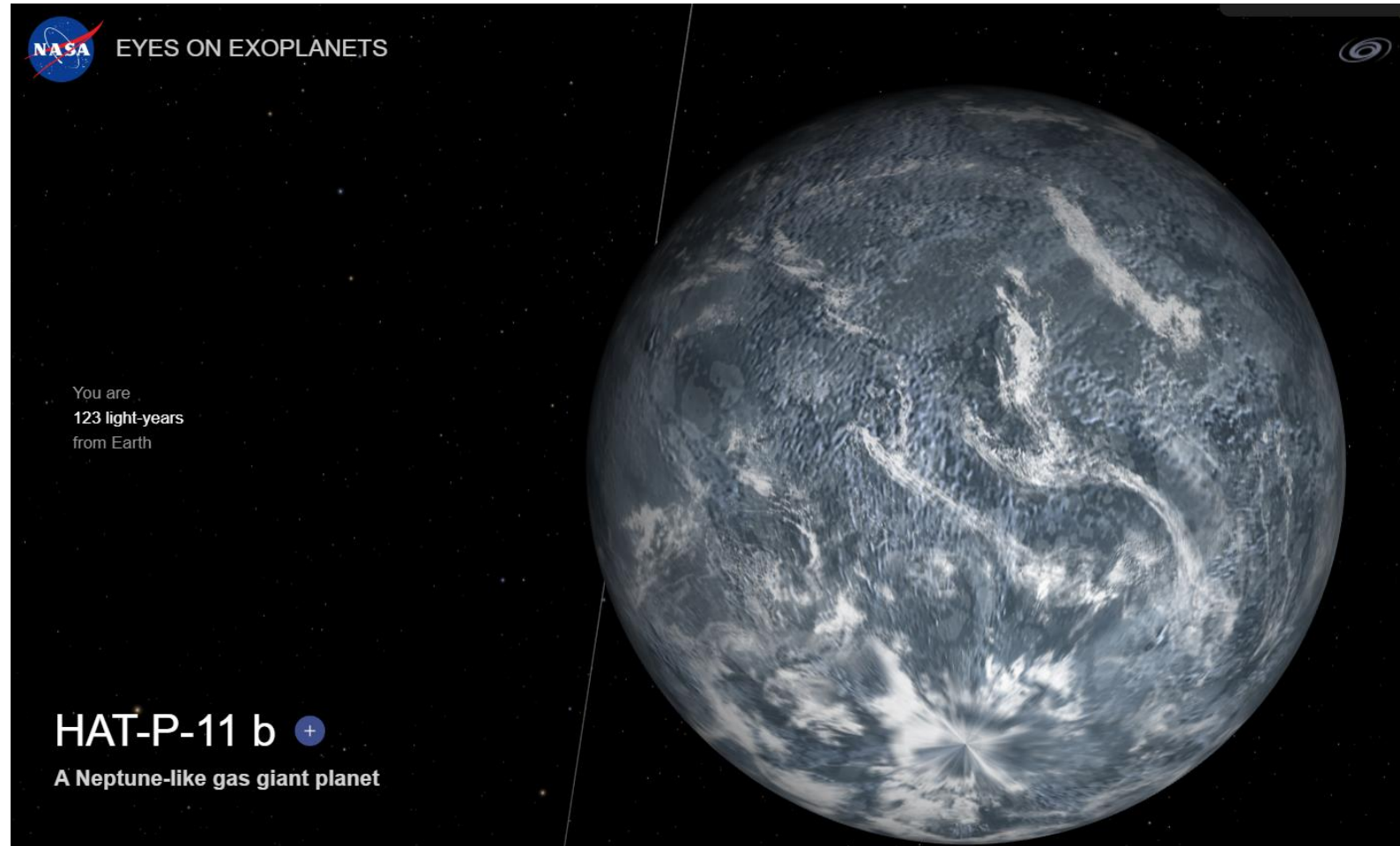
Exoplanet Radius vs. Distance from Star



Classificatie: Neptunus-achtige

HAT-P-11 b

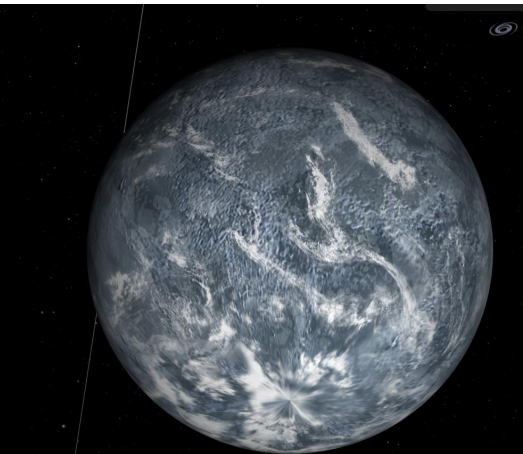
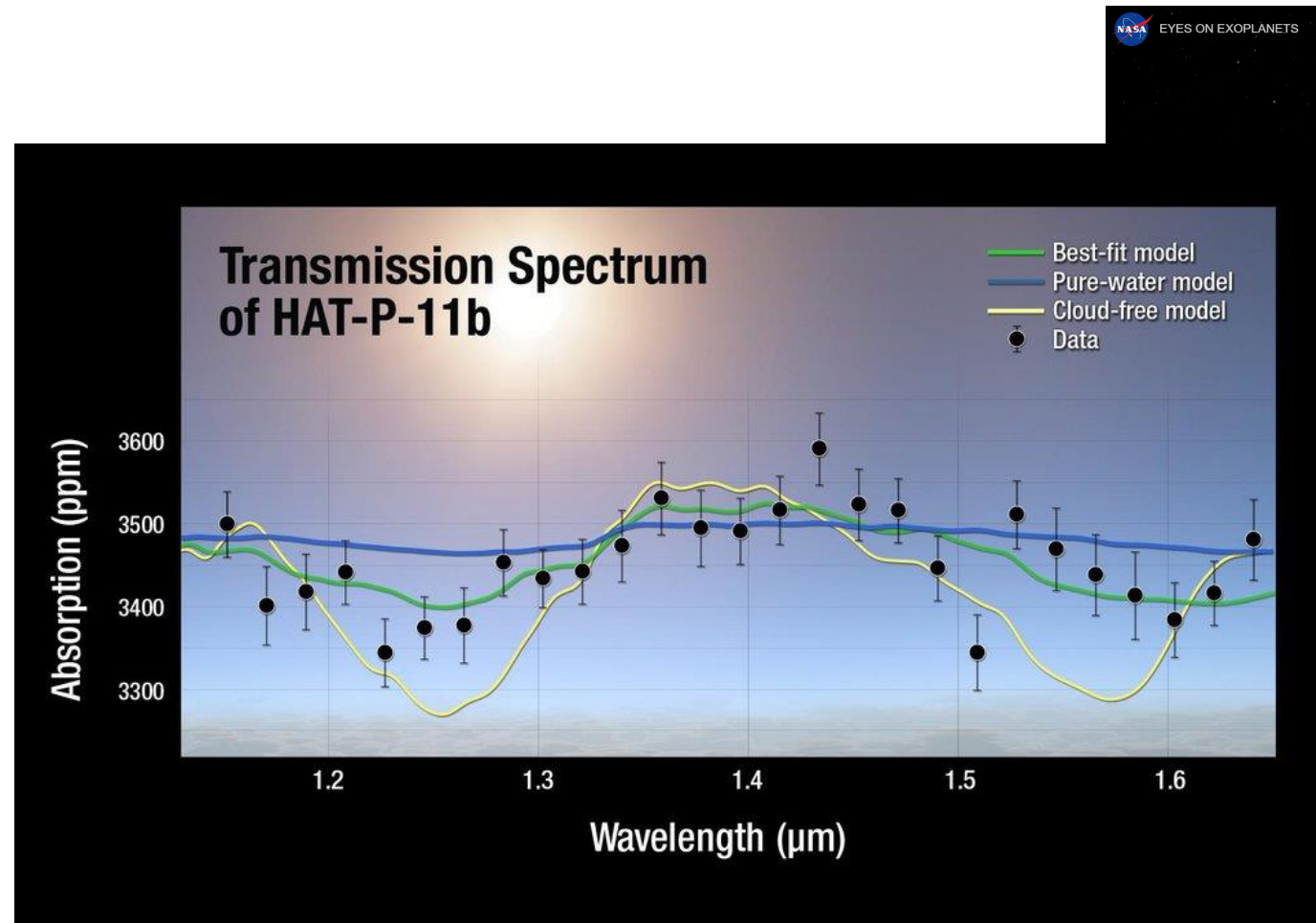
- 0.05254 AU
- Hot Neptune



Classificatie: Neptunus-achtige

HAT-P-11 b

- Waterdamp!

