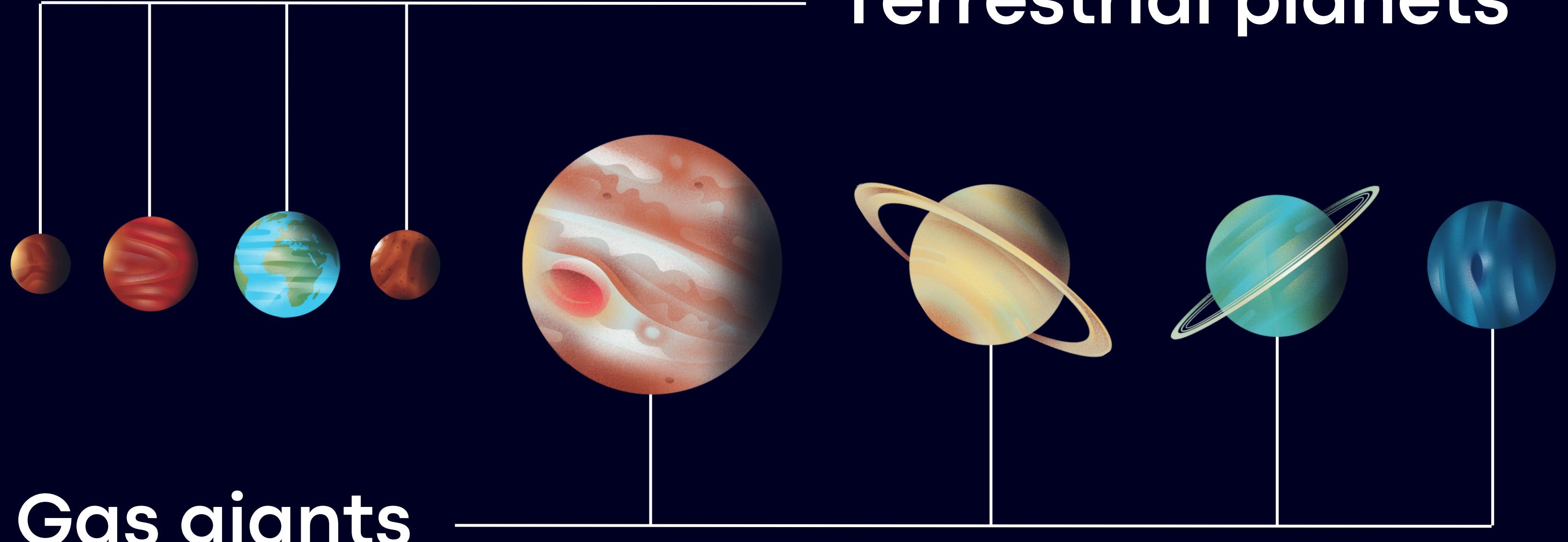


THE PLANETS BEYOND OUR SOLAR SYSTEM

Bibiana Prinoth

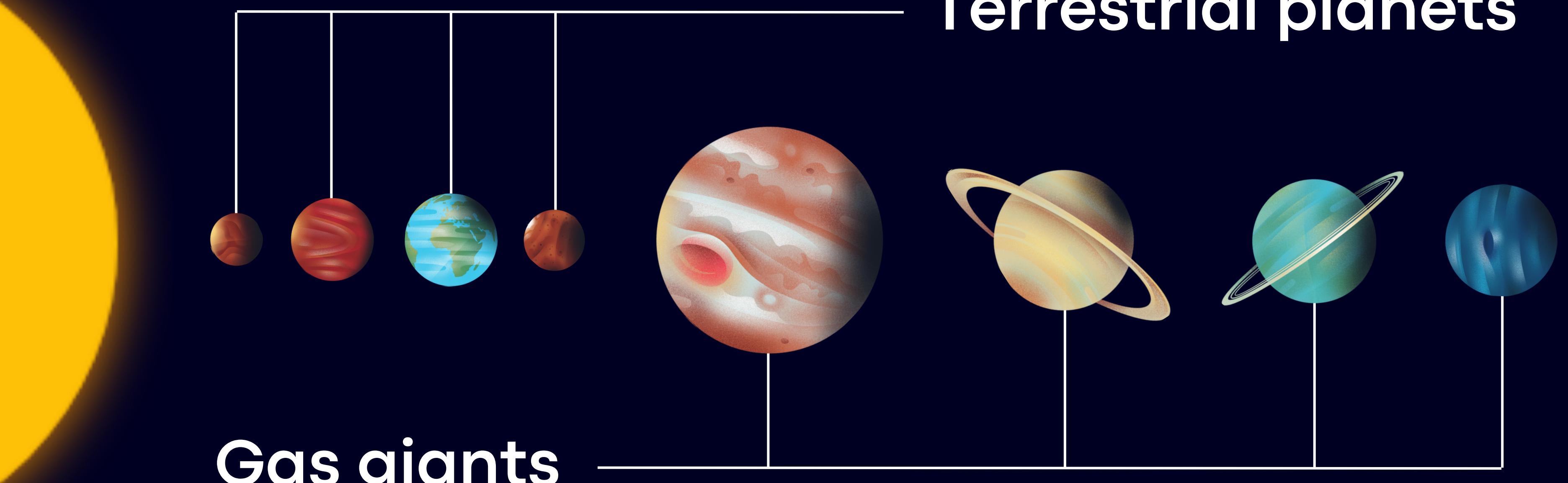


Credit: NASA/JPL-Caltech/Lizabeth B. De La Torre



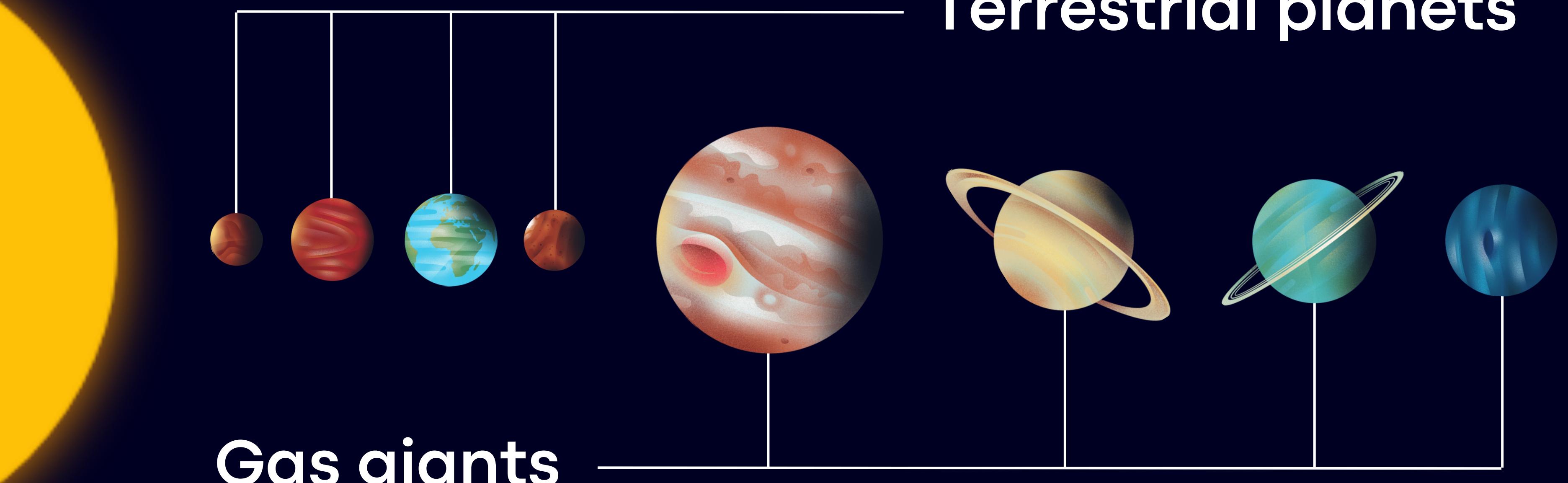
"My Very Educated Mother Just Served Us Nachos".

Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune



"Mamma Vattnar Jorden Medan Jag Sätter Ut Nya (Plantor)."

Mercury Venus Earth Mars Jupiter Saturn Uranus Neptune





I might have been habitable in the past? I don't remember...

I have a weird rotation period.

My atmosphere is super thin, I must have lost it. It is mostly made of CO₂.

Well, I am your favourite, aren't I?

My atmosphere is dominated by hydrogen.

Please put me in water, I float. I promise!

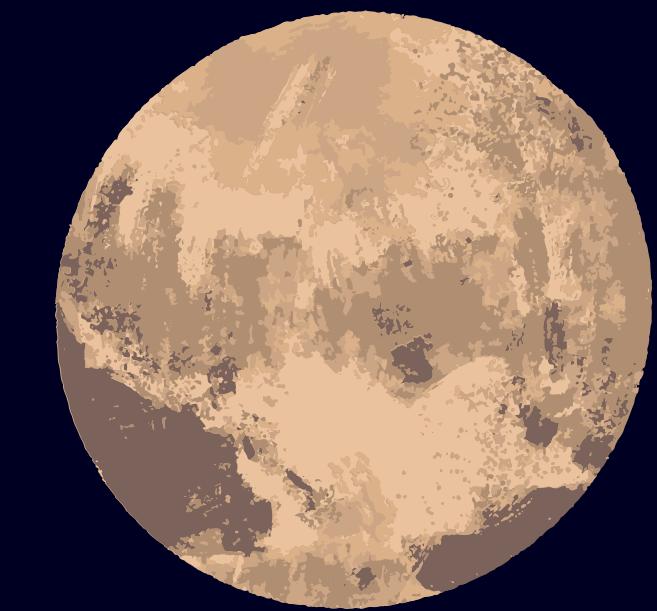
I also have rings! Did you know?

I am the cool kid in the family. I am the coldest.



I wonder if
anyone in this
room actually
remembers me...

What is actually a planet?



INTERNATIONAL ASTRONOMICAL UNION
UNION ASTRONOMIQUE INTERNATIONALE



***** IAU0603:

FOR IMMEDIATE RELEASE *****

<http://www.iau2006.org/mirror/www.iau.org/iau0603/index.html>

IAU 2006 General Assembly: Result of the IAU Resolution votes

24-August-2006, Prague: The first half of the Closing Ceremony of the 2006 International Astronomical Union (IAU) General Assembly has just concluded. The results of the Resolution votes are outlined here.

