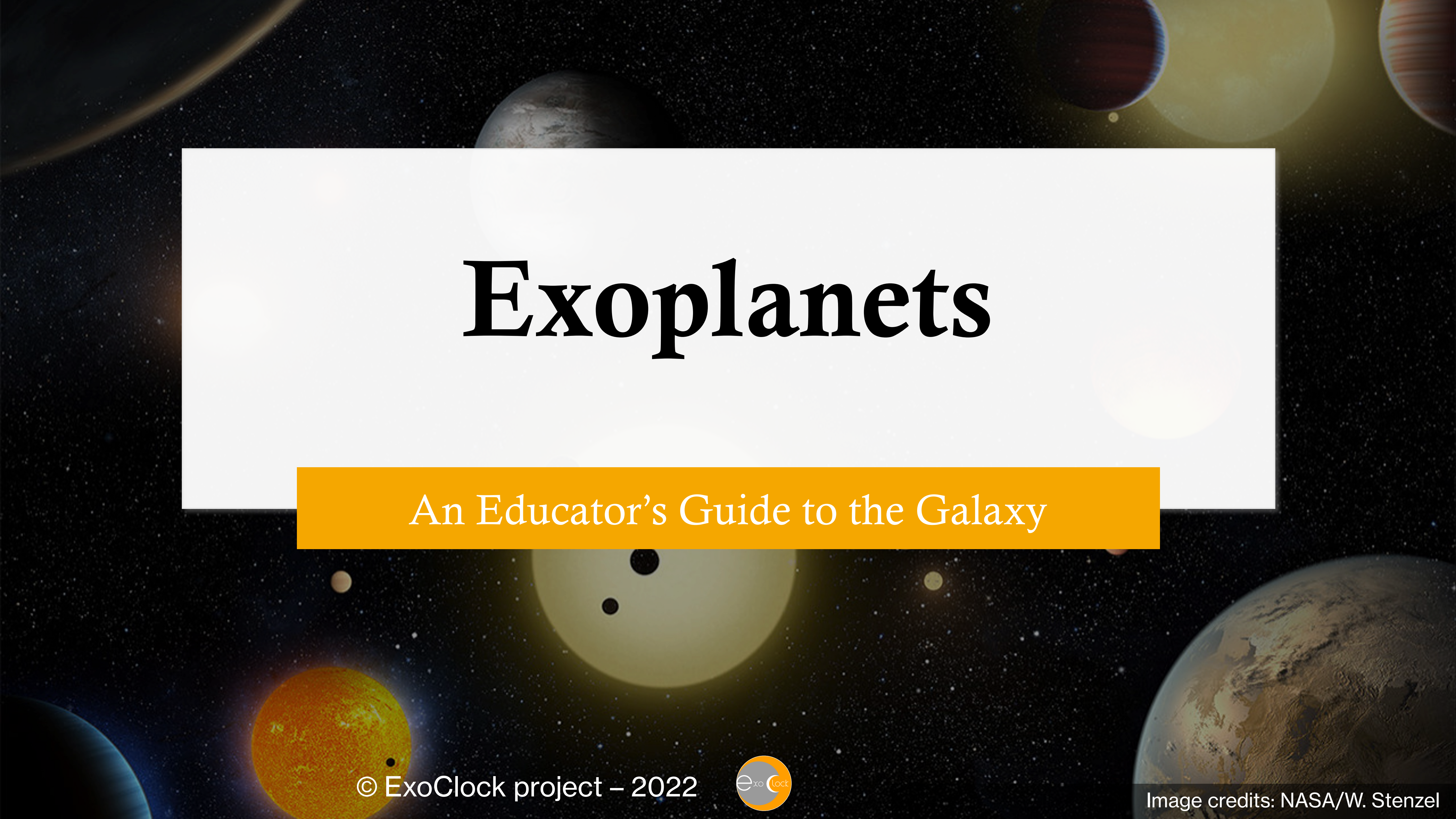


Exoplanets

An Educator's Guide to the Galaxy

Image credits: NASA/W. Stenzel

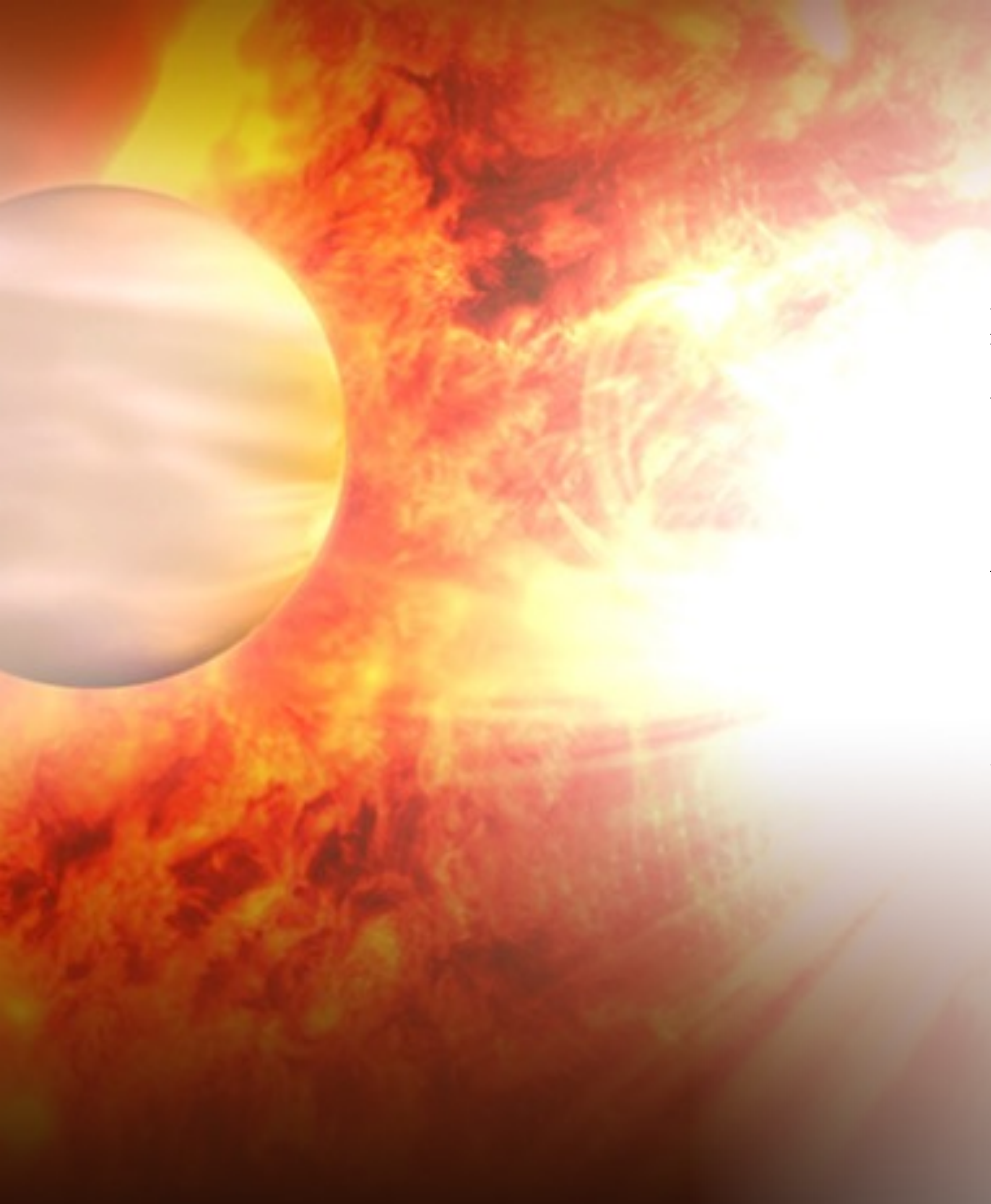
What are Exoplanets?

Our Solar System is made up of the Sun and the 8 major planets that orbit the Sun. There are also Dwarf Planets (such as Pluto and Makemake), comets, asteroids and moons.