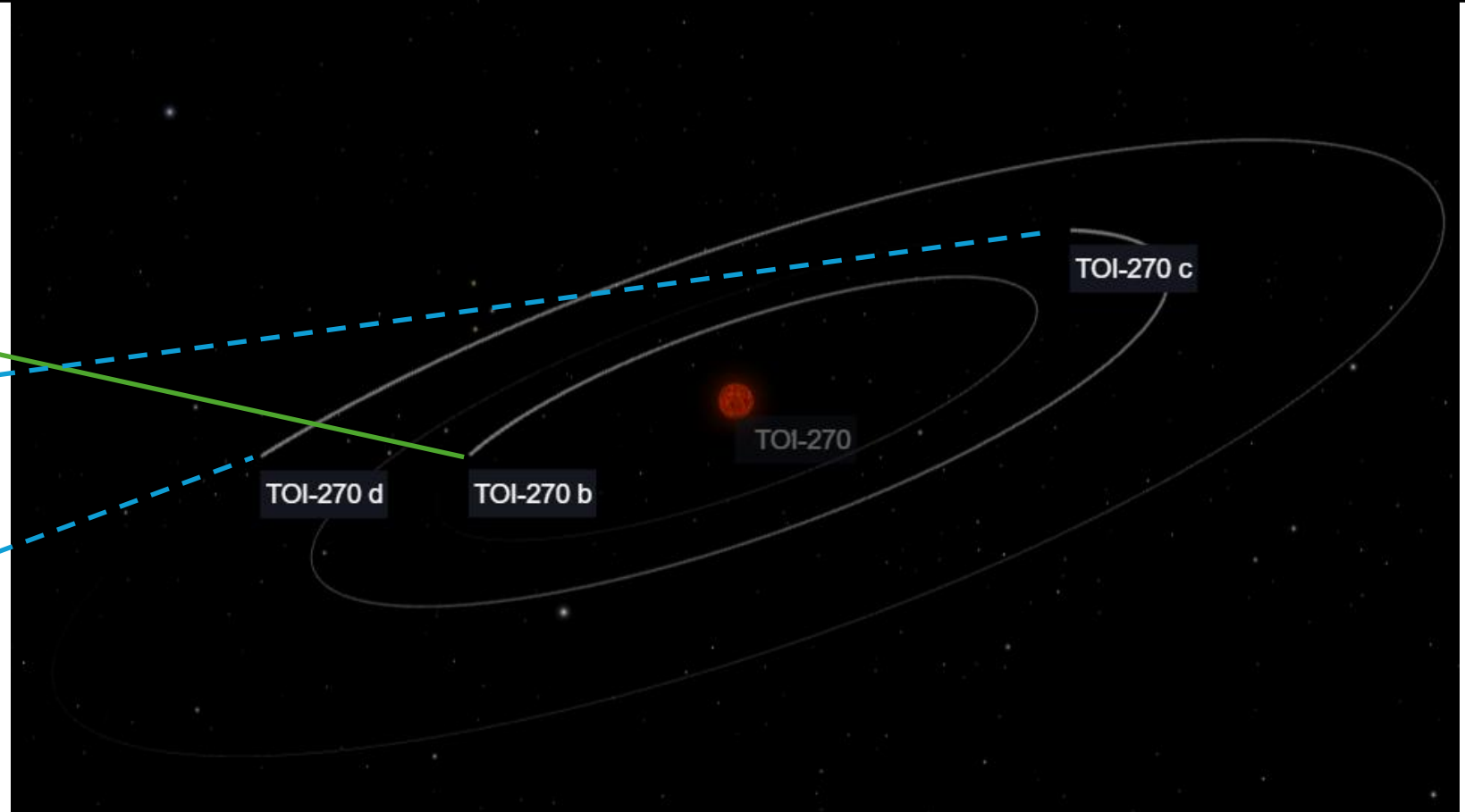
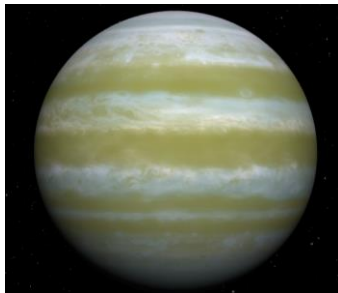
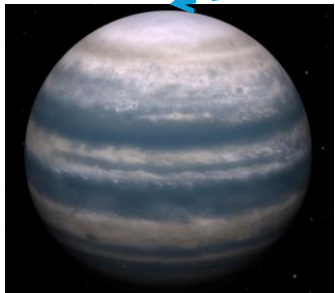
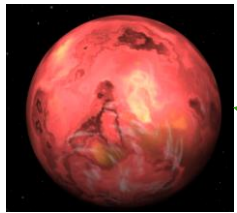


Classificatie: Super Aardes

- 'Mini-Neptunussen'
- Aarde < grootte < Neptunus
- Zeer variërende samenstelling: gas, gesteente of combinatie