It is official: The 26th General Assembly for the International Astronomical Union was an astounding success! More than 2500 astronomers participated in six Symposia, 17 Joint Discussions, seven Special Sessions and four Special Sessions. New science results were vigorously discussed, new international collaborations were initiated, plans for future facilities put forward and much more.

In addition to all the exciting astronomy discussed at the General Assembly, six IAU Resolutions were also passed at the Closing Ceremony of the General Assembly:

1. Resolution 1 for GA-XXVI : "Precession Theory and Definition of the Ecliptic"
2. Resolution 2 for GA-XXVI: "Supplement to the IAU 2000 Resolutions on reference systems"
3. Resolution 3 for GA-XXVI: "Re-definition of Barycentric Dynamical Time, TDB"
4. Resolution 4 for GA-XXVI: "Endorsement of the Washington Charter for Communicating Astronomy with the Public"
5. Resolution 5A: "Definition of 'planet'"
6. Resolution 6A: "Definition of Pluto-class objects"

The IAU members gathered at the 2006 General Assembly agreed that a "planet" is defined as a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round shape), and (c) has cleared the neighbourhood around its orbit.

This means that the Solar System consists of eight "planets" Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. A new distinct class of objects called "dwarf planets" was also decided. It was agreed that "planets" and "dwarf planets" are two distinct classes of objects. The first members of the "dwarf planet" category are Ceres, Pluto and 2003 UB₃₁₃ (temporary name). More "dwarf planets" are expected to be announced by the IAU in the coming months and years. Currently a dozen candidate "dwarf planets" are listed on IAU's "dwarf planet" watchlist, which keeps changing as new objects are found and the physics of the existing candidates becomes better known.

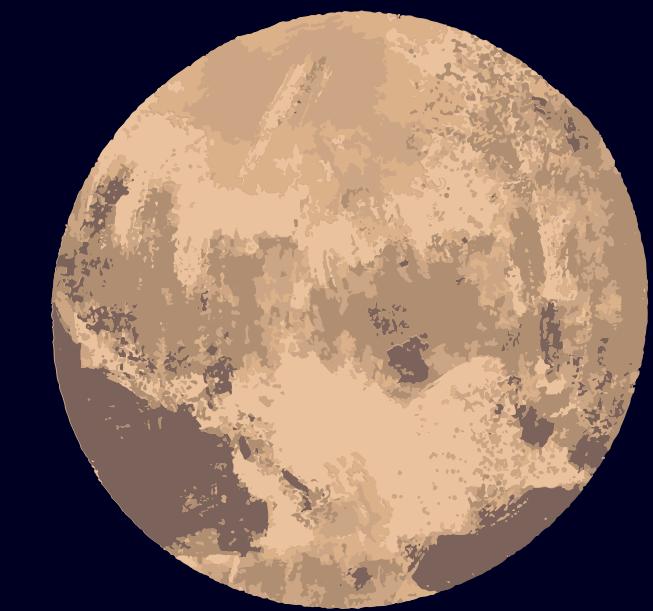
The "dwarf planet" Pluto is recognised as an important proto-type of a new class of trans-Neptunian objects. The IAU will set up a process to name these objects.

Below are the planet definition Resolutions that were passed.

A "planet" is a celestial body that:

- (a) is in orbit around the Sun,
- (b) has sufficient mass so that it assumes hydrostatic equilibrium (nearly round shape), and
- (c) has "cleared the neighbourhood" around its orbit.

What is actually a planet?



Since 2006, Pluto is not a planet anymore.

INTERNATIONAL ASTRONOMICAL UNION
UNION ASTRONOMIQUE INTERNATIONALE



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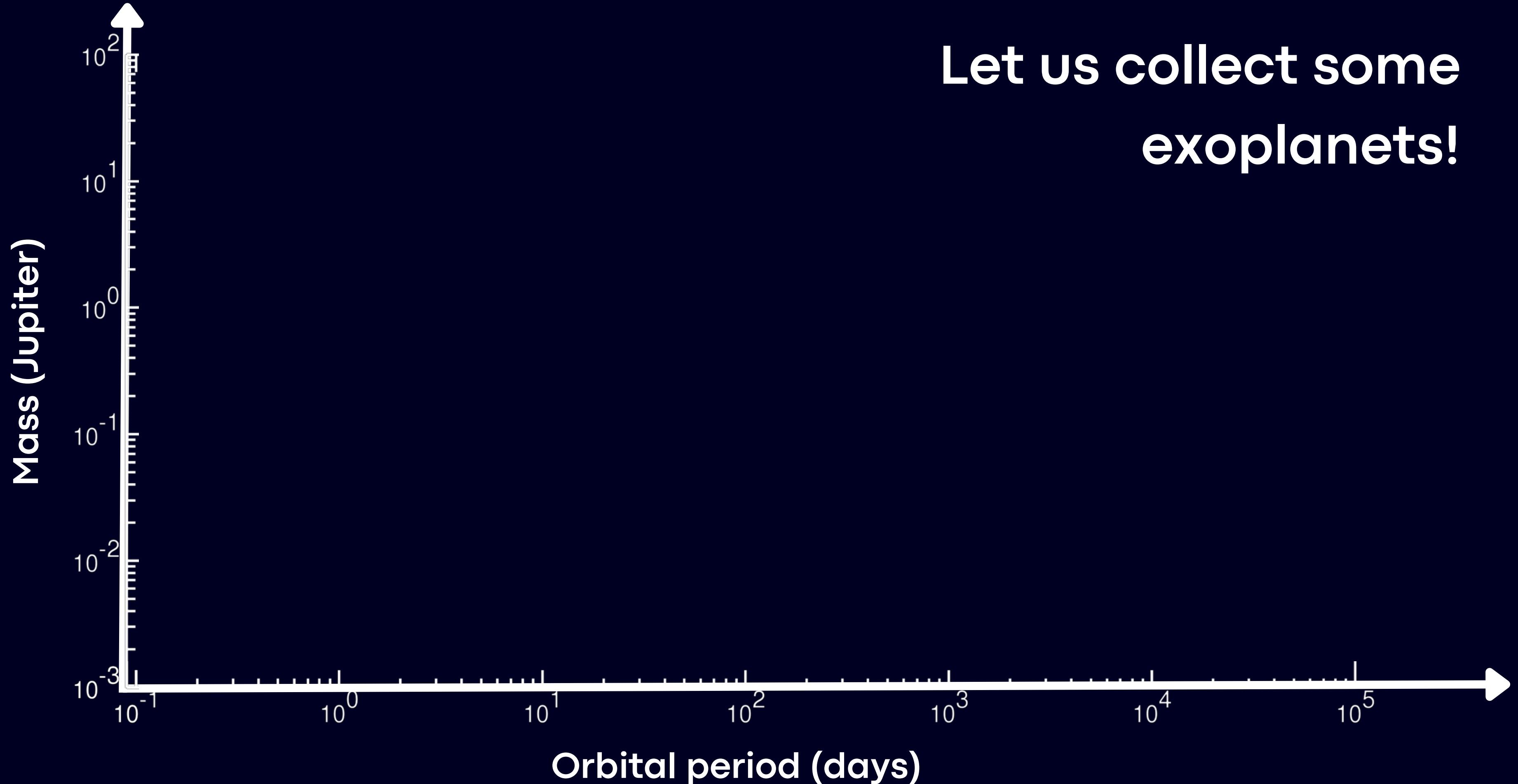
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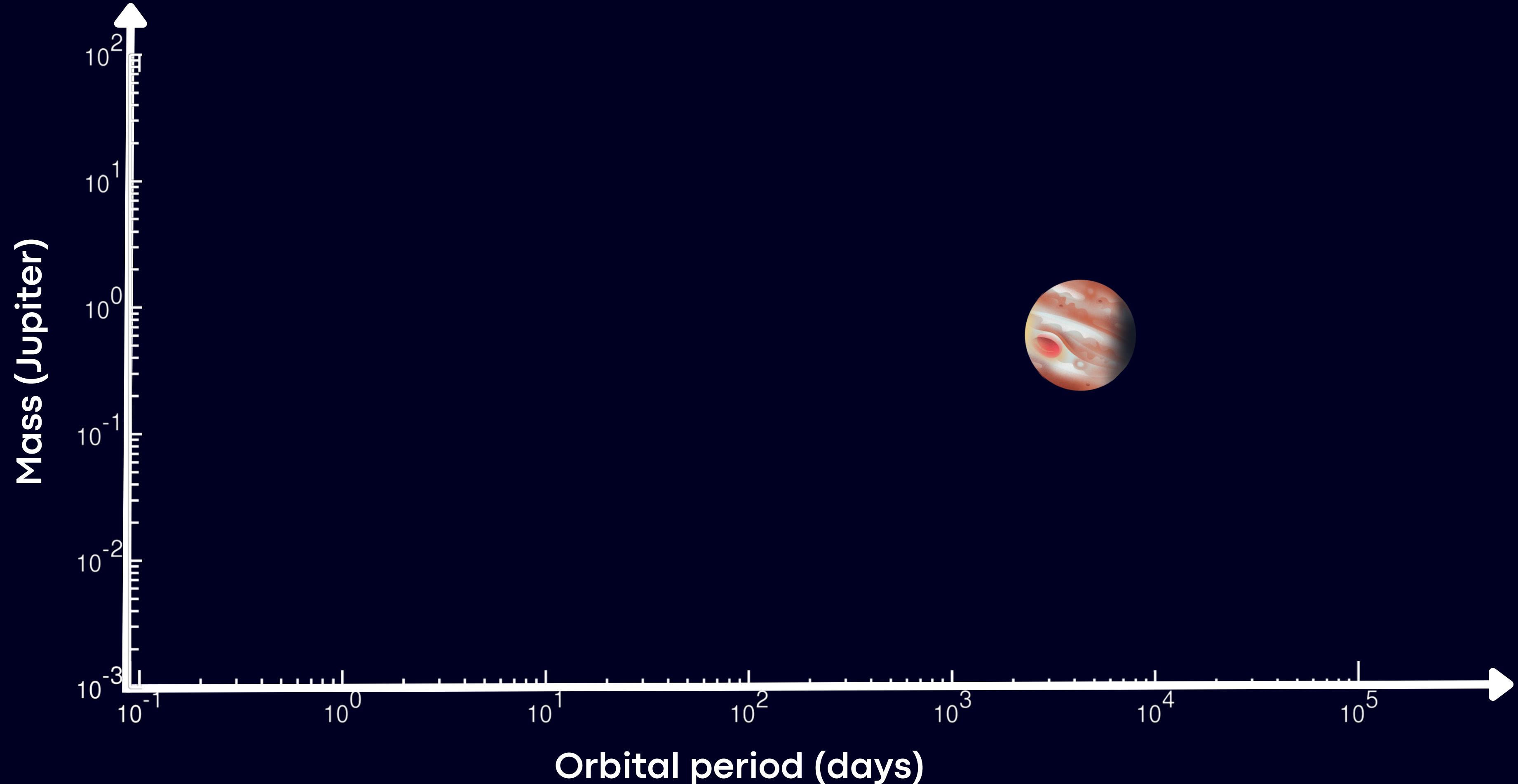
And what about planets around other stars?