Planets that orbit stars other than the Sun are called Exoplanets. Some exoplanets are similar to planets within our Solar System, such as the Earth or Jupiter, and others are wildly different and are made of exotic materials, such as diamond. Other planets have volatile atmospheres that cause the rain to be made of the gemstones, ruby and sapphire!

Why teach about Exoplanets?

The discovery of thousands of exoplanets (now over 5000 at the time of writing) has been termed "The Second Copernican Revolution". The field of exoplanet science is a rapidly changing and exciting field that is truly interdisciplinary. Exoplanets have atmospheres, compositions and orbital characteristics that are inspirational to Physics, Chemistry, Biology and Geology/Geography. Young peoples'(and older peoples'!) imaginations are captured by space and its exploration. The launch of NASA's JWST and the upcoming ESA Ariel mission will investigate the nature of the planets in our Galaxy and put our own Earth in context.
https://www.nasa.gov/audience/forstudents/k-4/dictionary/Solar_System.html



The Discovery of Exoplanets

1992 – Aleksander Wolszczan and Dale Frail discover two rocky planets orbiting a pulsar, PSR B1 257+12 in the constellation Virgo. These planets would not be able to support organic life as we know it as the pulsar emits too much radiation for life to be sustained on these irradiated worlds.

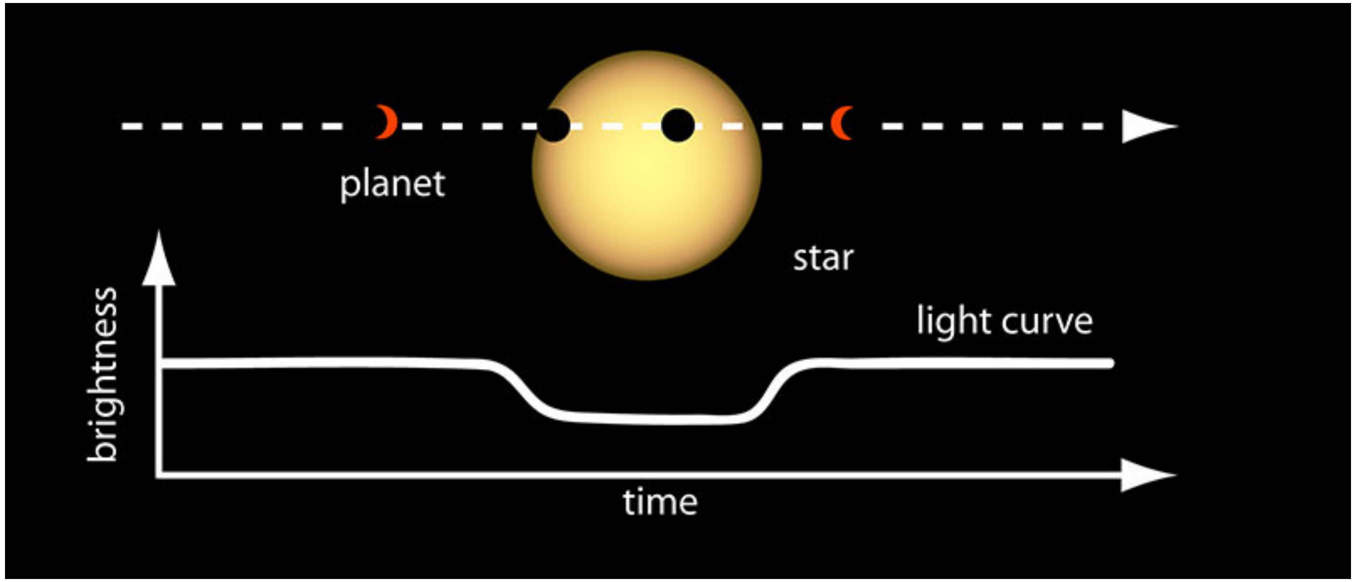
1994 – Didier Queloz and Michael Mayor (awarded the Physics Nobel prize in 2019) discover the first planet orbiting a Sun – like star, 50 light years away in the constellation Pegasus, named 51 Pegasi b. The planet is a gas planet like Jupiter, but half the size of Jupiter. It orbits its parent star every 4 days and has a surface temperature of 1000 degrees Celsius!

https://exoplanets.nasa.gov/resources/289/infographic-profile-of-planet-51-pegasi-b/

https://exoplanets.nasa.gov/alien-worlds/historic-timeline/#first-exoplanet-found-around-a-main-sequence-star

How are Exoplanets Discovered?