Classificatie: Super Aardes

TOI 270 systeem

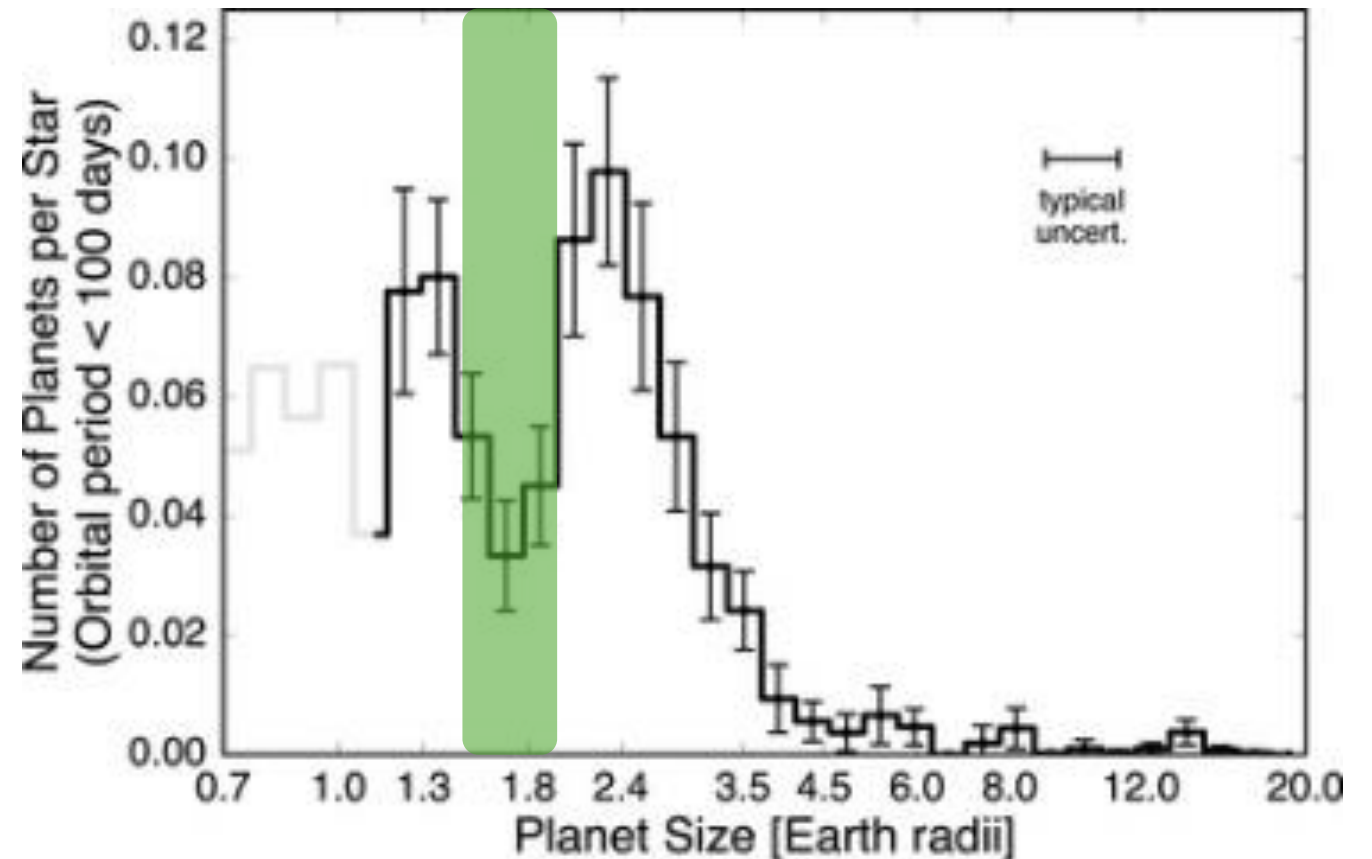


Classificatie: Super Aardes

Fulton gat /

Straal vallei

- 2025 Kepler planeten
- Periode < 100 dagen
- Kritiek interval

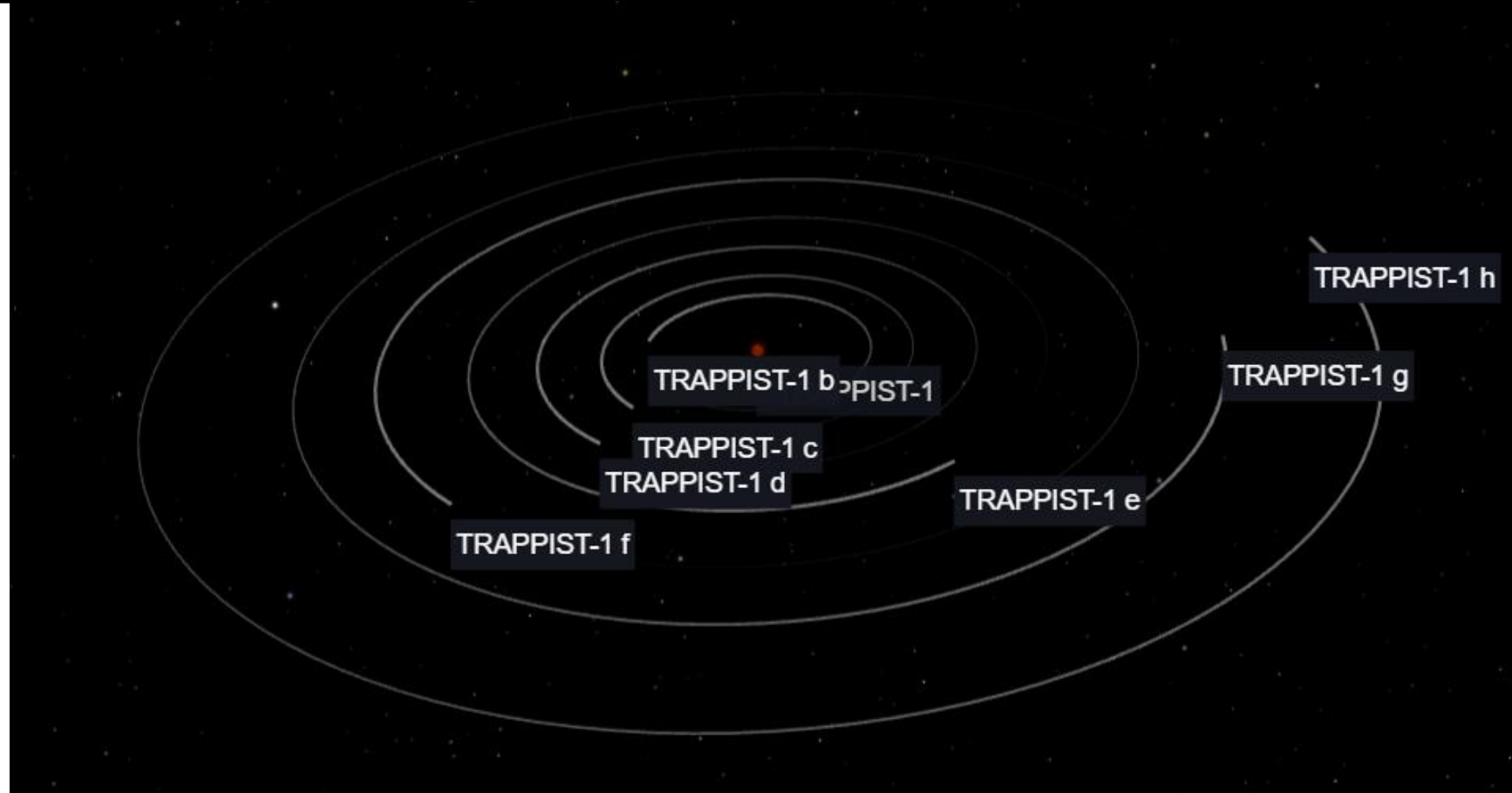


Classificatie: Rotsachtige

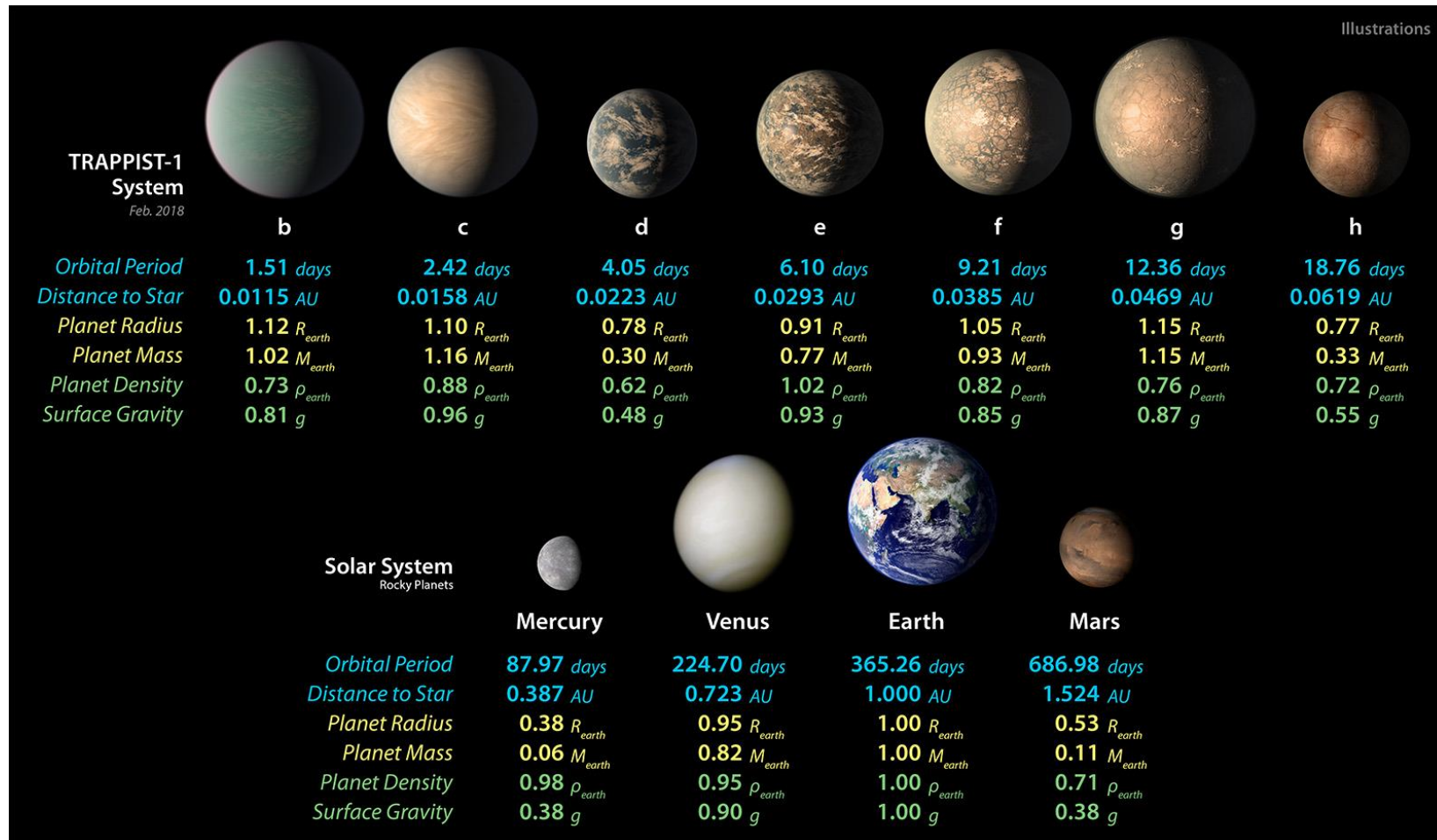
- Samenstelling: gesteente
- Grootte \leq Aarde

Classificatie: Rotsachtige

TRAPPIST 1 systeem



Classificatie: Rotsachtige



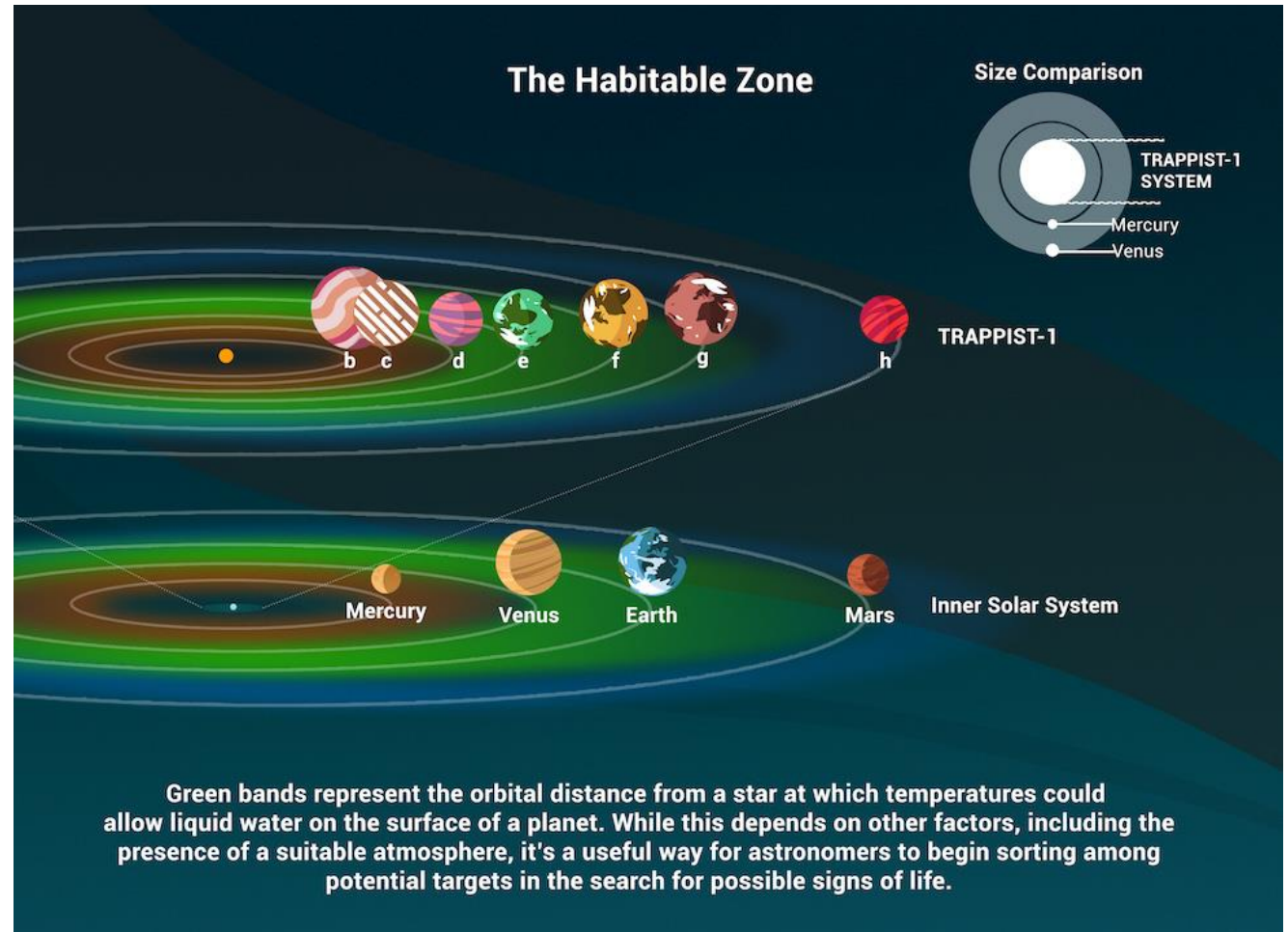
Overzicht

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 - Rotsachtige
- **Zoektocht**
 - **Naar leven**
 - **De tools**
- Vervoer