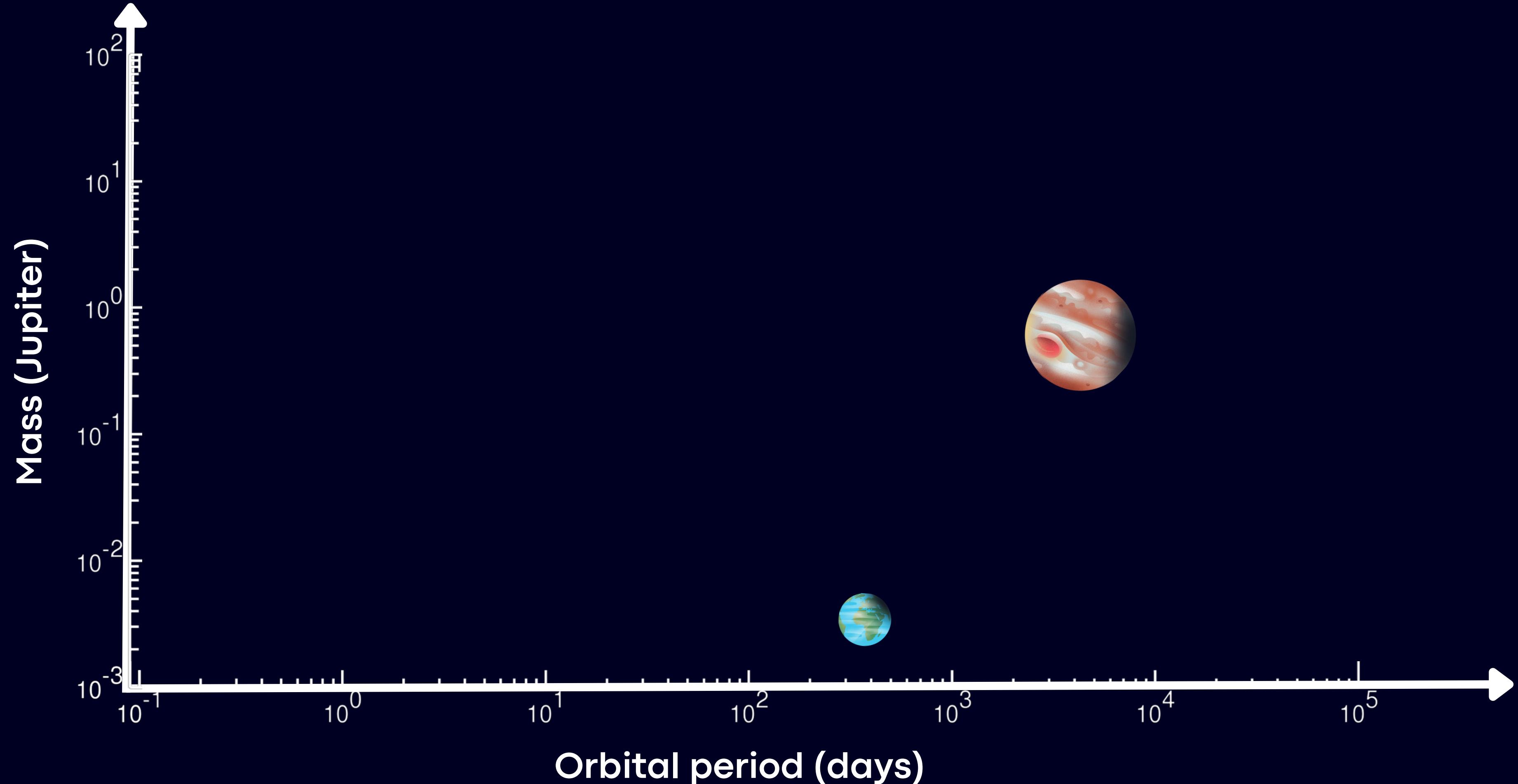
Planets that orbit other stars than the Sun are called **exoplanets**.

While Pluto is still sad about being downgraded to the class of dwarf planets, we'll be taking a tour outside our solar system!

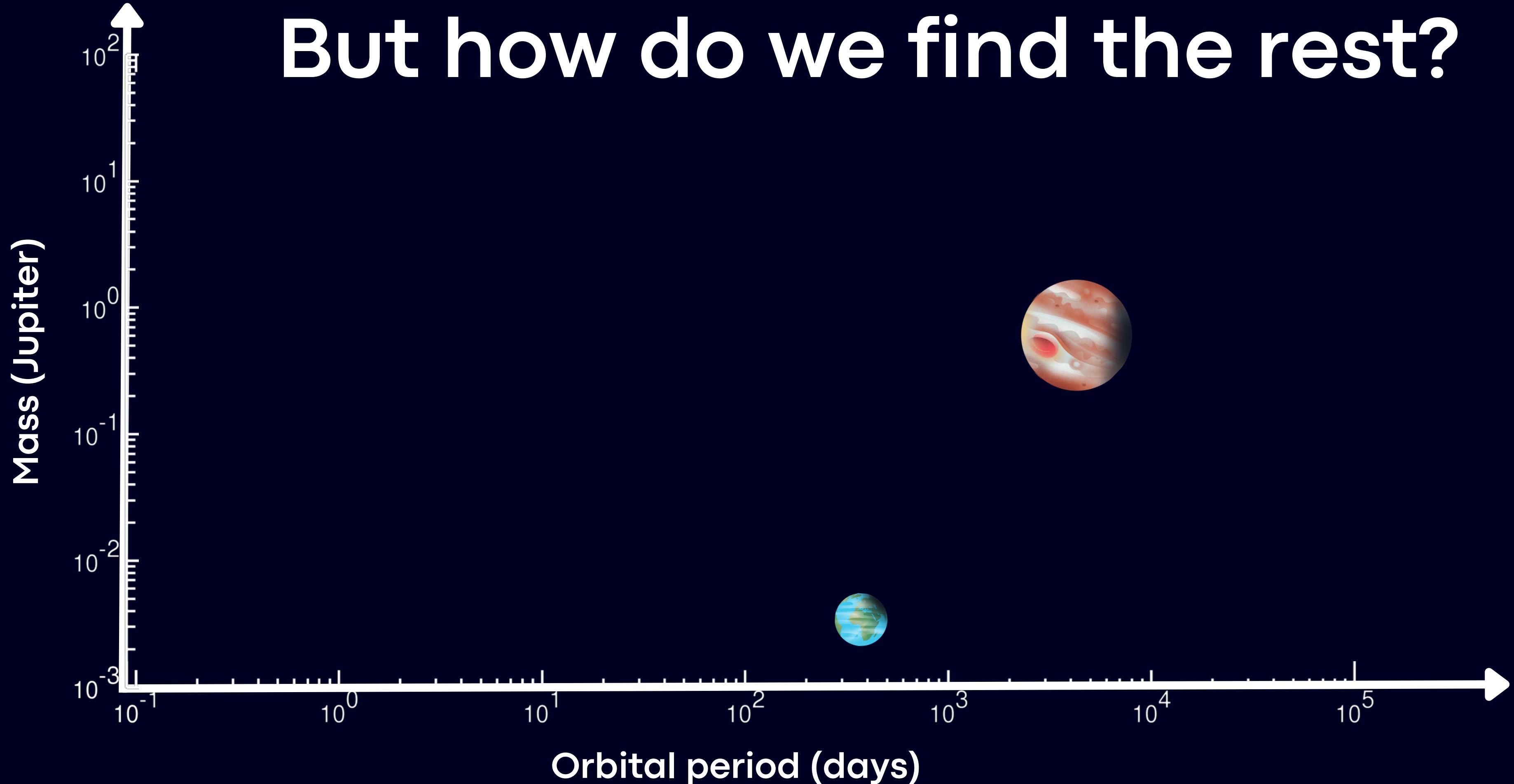
Let us collect some
exoplanets!