There are five methods for discovering exoplanets (transit, radial velocity, direct imaging, gravitational microlensing and astrometry.) The two main methods (that have discovered the most planets) are Transit and Radial Velocity. Radial velocity is the detection of the movement of a star (through spectroscopy) by the gravitational effects of the planet(s) orbiting the star.
The transit method is the measurement of the dimming of the star's light as a planet passes in front of the star.



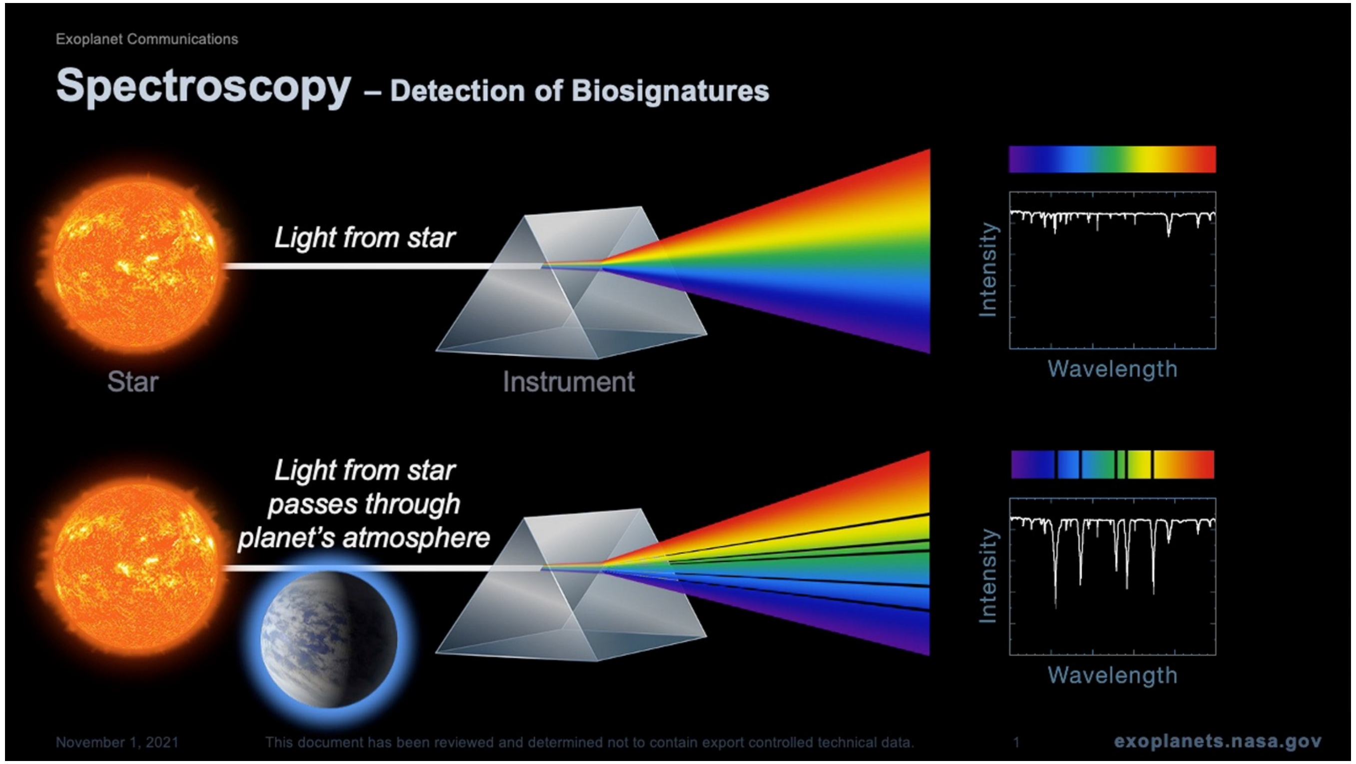
When a planet passes in front of its star, it blocks some of the light emitted by the star. This is detectable by telescopes. The larger the planet, the more light the planet blocks and the more significant the dip. Larger planets are easier to detect than smaller ones.