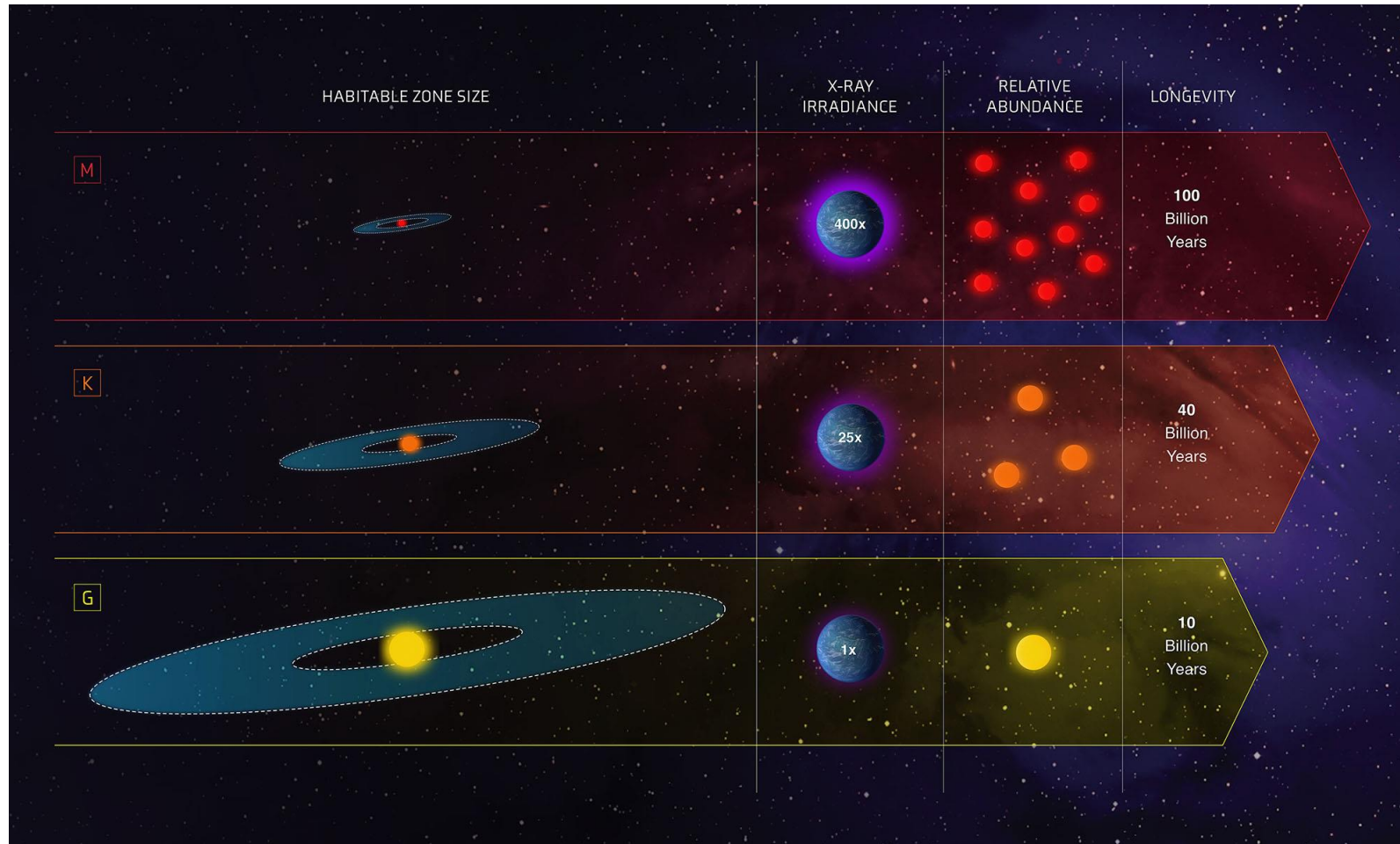
Zoektocht: leven

Goudlokjeszone

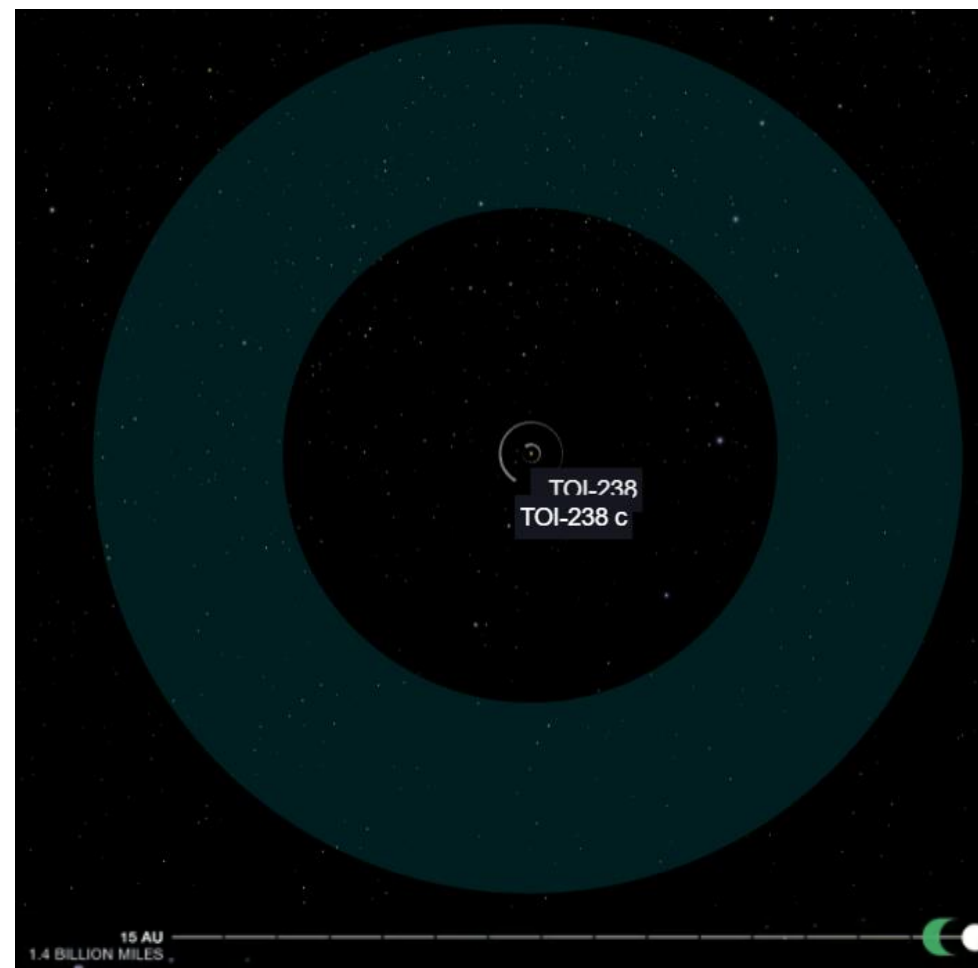
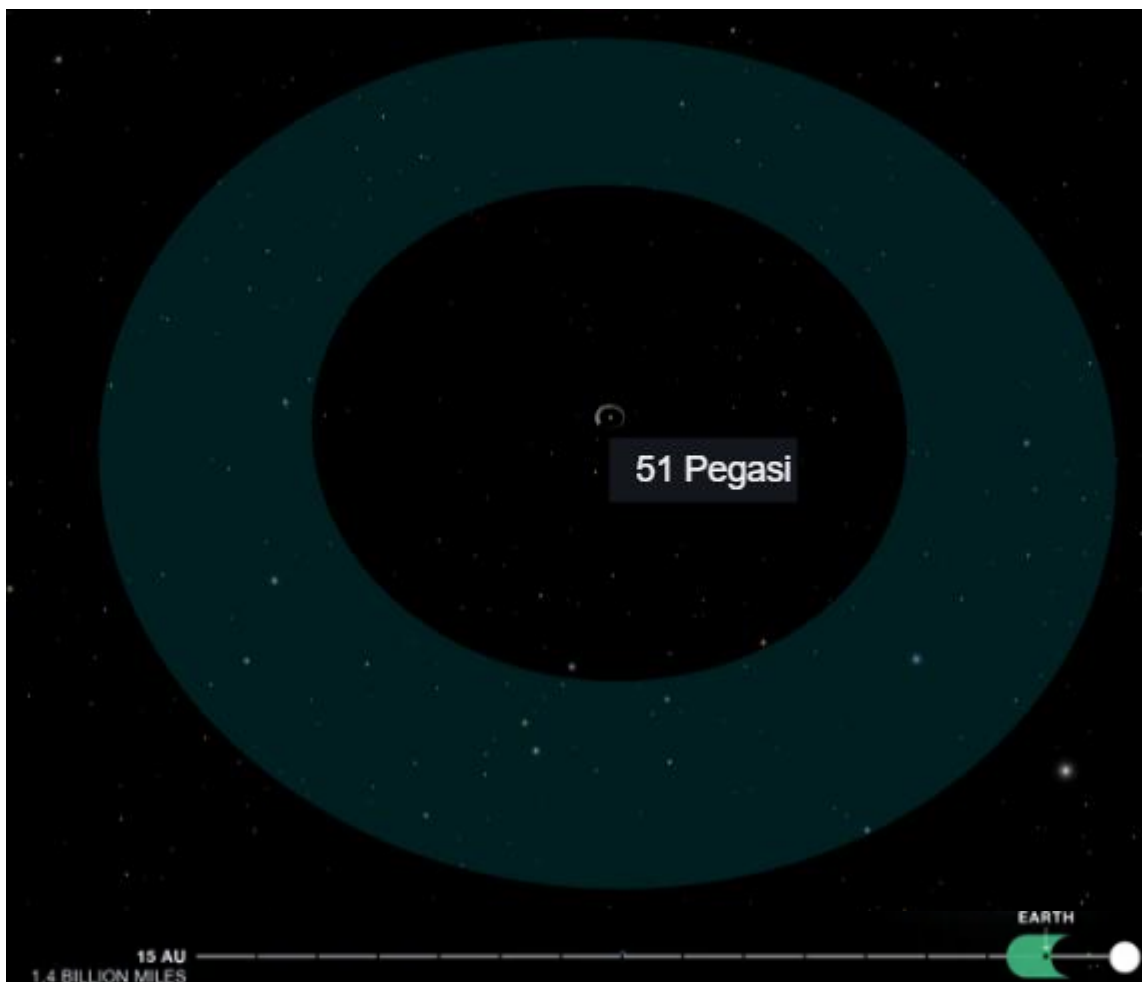
= zone rond ster waar de temperaturen het toelaten om vloeibaar water te hebben.