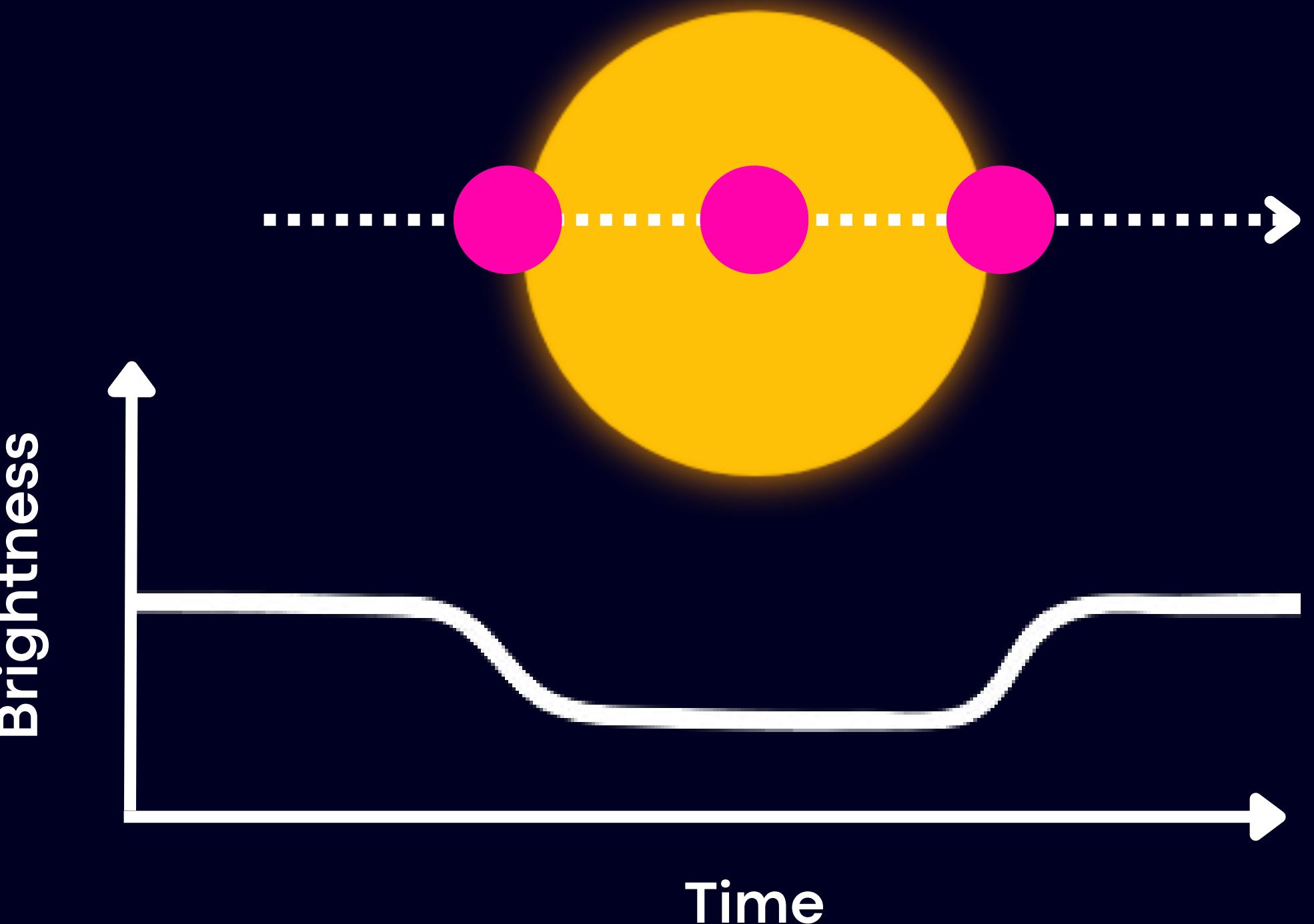


But how do we find the rest?



Transit method

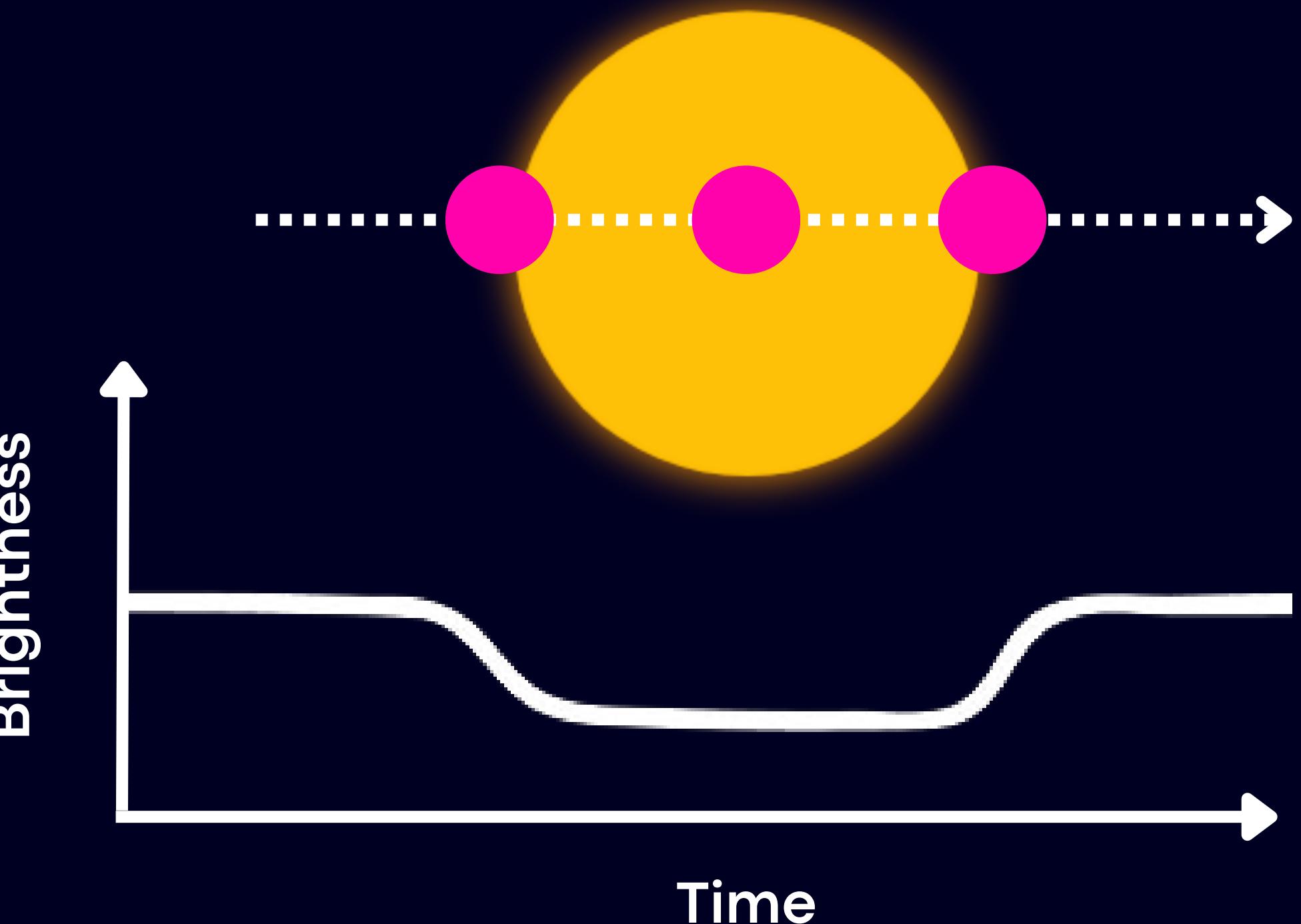
- Indirect method to detect exoplanets.
- The decrease in brightness of the host star is being observed.
- Multiple transits are necessary to confirm the planet.
- The first detection of a transiting planet was in 1999.



Transit method

What do we get to know about the planet?

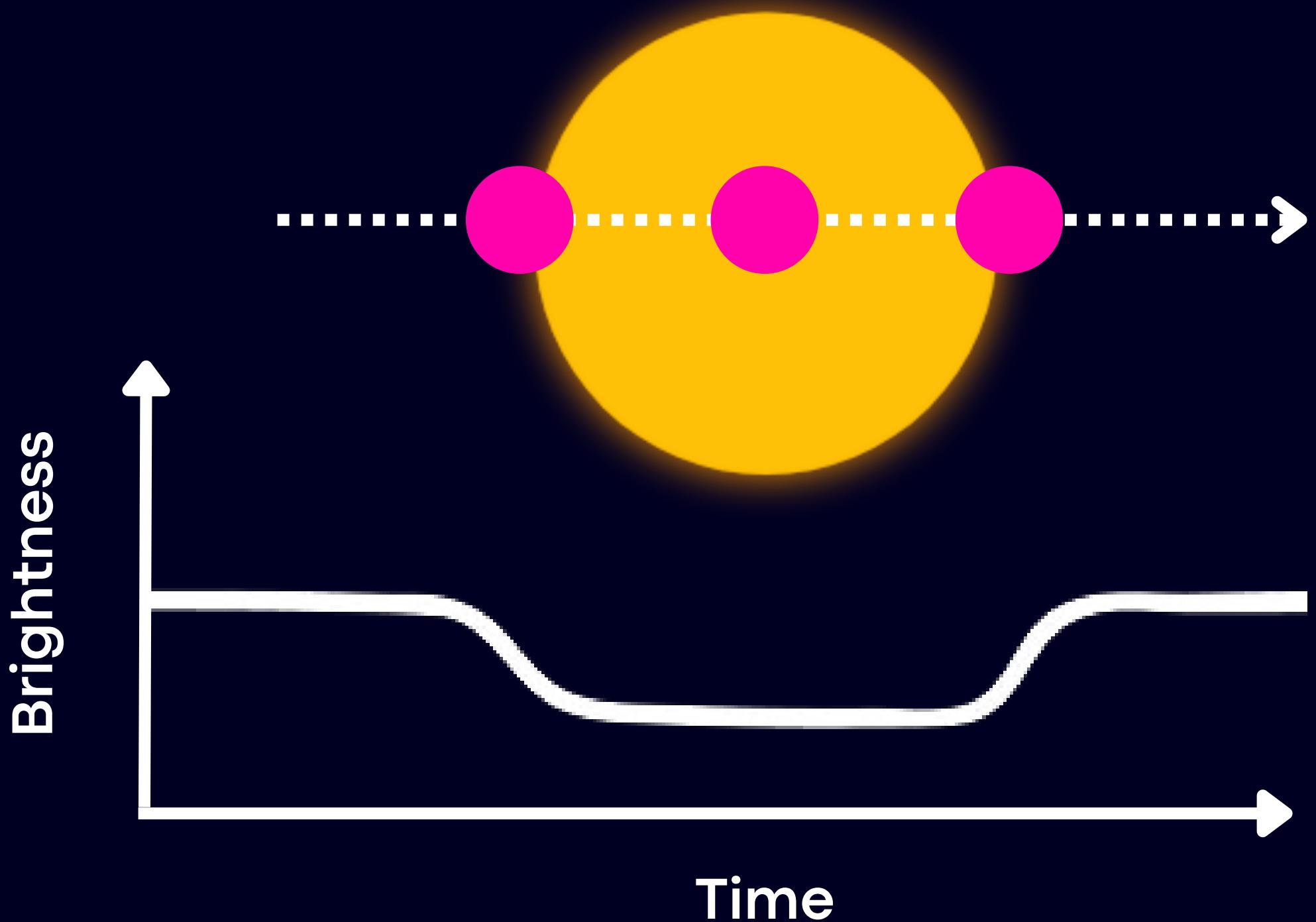
- Its radius, if we know the star's radius
- How long it takes to go around its star (orbital period)
- Distance to the host