https://exoplanets.nasa.gov/faq/31/whats-a-transit/#:~:text=Most%20known%20exoplanets%20have%20been,between%20us%20and%20the%20Sun.

What are Exoplanet Atmospheres made from?

When light passes through a gas, some of the wavelengths of light are absorbed. When this light is passed through a spectrometer (which contains a prism to split the light) dark lines, called absorption lines are seen on the spectrum. The pattern of the dark lines depends on the elements that that gas is made from.
We can study the gases in the atmosphere of exoplanets by analysing the star's light passing through the atmosphere of the planet.
The absorption lines are like a "bar code" and tell us that the atmosphere may contain oxygen, carbon dioxide, methane and other gases.

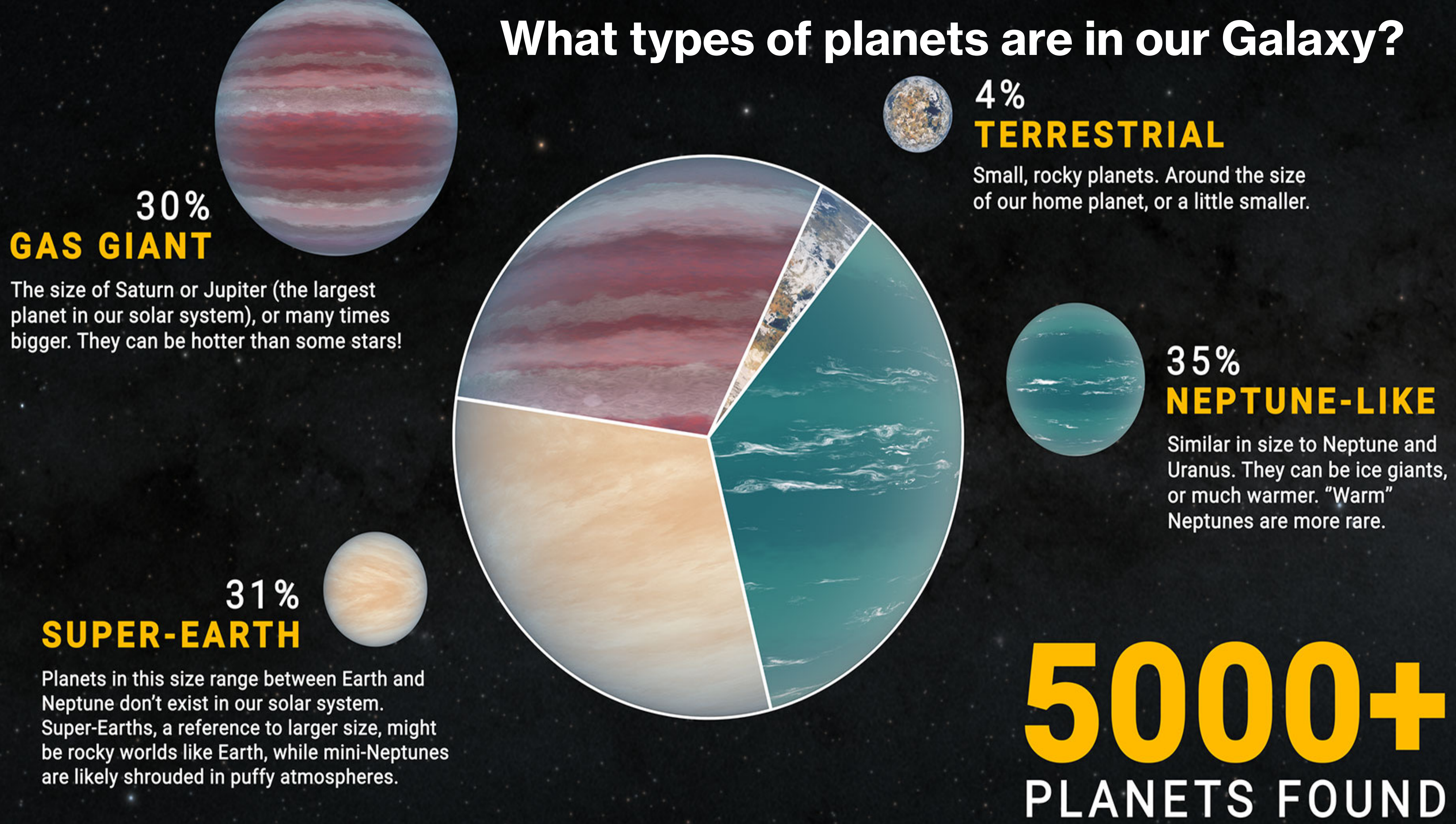
https://exoplanets.nasa.gov/resources/2312/spectroscopy-detection-of-biosignatures/