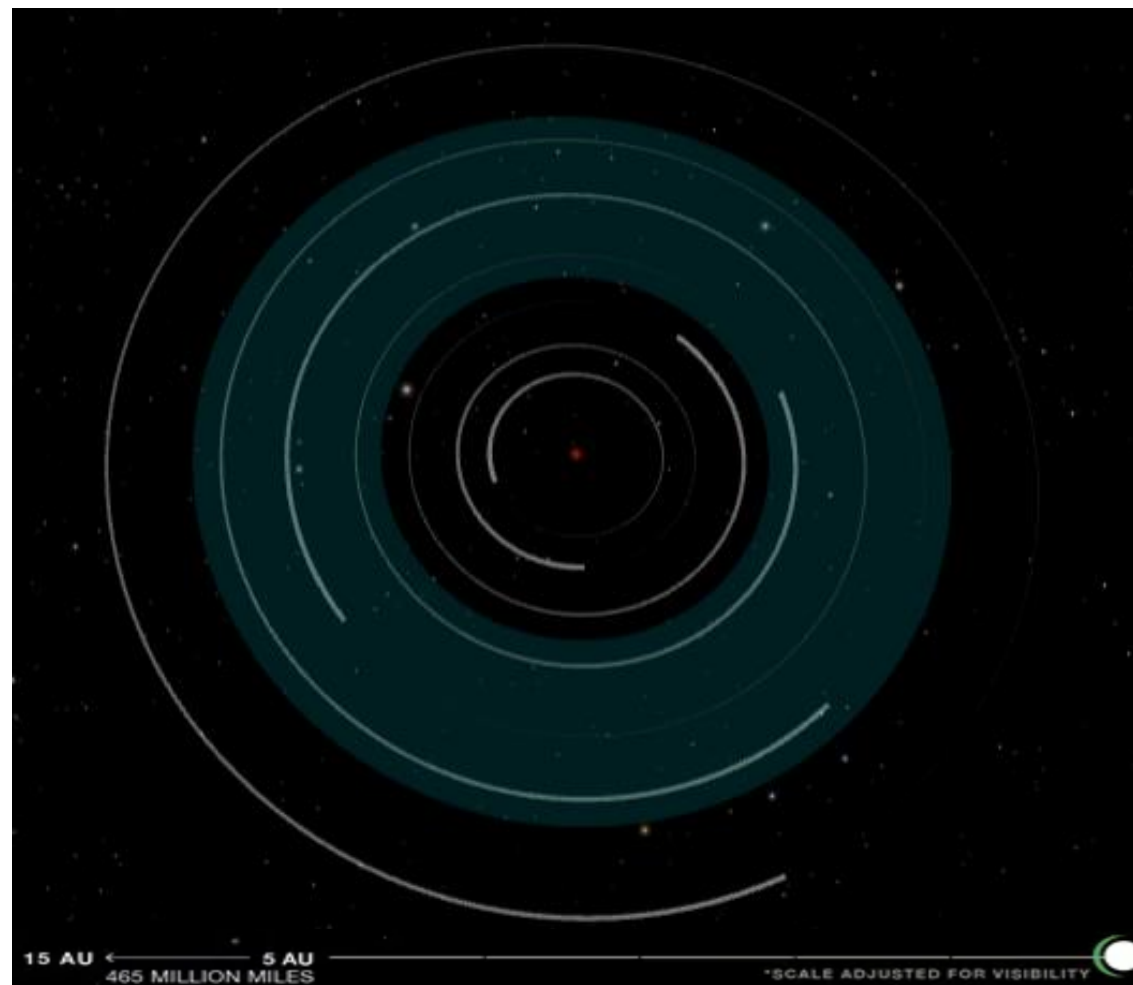
Zoektocht: leven



Zoektocht: leven

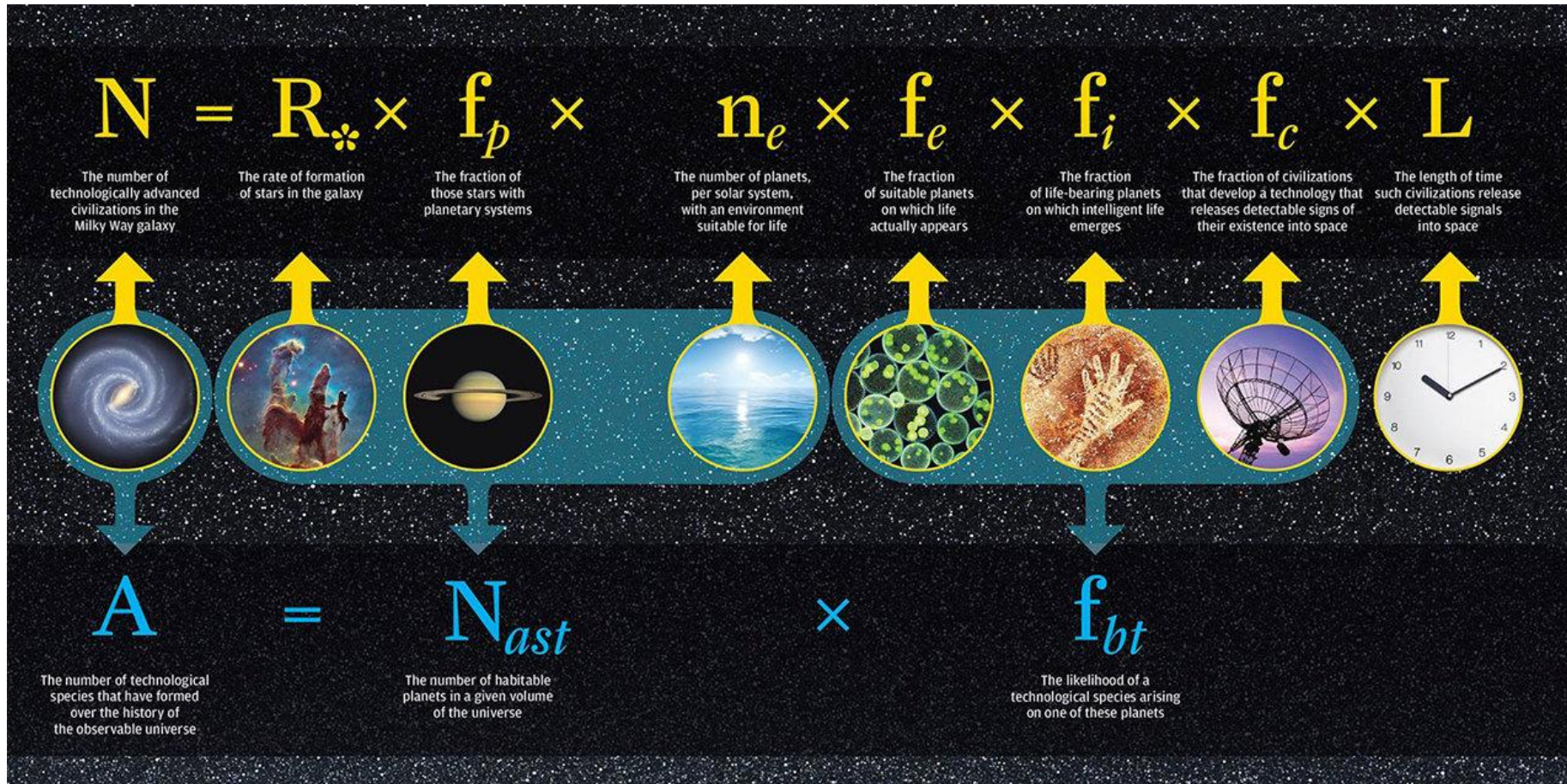


Zoektocht: leven



Zoektocht: leven

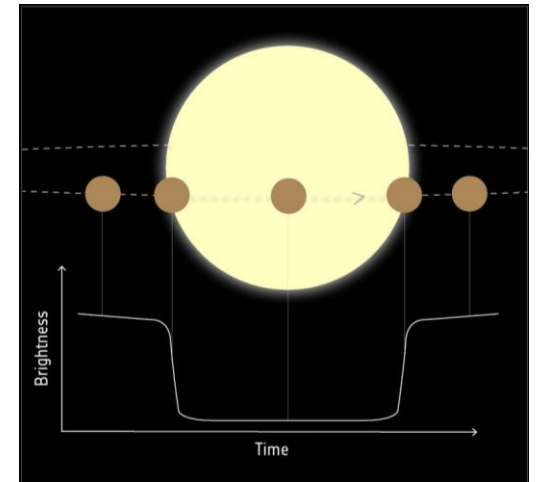
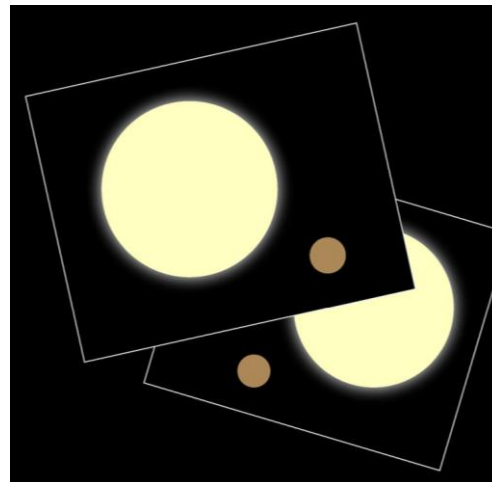
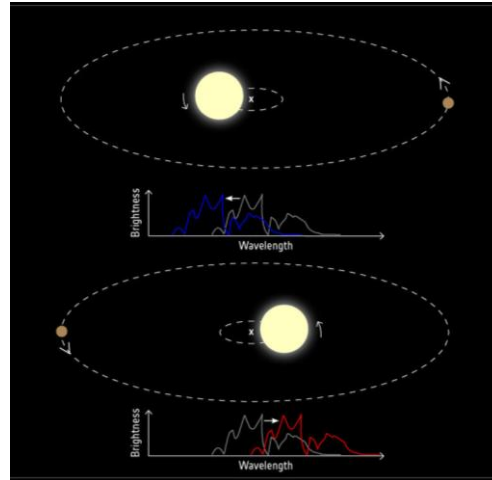
Drake vergelijking, 1961



<https://www.youtube.com/watch?v=HPQz-kdaxNo>

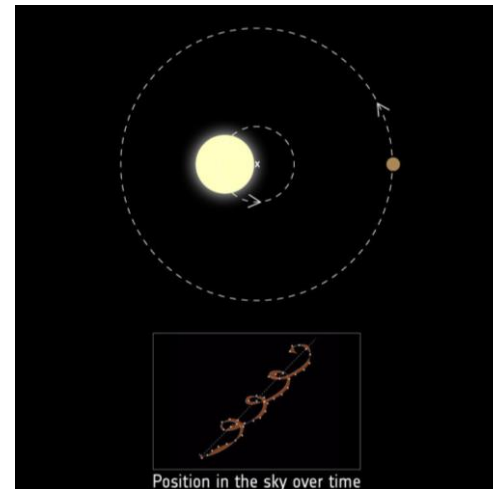
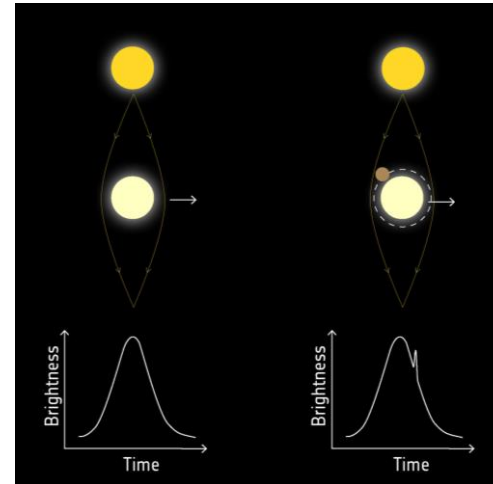
Zoektocht: De tools, technieken

- Radiële snelheidsmethode
 - Wobbeling
 - Doppler
- Transitie methode
 - Dip
- Direct imaging
 - Sterlicht afblokken