Transit method

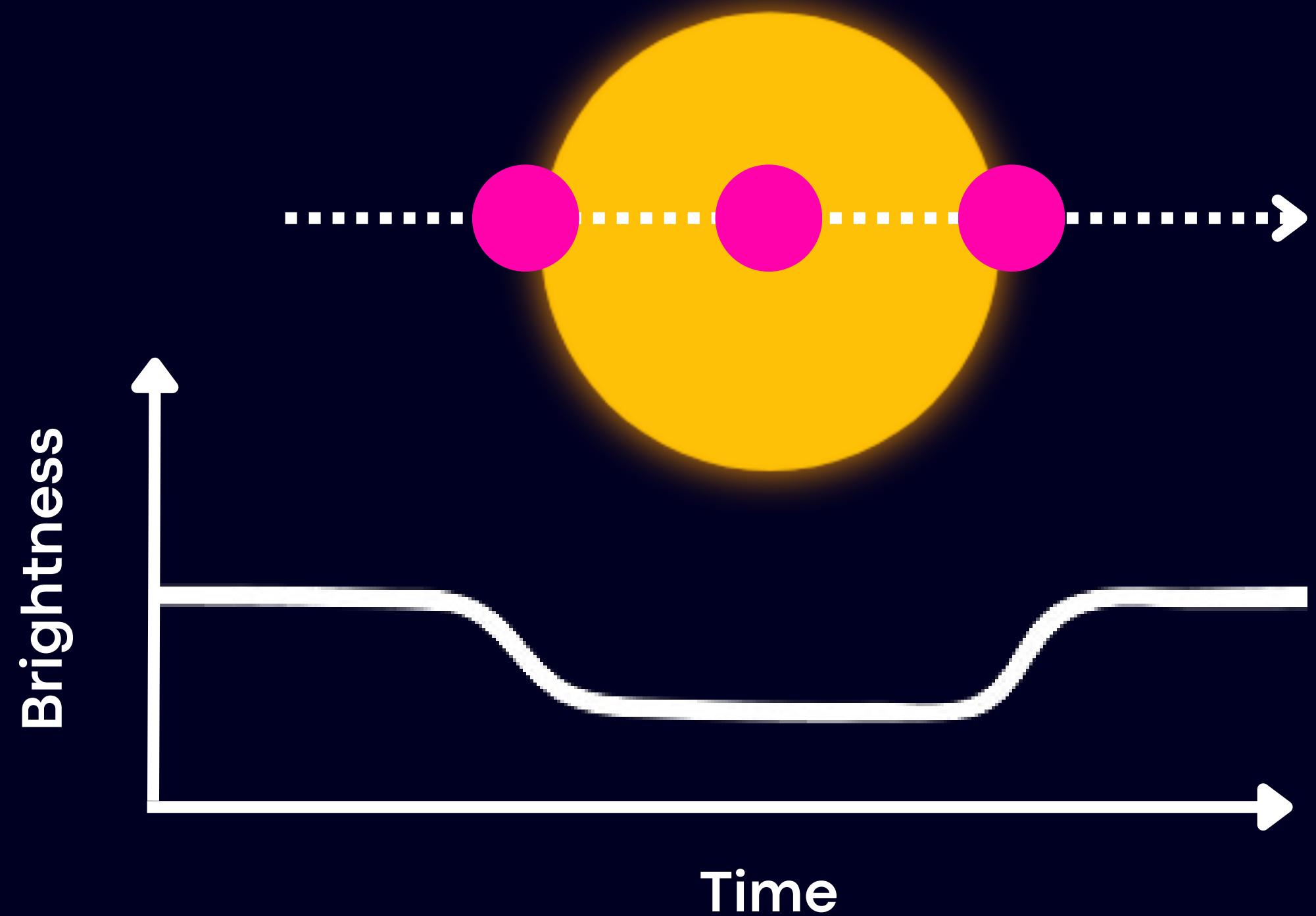


And how is this useful now to fill our plot? We don't know the mass, right?



Transit method

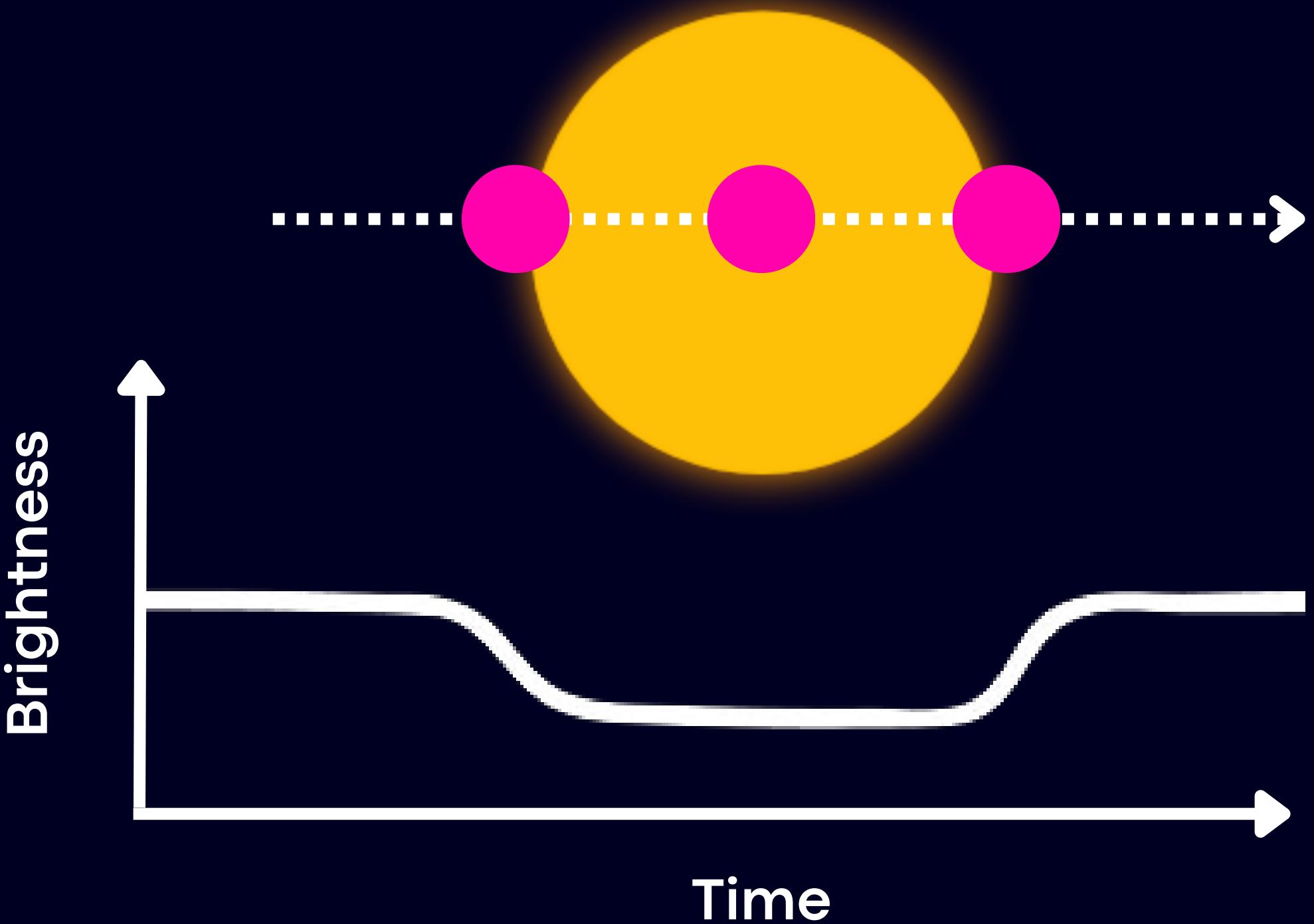
Luckily, we can use other methods to determine the mass. Or even calculate it!