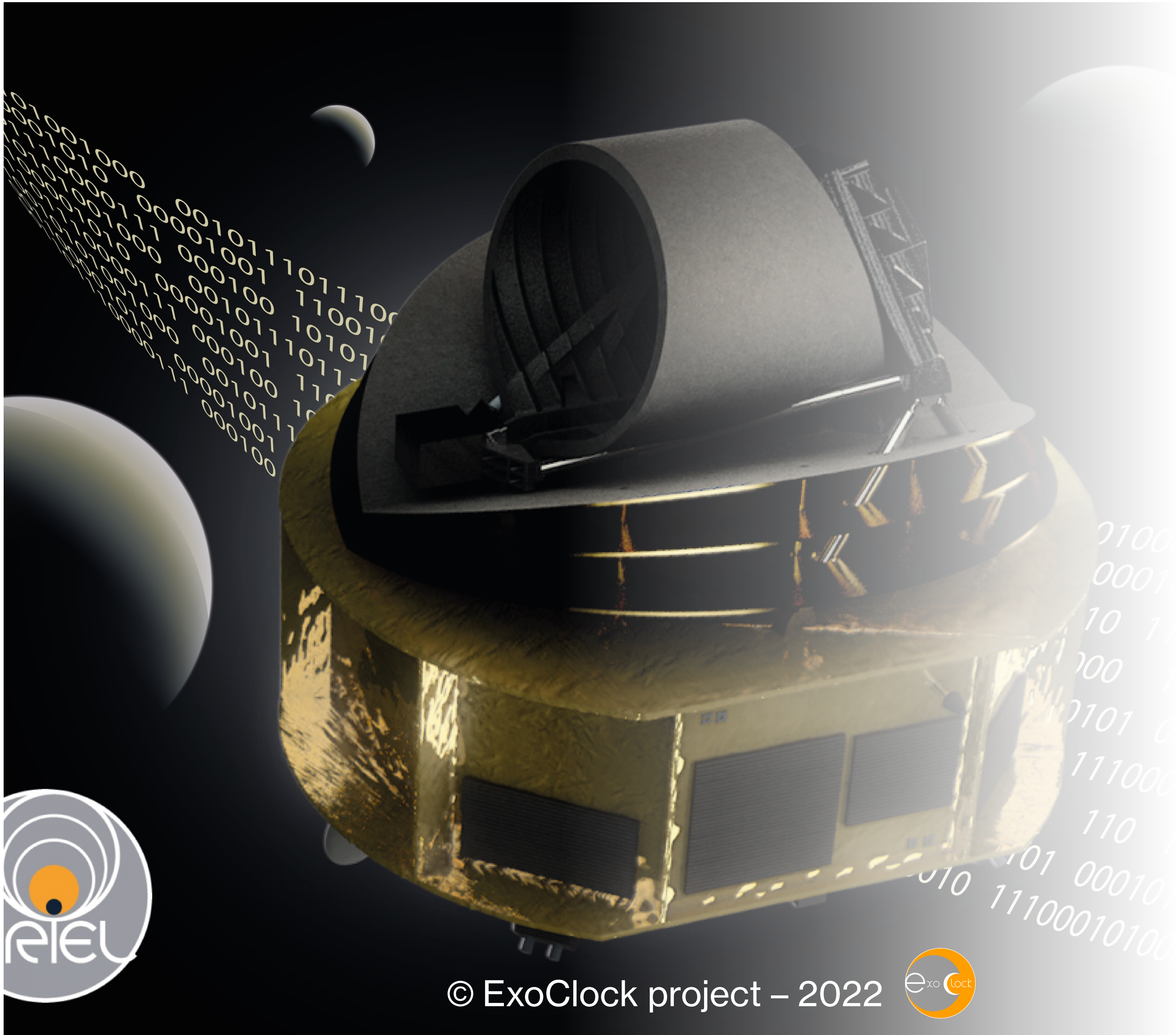
A Gas Giant or a Rocky Planet?