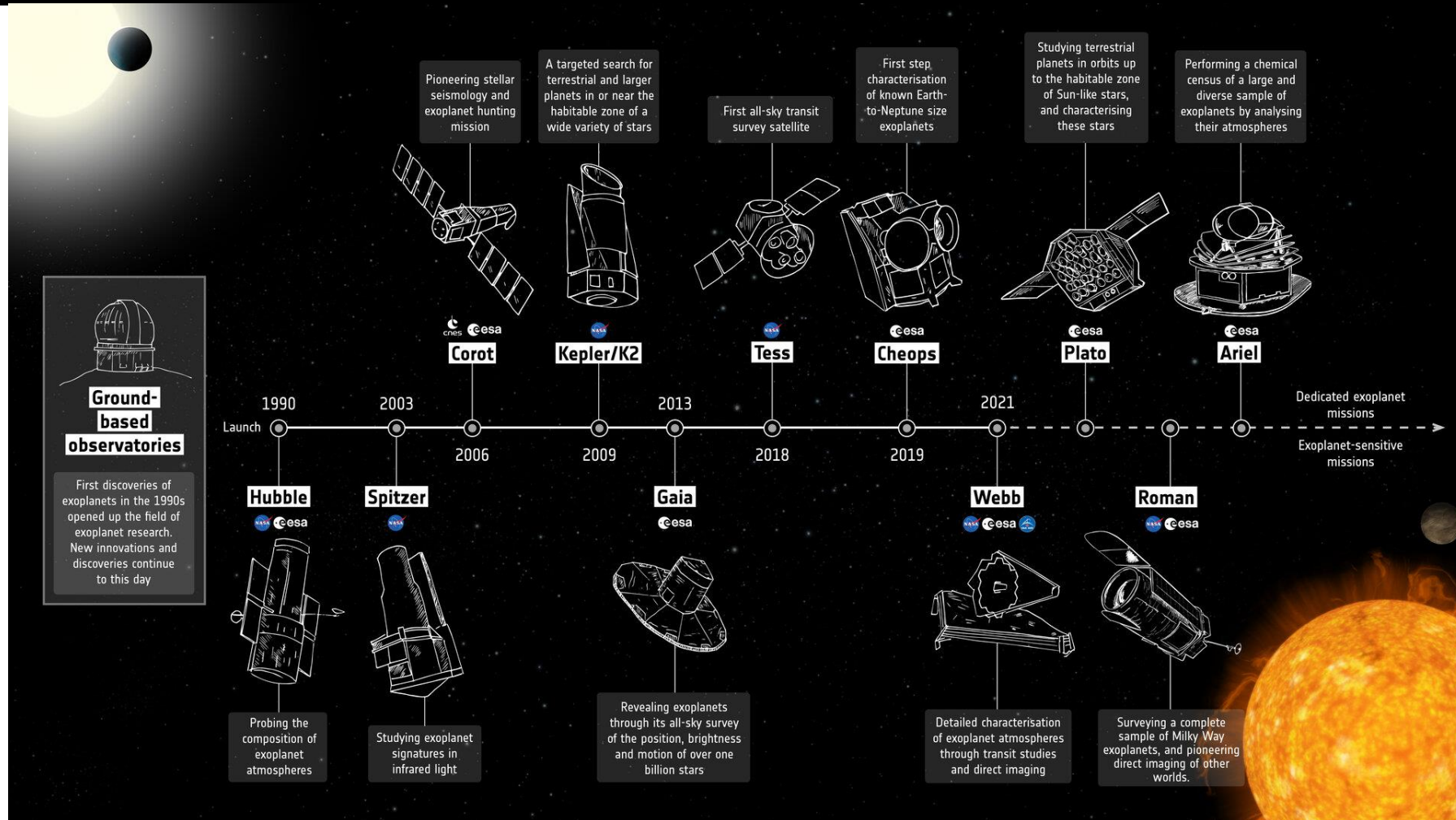


Zoektocht: De tools, technieken

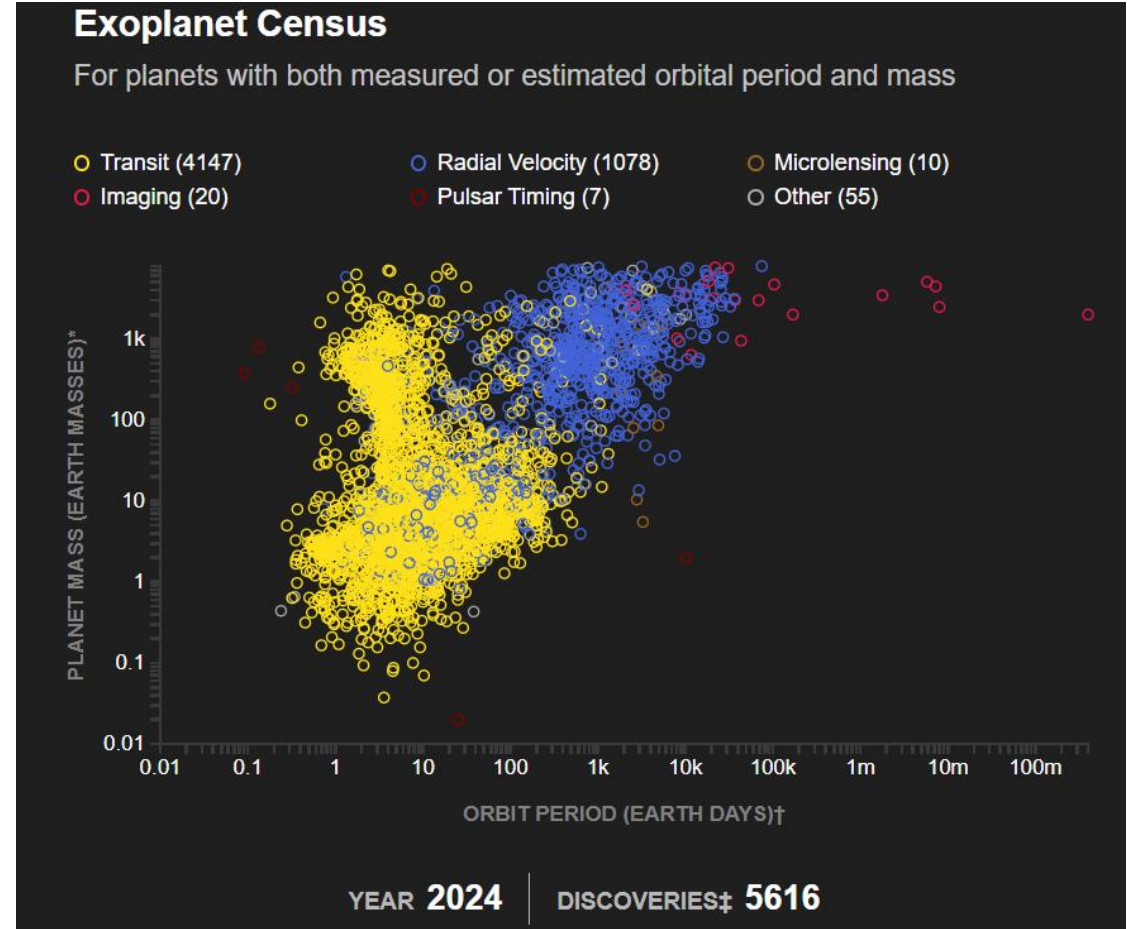
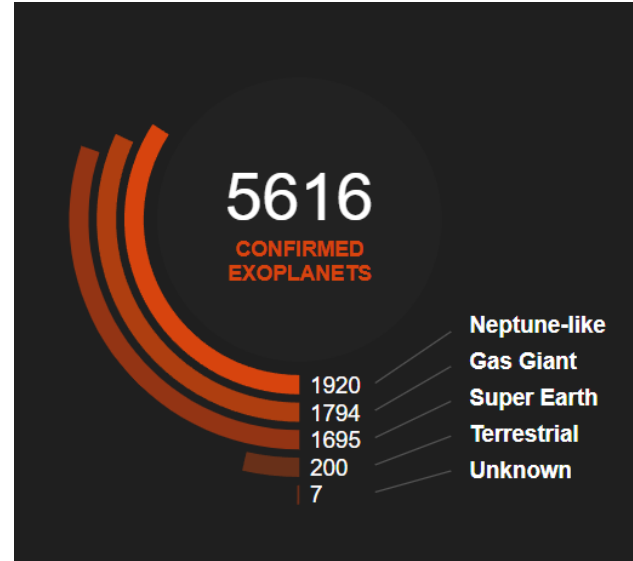
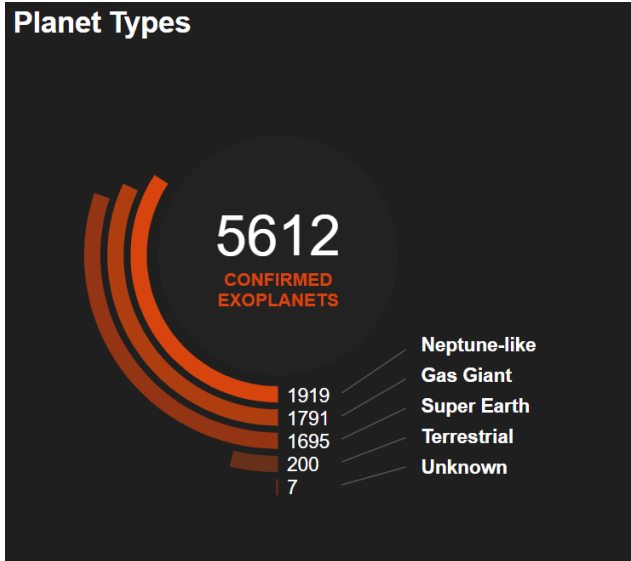
- Gravitationele microlensing
 - Einstein
- Astrometrie
 - Wobbeling
 - Beweging