Transit method

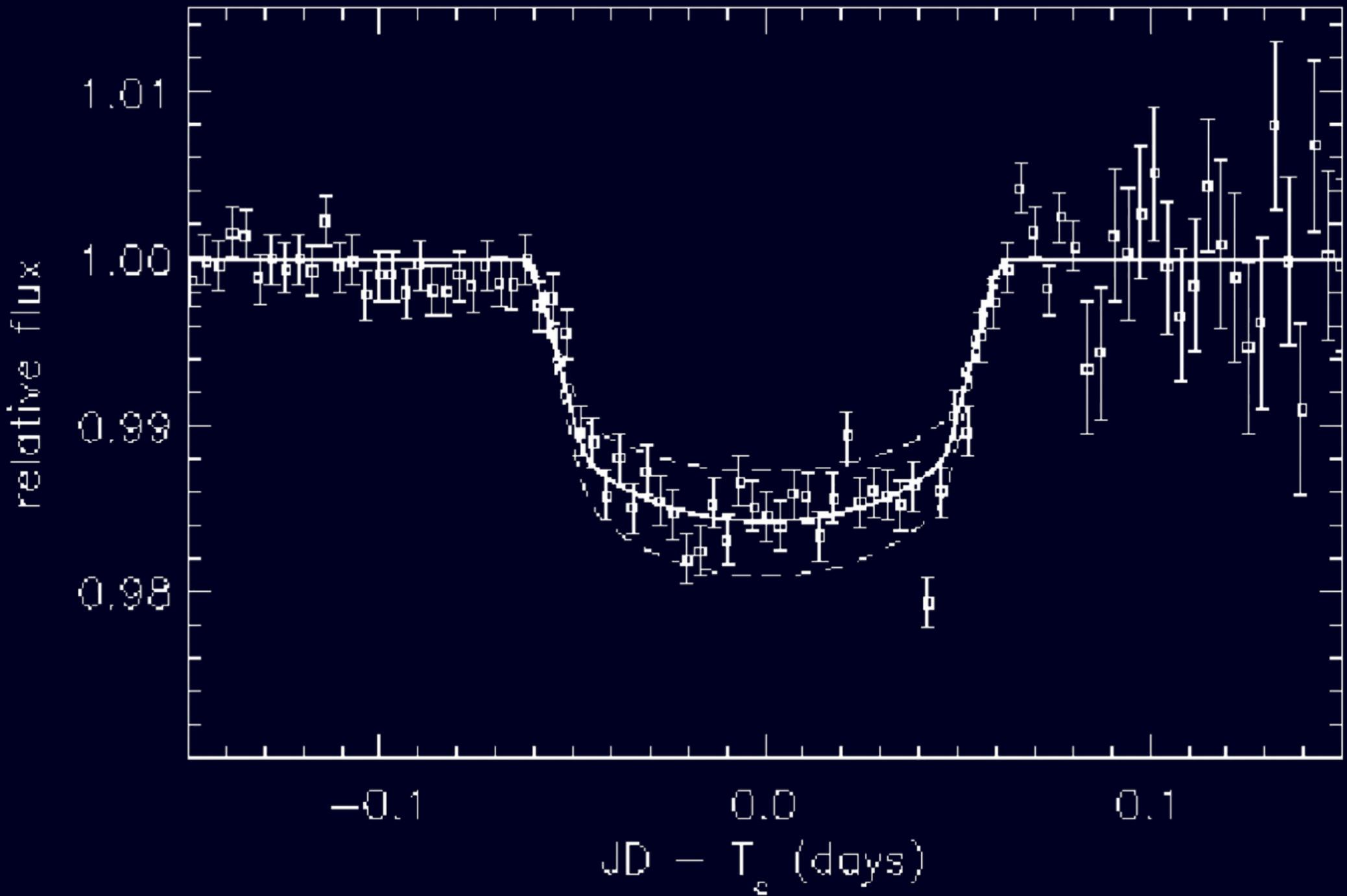
Comparison to the Solar System

How long do we need to observe - at least - to detect Jupiter around the Sun?



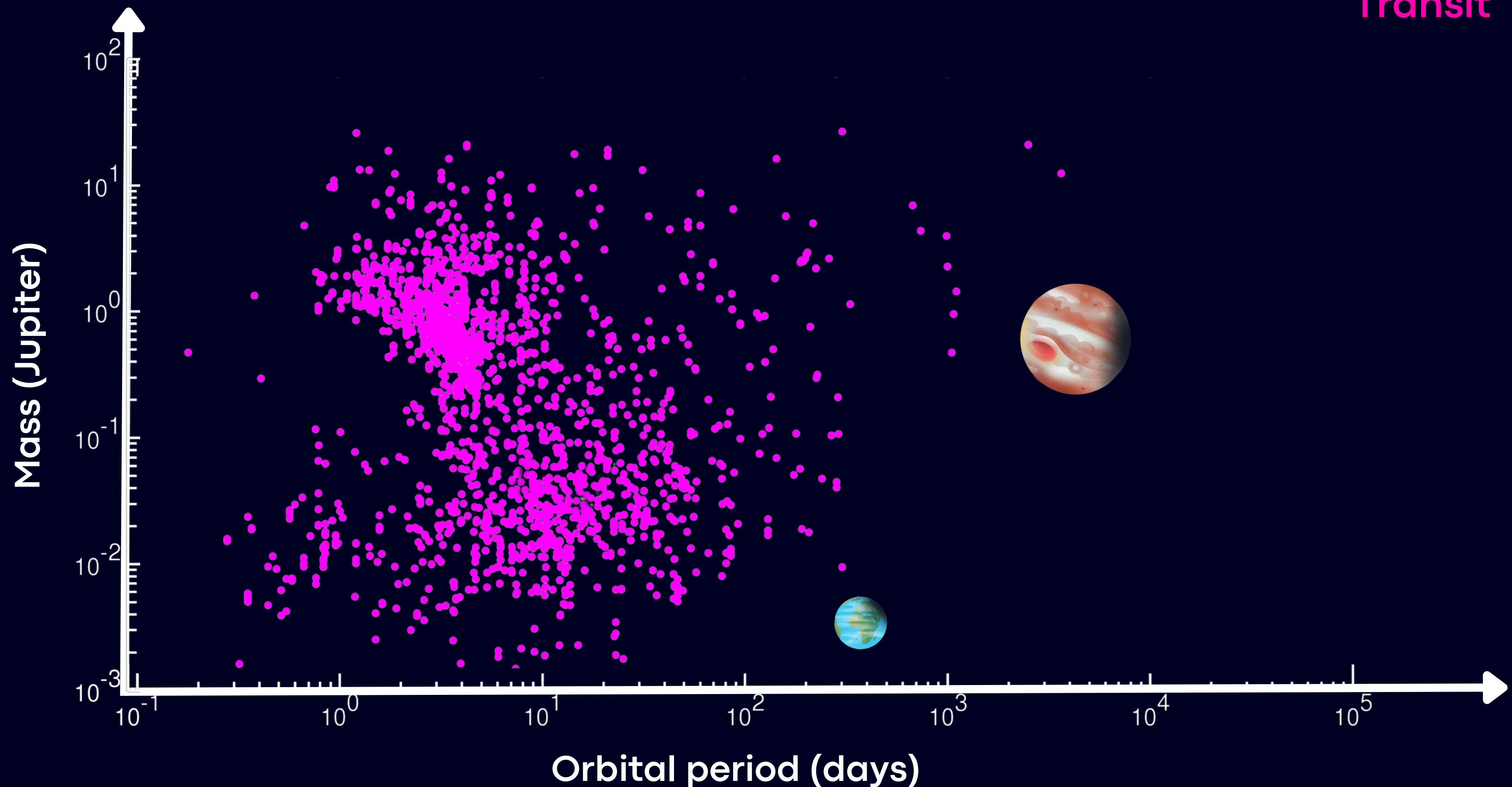
Transit method

	P (d)	Depth (%)
Mercury	88	0.001
Venus	225	0.008
Earth	365	0.008
Mars	687	0.002
Jupiter	4332	1.06
Saturn	10759	0.75
Uranus	30685	0.14
Neptune	60182	0.13
HD 209458b	3.52	1.6



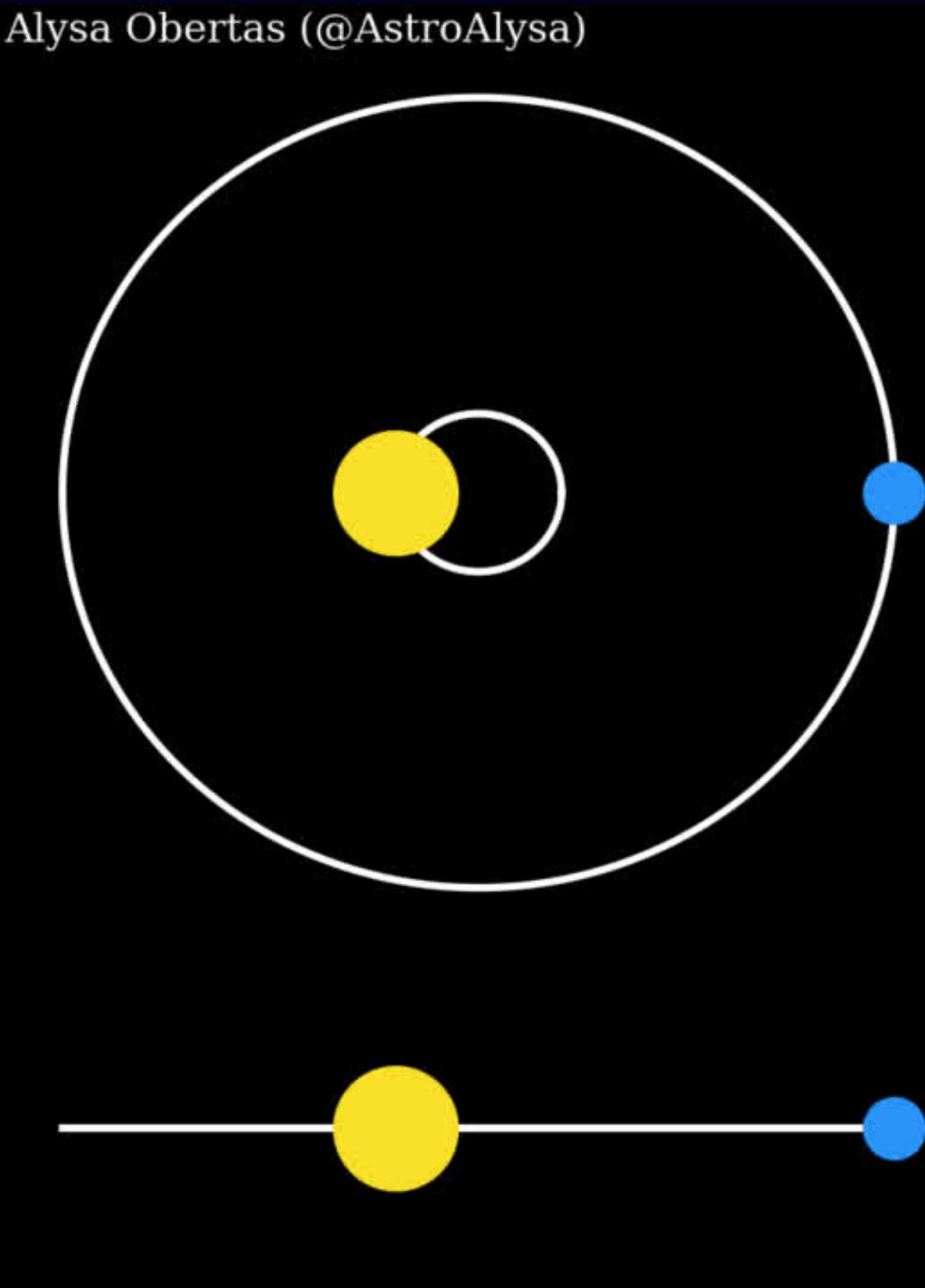
Charbonneau et al., (2000)