If the exoplanet is very hot, some of the surface may evaporate and become part of the atmosphere, so the solid part of the planet (or at least the part at the surface) can be deduced by spectroscopy. For other planets, the density of the planet can be inferred from radius and mass measurements to distinguish a rocky planet from a gas giant.

What types of planets are in our Galaxy?



https://exoplanets.nasa.gov/resources/2318/5000-exoplanets-infographic/



The Ariel Mission

The European Space Agency Mission, Ariel (Atmospheric Remote – sensing Exoplanet Large Survey) will launch in 2029 with the aim of conducting a survey of approximately 1000 exoplanet atmospheres. This will provide the first large scale exoplanet atmosphere catalogue of its kind, enabling new and exciting scientific discoveries. The mission will investigate a wide variety of planets, including Earth like "temperate terrestrials" to superhot Jovian giants. The list of planetary and stellar targets for the mission has been rising steadily over the last few years. Citizen scientists will have the opportunity to contribute to the Ariel mission through the ExoClock mission

(see next slide for the ExoClock mission)

https://sci.esa.int/web/ariel/-/ariel-definition-study-report-red-book

https://arxiv.org/abs/2205.05073

https://arielmission.space/

How can I be involved? The ExoClock Mission

Currently the number of exoplanets is rapidly growing, with over 4000 planets discovered. This number is expected to grow even more in the future with dedicated missions that are expected to find additional planets.

While discovering new exoplanets is still important, we have now entered a new era, where the better characterisation of these planets and their host stars is of extreme importance. A technique that is being used to probe the atmosphere of an exoplanet is transit spectroscopy. During a transit, the stellar and the planetary discs overlap, and while a part of the stellar light is blocked by the core of the planet, another, smaller, part is filtered through its atmosphere. Future space observatories will observe known exoplanets to obtain their spectra and characterise their chemical consistency.

For this technique to be as efficient as possible and to organise large-scale surveys we need to have a good knowledge of the orbital parameters of the planets observed, especially of the expected transit time.

This is where small and medium-scale telescopes and the public can contribute significantly and make a difference.

Head over now to the websites below for more information on how to be involved in this exciting endeavour!

https://www.exoclock.space/project

https://www.exoworldsspies.com/en/science

References

NASA

https://exoplanets.nasa.gov/resources/289/infographic-profile-of-planet-51-pegasi-b/
https://exoplanets.nasa.gov/alien-worlds/historic-timeline/#first-exoplanet-found-around-a-main-sequence-star
https://exoplanets.nasa.gov/faq/31/whats-a-transit/#:~:text=Most%20known%20exoplanets%20have%20been,between%20us%20and%20the%20Sun.
https://exoplanets.nasa.gov/resources/2312/spectroscopy-detection-of-biosignatures/

Ariel and ExoClock

https://sci.esa.int/web/ariel/-/ariel-definition-study-report-red-book

https://arxiv.org/abs/2205.05073

https://arielmission.space/

https://www.exoclock.space/project

https://www.exoworldsspies.com/en/science