Zoektocht: De tools, telescopen



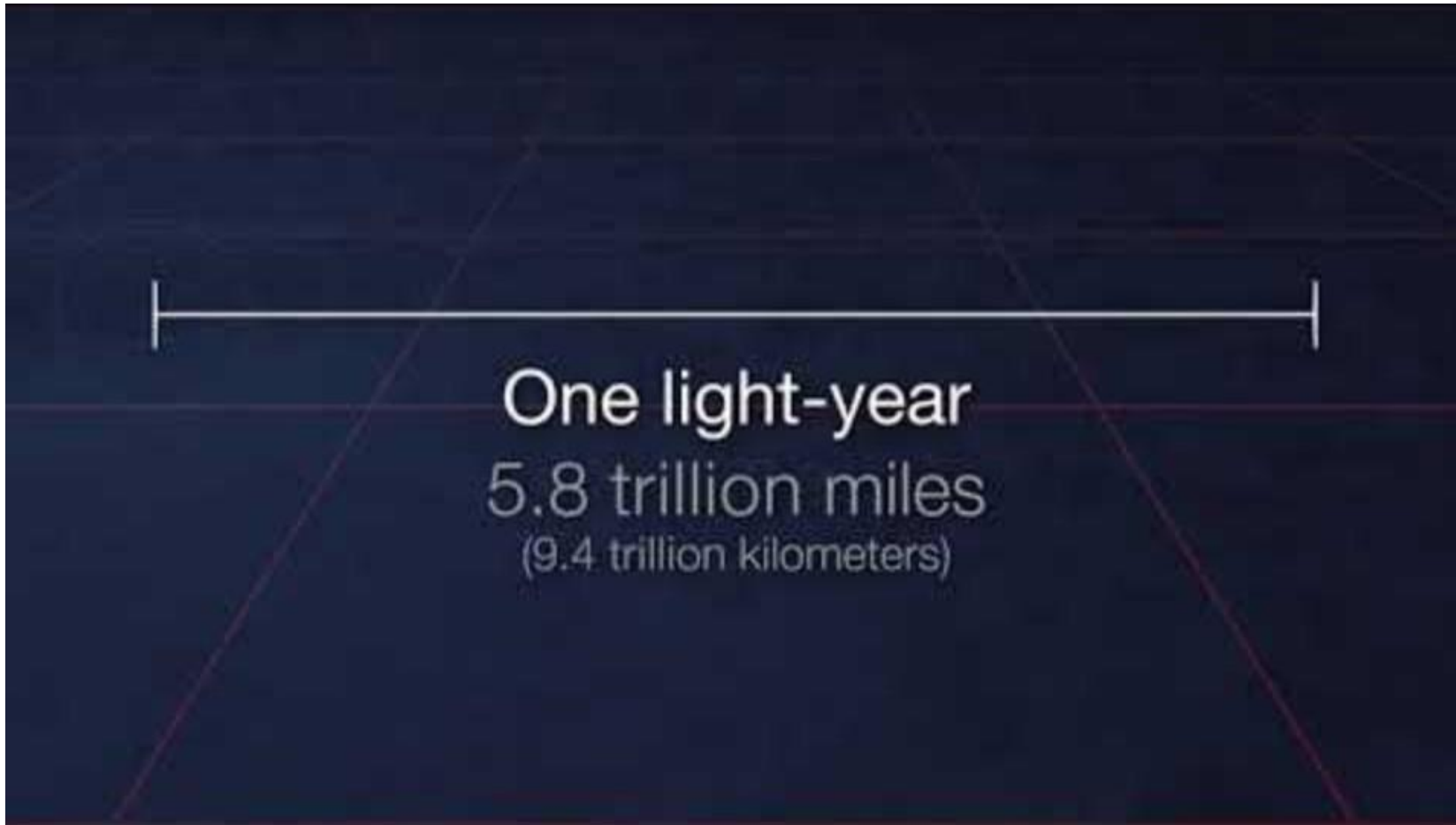
Zoektocht



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Vervoer



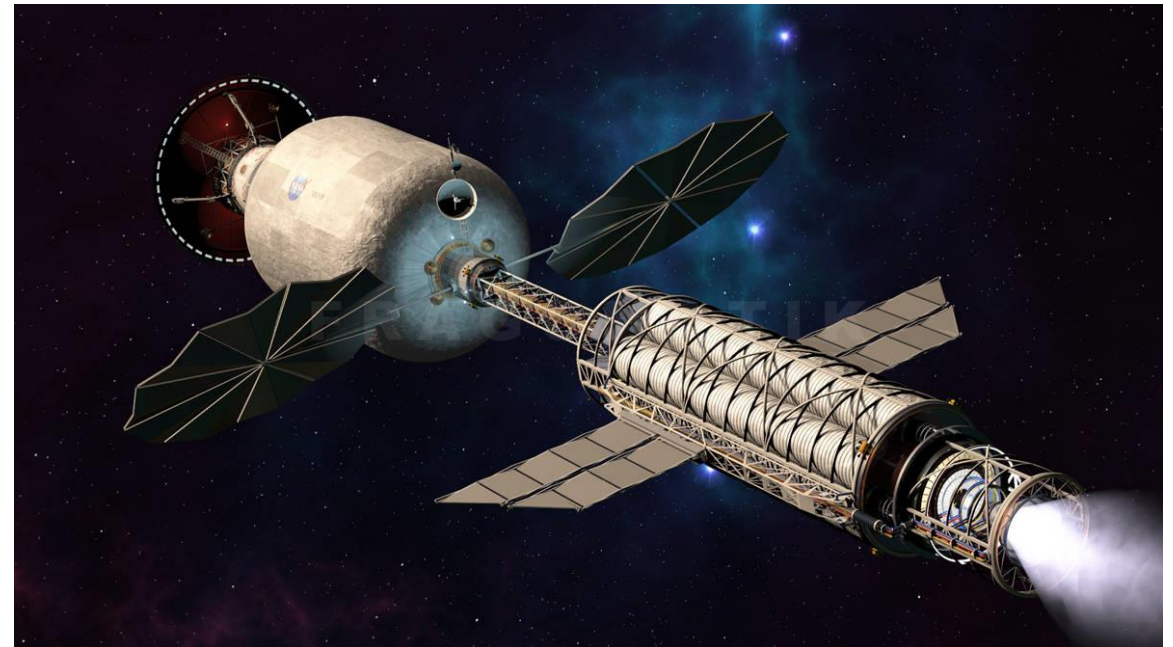
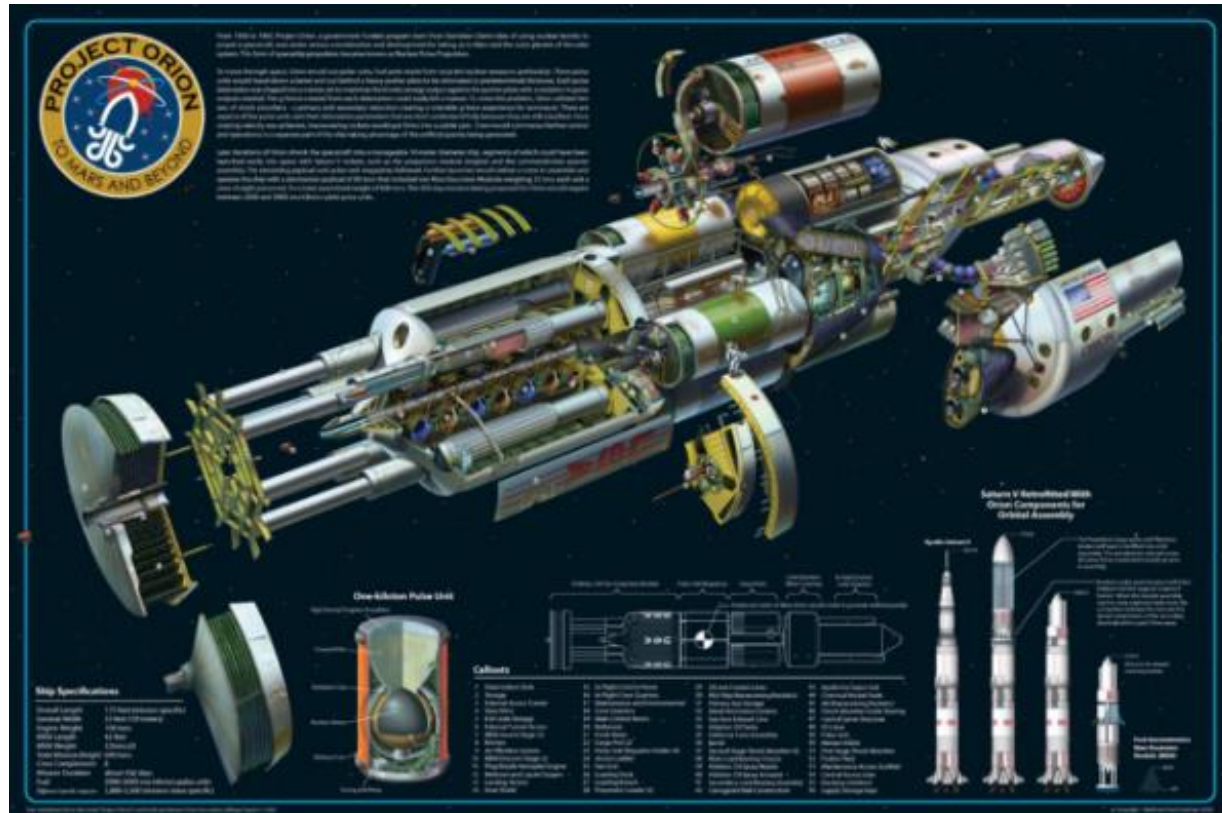
Vervoer: Hoe snel gaan we nu?

- Om aan de zon te ontsnappen

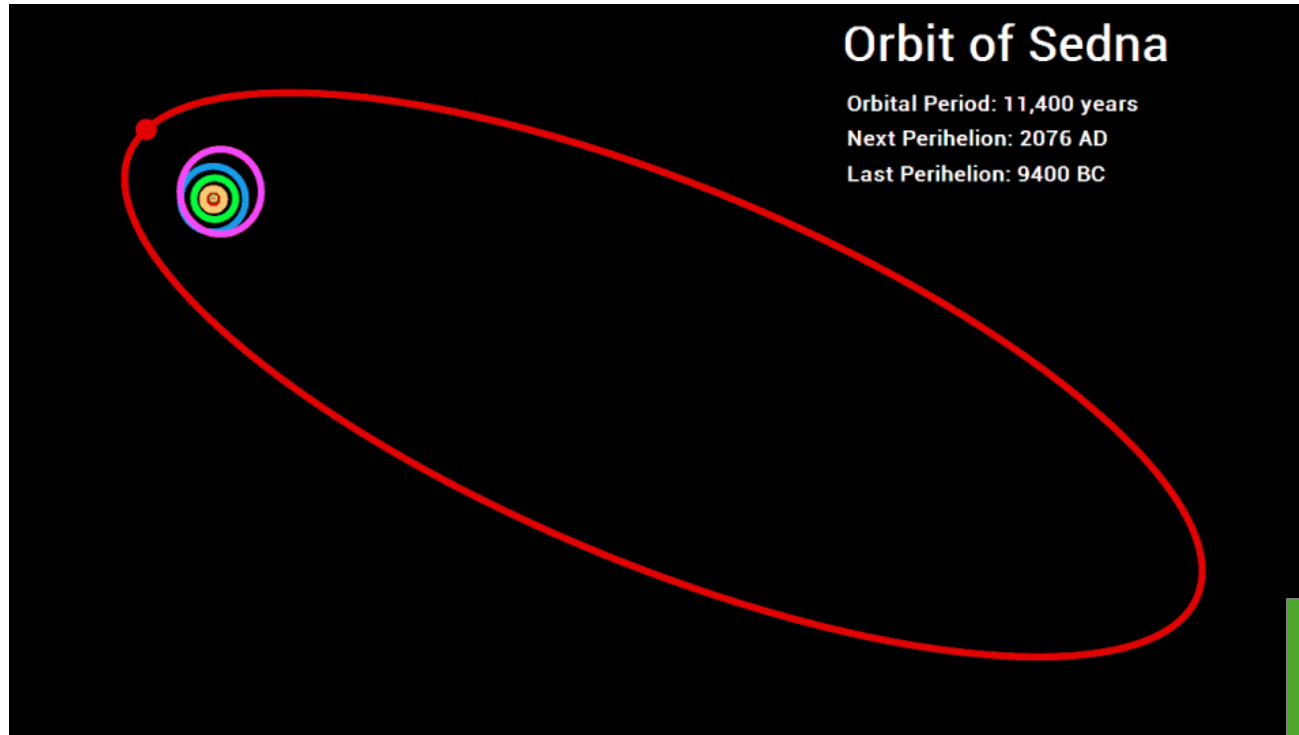
$$v_e = \sqrt{\frac{2GM_{sun}}{r}}$$

- 42,1 km/s → 1,4% c
- Naar Proxima centauri b: 29 902 jaar
- Voor binnen mensen leven: 5,2% c halen
- Haalbaar ??

Vervoer: Hoe meer snelheid halen?

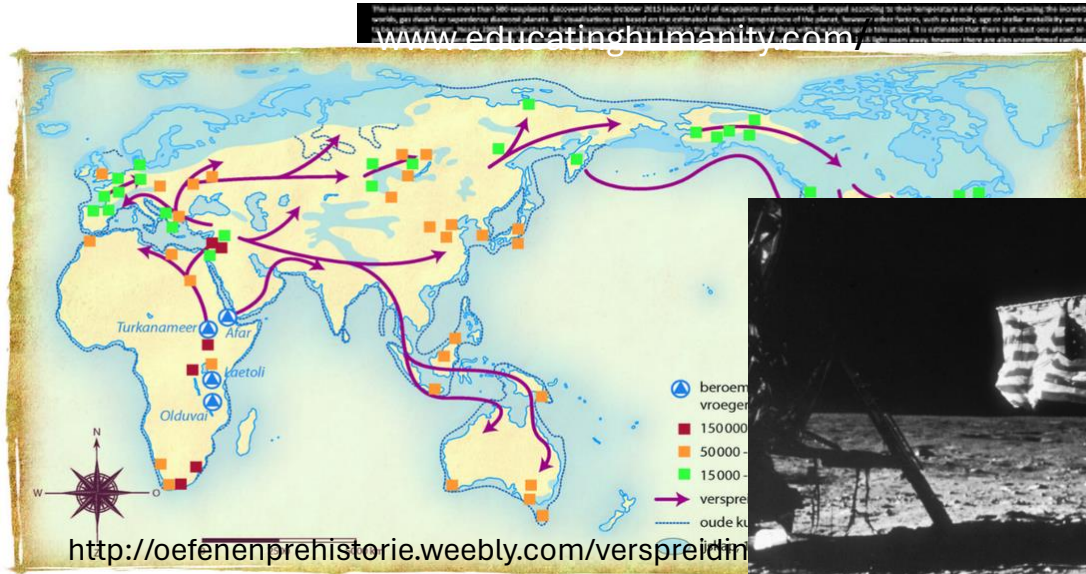


Vervoer: Andere mogelijkheden



“I propose that extraterrestrial civilizations may use free-floating planets as interstellar transportation to reach, explore and colonize planetary systems,” Romanovskaya

Dé vraag: waarom?