Transit



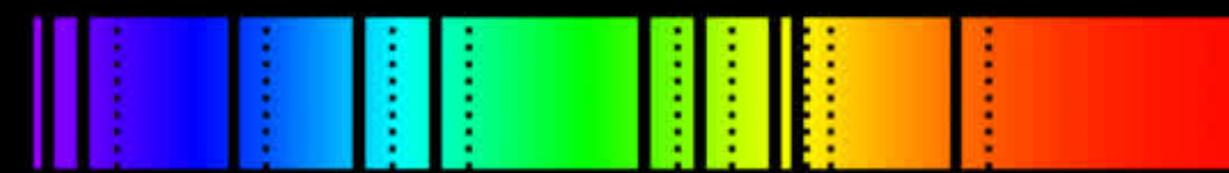
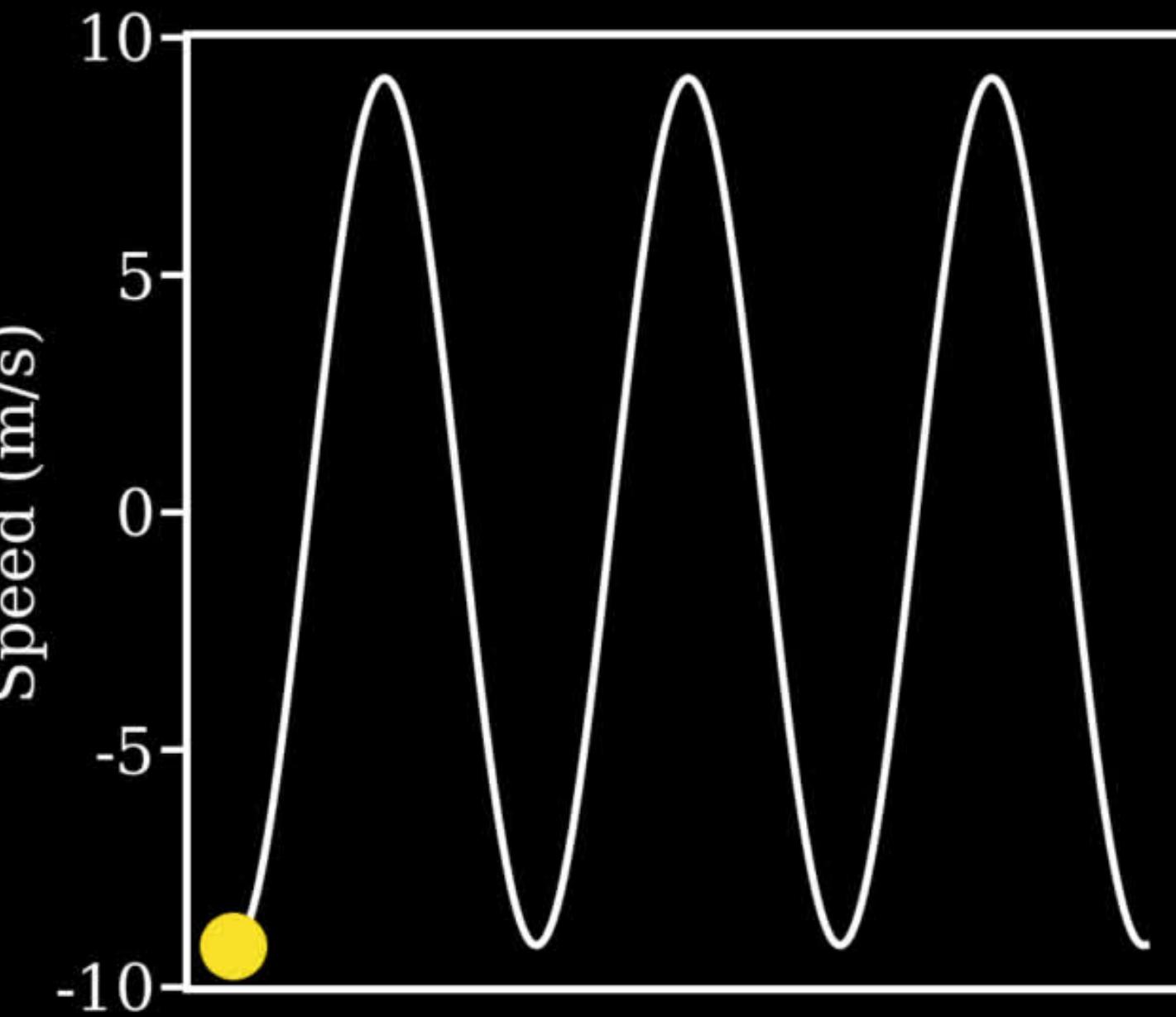
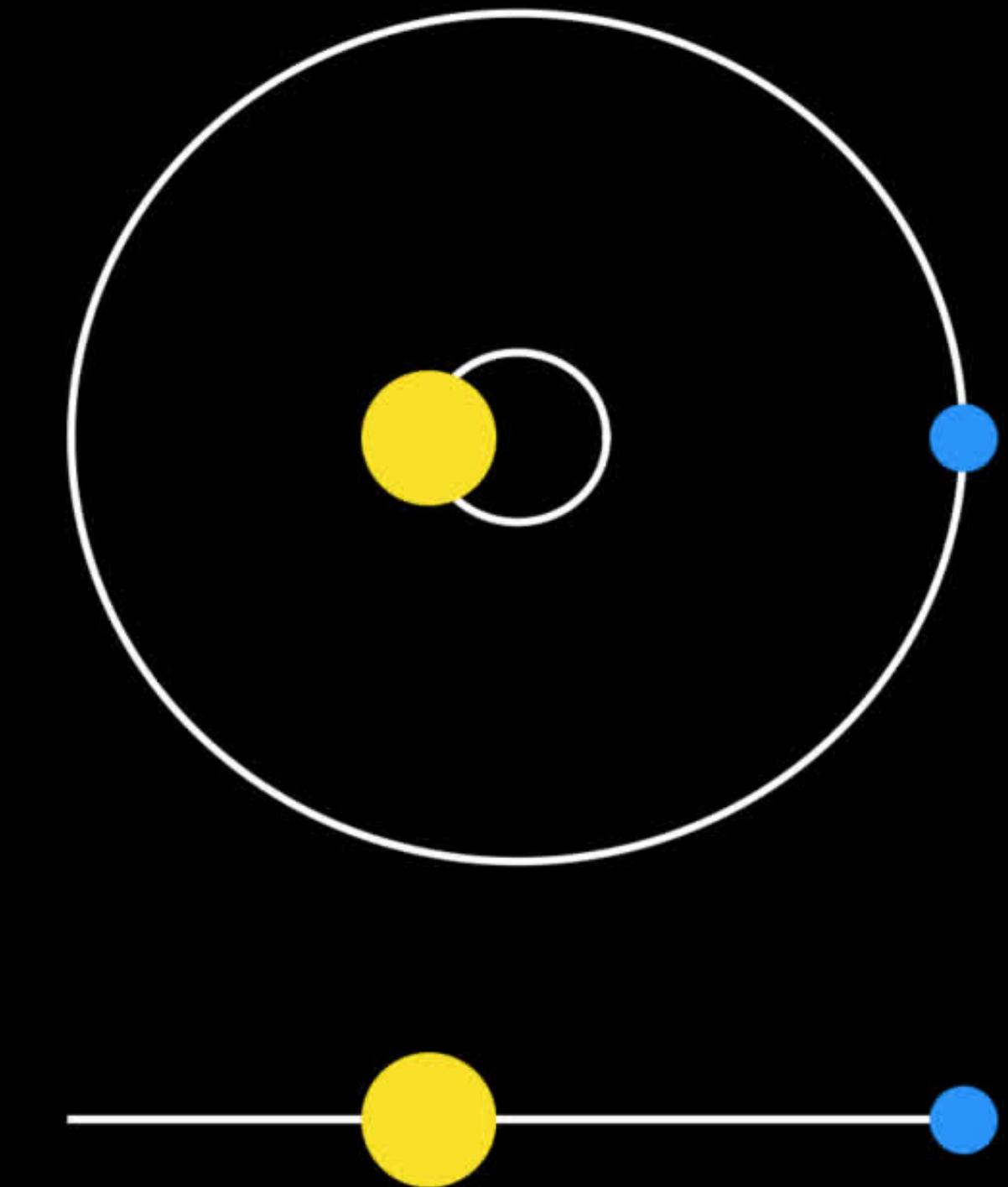
Radial velocity method

- Indirect method to detect exoplanets.
- The change in stellar colour is observed.
- The first detection of a planet using radial velocity was in 1995.