The illustration shows more than 300 exoplanets discovered before October 2013 (about 1/4 of all exoplanets yet discovered), arranged according to their temperature and density, showcasing the incredible variety of the extraterrestrial world. Various known classes of exoplanets are shown on the graphic, such as super-Earths, hot Jupiters, hot Neptunes, water worlds, gas dwarfs or superdense diamond planets. All visualizations are based on the estimated radius and temperature of the planet, however other factors, such as density, age or stellar metallicity were also taken into consideration. These visualizations were meant to be as accurate as possible, however the true nature of the journey of exoplanets is still unknown. It is estimated that there is at least one planet on average per star. Around 1 in 5 for the stars have at least one planet between 1 and 2 times the size of Earth in the habitable zone. A visualization shows how many there are also some of the most distant planets orbiting the star Alpha Centauri.

Until this, the idea of a plurality of worlds was not completely new. As for both in the ancient Greece, philosophers have in fact, imagined planets thinking human. In the beginning of the 20th century, Edwin Hubble, using what was then the largest telescope planets is infamously in number. However, almost the whole of 20th century went by without any convincing proof.

After van de Kamp claimed to have detected two planets orbiting the Barnard's Star using his technique. However, subsequent a complete proof of his claims observations systems. Waldemar had discovered one of the planet-sized objects orbiting a star not far. The first discovery of a planet orbiting a medium-sized star similar to the sun came in 1995. The Swiss team of Michel Mayor. By the end of the 20th century, several dozen other exoplanets had been discovered, many the result of work of discovered most discoveries in the recent years. The French CoRoT mission, launched in 2006, was the first space mission end-goal solely in exoplanet mission. Kepler Space Telescope, launched in 2009 and quickly became the most successful exoplanet-focused mission it renders its mission, it's likely that Kepler will find even more fascinating exoplanets, some of them possibly harboring life.



Bedankt voor jullie aandacht!

and according to their temperature and density, showcasing the incredible variety of the extraterrestrial worlds. Various known classes of exoplanets are shown on the graphic, such as super-Earths, hot Jupiters, hot neptunes, but numerous other factors, such as density, age or stellar metallicity were also taken into consideration. These visualizations were meant to be as accurate as possible, however the true nature of the portrayed exoplanets might turn out to be quite different. It is estimated that there is at least one planet for average per star. Around 1 in 5 star-like stars have at least one planet between 1 and 2 times the size of Earth in the habitable zone, putting the number of such 1.24 light years away. However there are also unconfirmed candidate planets orbiting Tau Cent and Alpha Centauri B.

Galileo Galilei was accused of heresy by the Catholic Church, but even in Galileo's time, the idea of a plurality of worlds was not completely new. As far back as in the ancient Greece, philosophers have speculated that other stellar systems like our. His insights, reluctantly accepted in the subsequent centuries, changed Western thinking forever. In the beginning of the 20th century, Edwin Hubble, using what was then the largest telescope in the world, found that Hubble's observations proved that the number of stars that could house habitable planets is astronomical in number. However, almost the whole of 20th century went by without any convincing proof of planets around other stars.

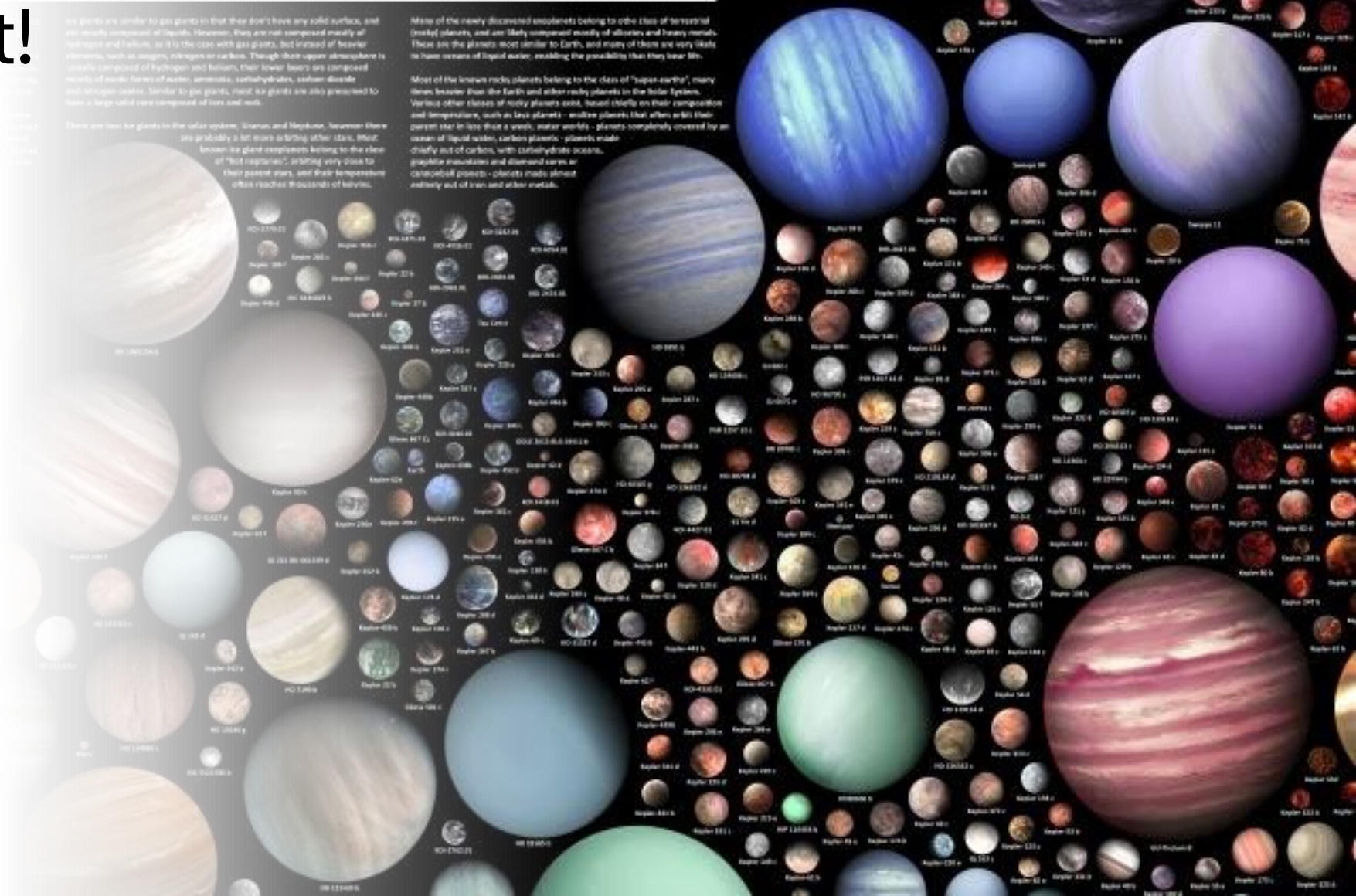
Overcoming their efforts on the first star. During the late 1990s, astronomer Peter van de Kamp claimed to have discovered two planets orbiting the Barnard's Star using this technique. However, subsequent observations failed to verify his discovery at Harvard-Smithsonian Center for Astrophysics, reported what he called "anomalous wobble" of extraterrestrial planets. However, he had discovered two or three planet-sized objects orbiting a pulsar, a supernova, rapidly spinning star, pulsating the planets' complex gravitational effects on the star's star. The first discovery of a planet orbiting a medium-sized star similar to the sun came in 1995. The Swiss team of Michel Mayor and Didier Queloz discovered the first exoplanet, orbiting the star 51 Pegasi, using the radial velocity method. By the end of the 20th century, several dozen other exoplanets had been discovered, many the result of years of observation of nearby stars. Significant progress in finding orbiting planets have enabled an almost surge of exoplanet discoveries in the recent years. The French Caltech mission, launched in 2006, was the first space mission dedicated solely to exoplanets, searching for planets of the most well-studied planets outside our solar system. First NASA exoplanet mission, Kepler Space Telescope, launched in 2009 and quickly became the most successful exoplanet-focused mission in history. Among 70 stars in our solar system and also numerous hot systems of variable star activity. As it continues its mission, it's likely that Kepler will find even more breathtaking exoplanets, some of them probably harboring life.

Ice giants are similar to gas giants in that they don't have any solid surface, and are mostly composed of liquids. However, they are not composed mainly of hydrogen and helium, as it is the case with gas giants, but instead of heavier elements, such as oxygen, nitrogen or carbon. Though their upper atmosphere is mostly composed of hydrogen and helium, their lower layers are composed mostly of water, ammonia, carbon dioxide, sulfur dioxide and nitrogen oxides. Similar to gas giants, most ice giants are also presumed to have a large solid core composed of iron and rock.

There are two ice giants in the solar system: Uranus and Neptune. However there are probably 3 hot stars orbiting other stars, that are known as giant exoplanets orbiting to the star of "hot neptunes", orbiting very close to their parent stars, and their temperature often reaches thousands of kelvins.

Many of the newly discovered exoplanets belong to the class of "terrestrial (rocky) planets", and are likely composed mostly of silicates and heavy metals. These are the planets most similar to Earth, and many of them are very likely to have oceans of liquid water, enabling the possibility that they bear life.

Most of the known rocky planets belong to the class of "super-Earths", many being heavier than the Earth and other rocky planets in the solar system. Various other classes of rocky planets exist, based chiefly on their composition and temperature, such as lava planets - molten planets that often orbit their parent star in less than a week, water worlds - planets completely covered by an ocean of liquid water, carbon planets - planets made chiefly out of carbon, with carbon dioxide oceans, graphite mantles and diamond cores or carbide planets - planets made almost entirely out of iron and other metals.



Bronnen

- https://www.esa.int/Science_Exploration/Space_Science/Exoplanets
- <https://www.leidensciencemagazine.nl/articles/exoplanets-here-we-come>
- <https://toughsf.blogspot.com/2021/01/moto-orion-mechanized-nuclear-pulse.html>
- <https://www.nationalgeographic.nl/ruimte/2020/07/exoplaneten-meer-planetten-dan-sterren-in-de-melkweg>
- <https://exoplanets.nasa.gov>
- Fulton, B. J., Petigura, E. A., Howard, A. W., Isaacson, H., Marcy, G. W., Cargile, P. A., Hebb, L., Weiss, L. M., Johnson, J. A., Morton, T., Sinukoff, E., Crossfield, I. J. M., & Hirsch, L. A. (2017). The California-Kepler Survey. III. A gap in the radius distribution of small planets*. *The Astronomical Journal*, 154(3), 109.
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- Schmidt, G. R., Bonometti, J. A., & Morton, P. J. (2000). NUCLEAR PULSE PROPULSION - ORION: A 100-YEAR JOURNEY BEYOND. American Institute of Aeronautics and Astronautics, Inc., 2000-3865.