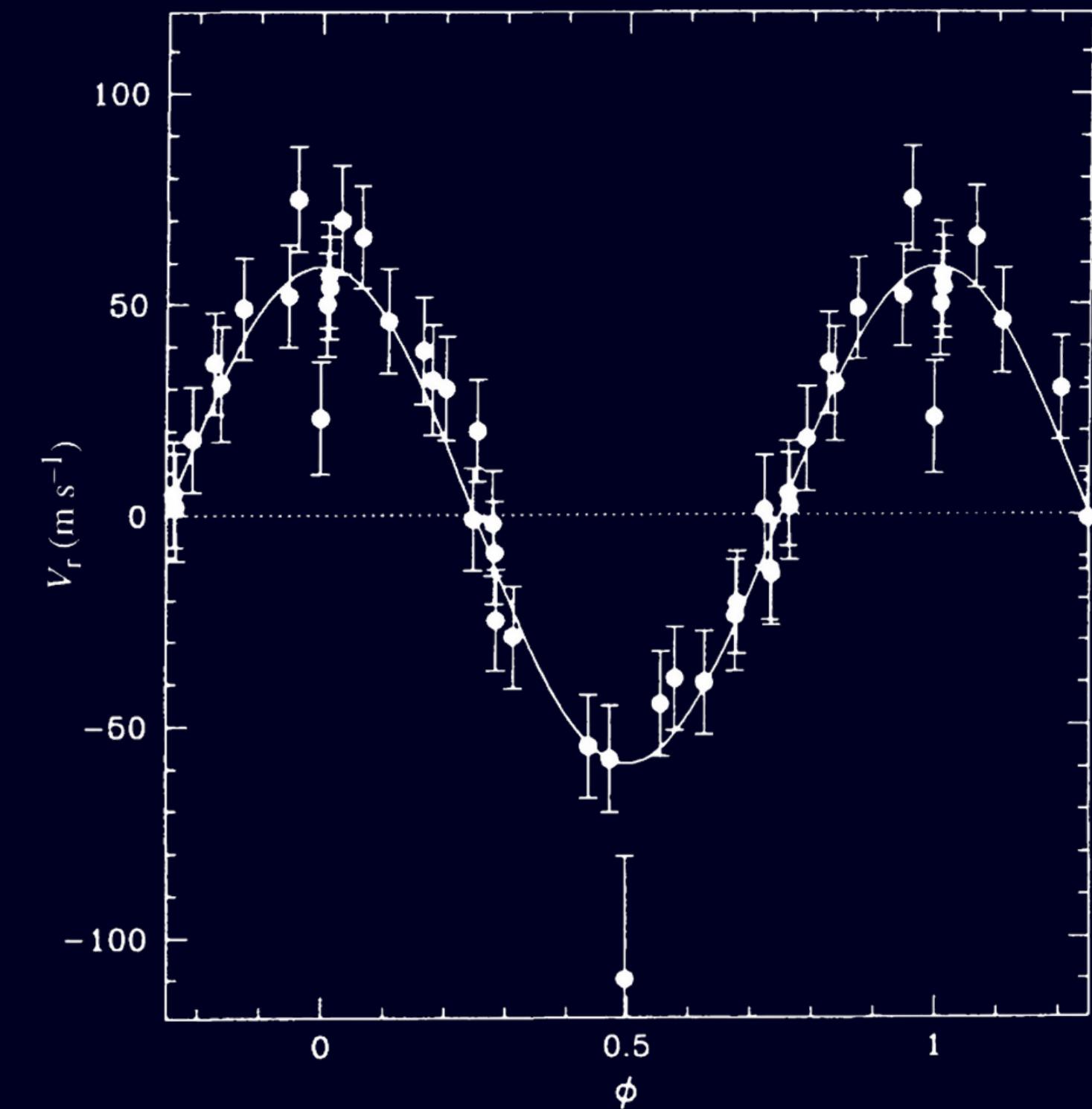
Radial velocity method

Alysa Obertas (@AstroAlysa)



Radial velocity method

- Using the radial velocity method, we can determine the minimum mass of the planet.
- It is easiest to observe heavy planets close to the star.

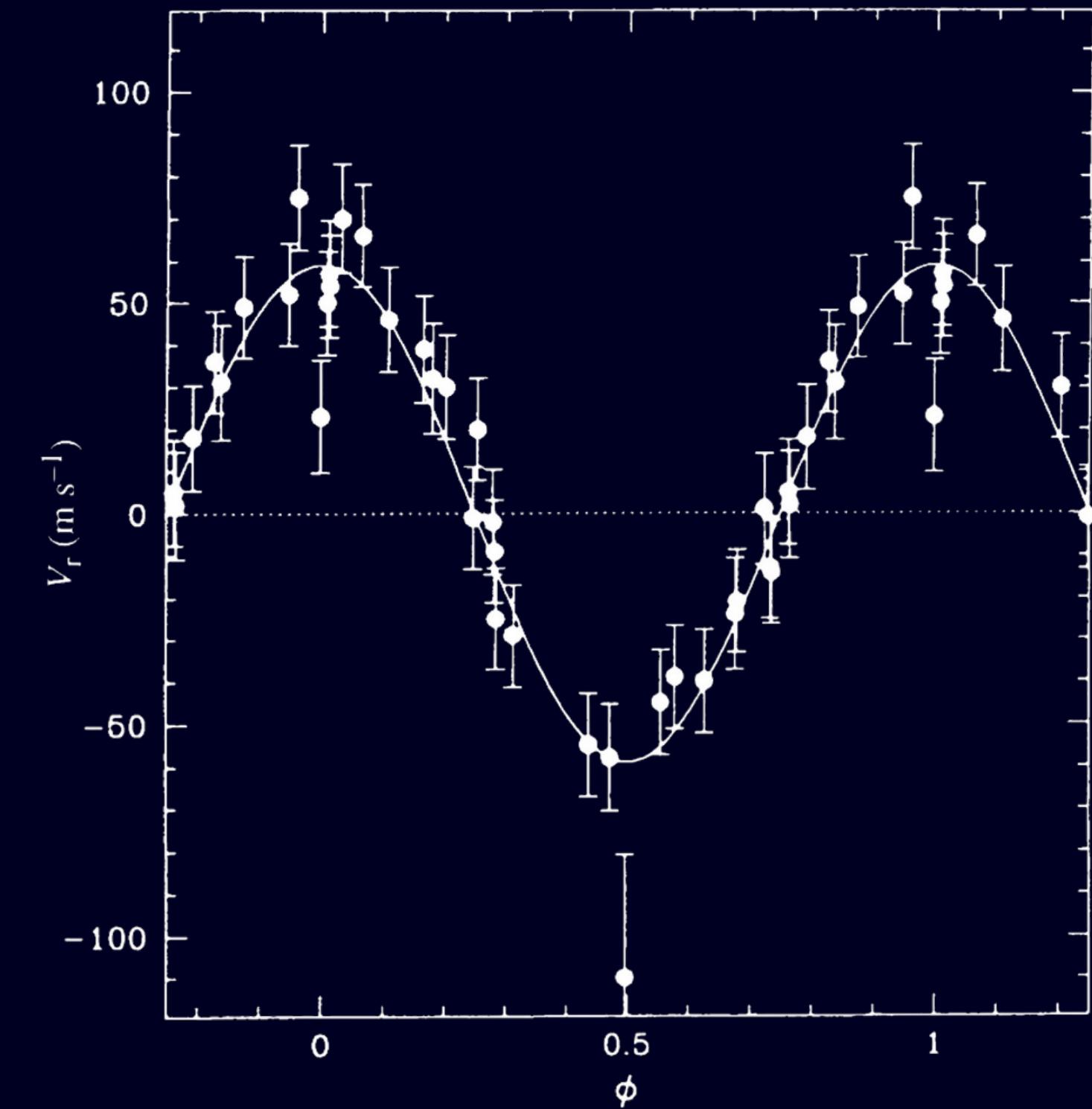


Mayor & Queloz, 1995

Radial velocity method

What do we know about this planet?

- Minimal mass
- Orbital period
- Distance to the host star

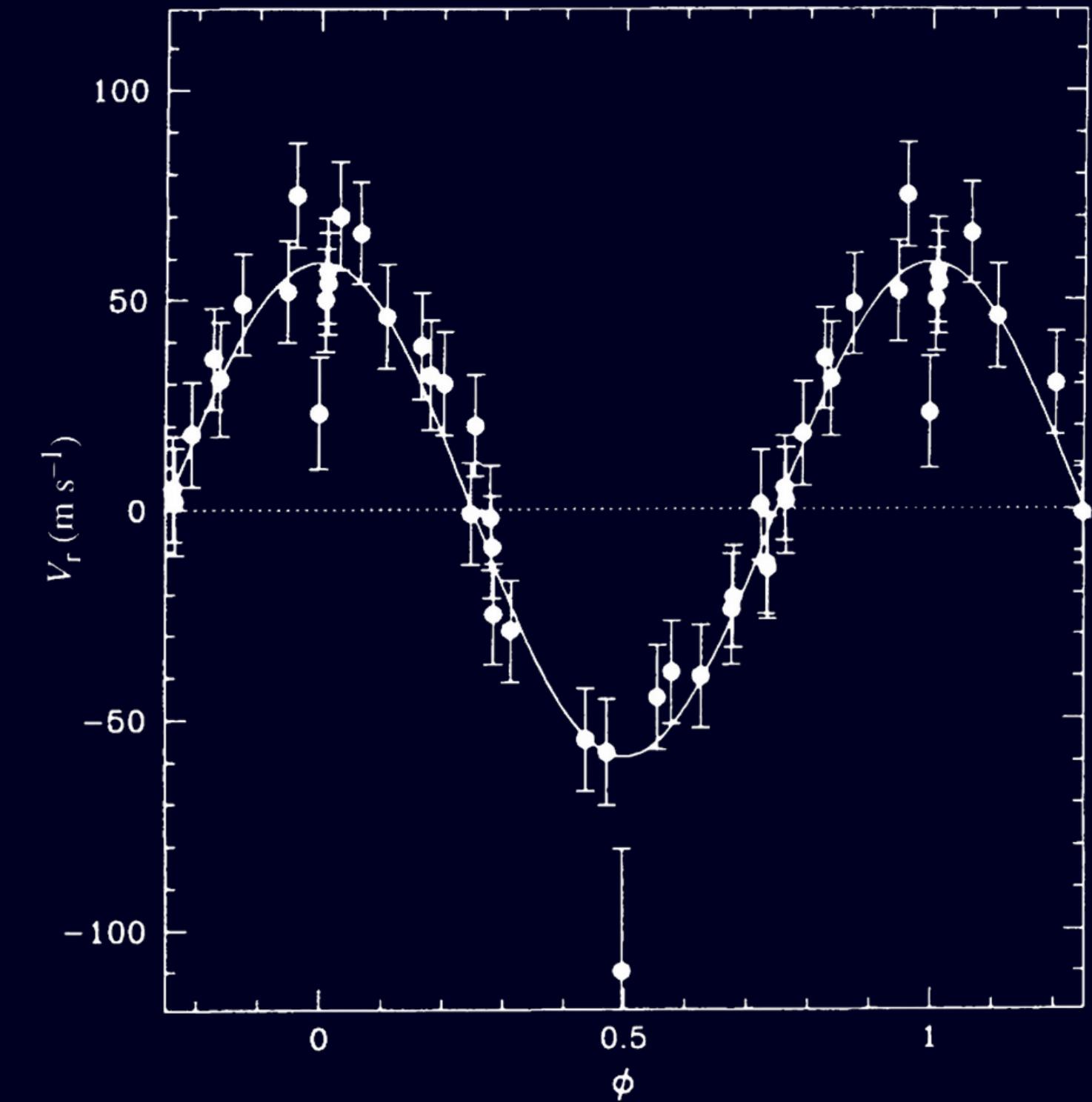


Mayor & Queloz, 1995

Radial velocity method

Comparison to the Solar System

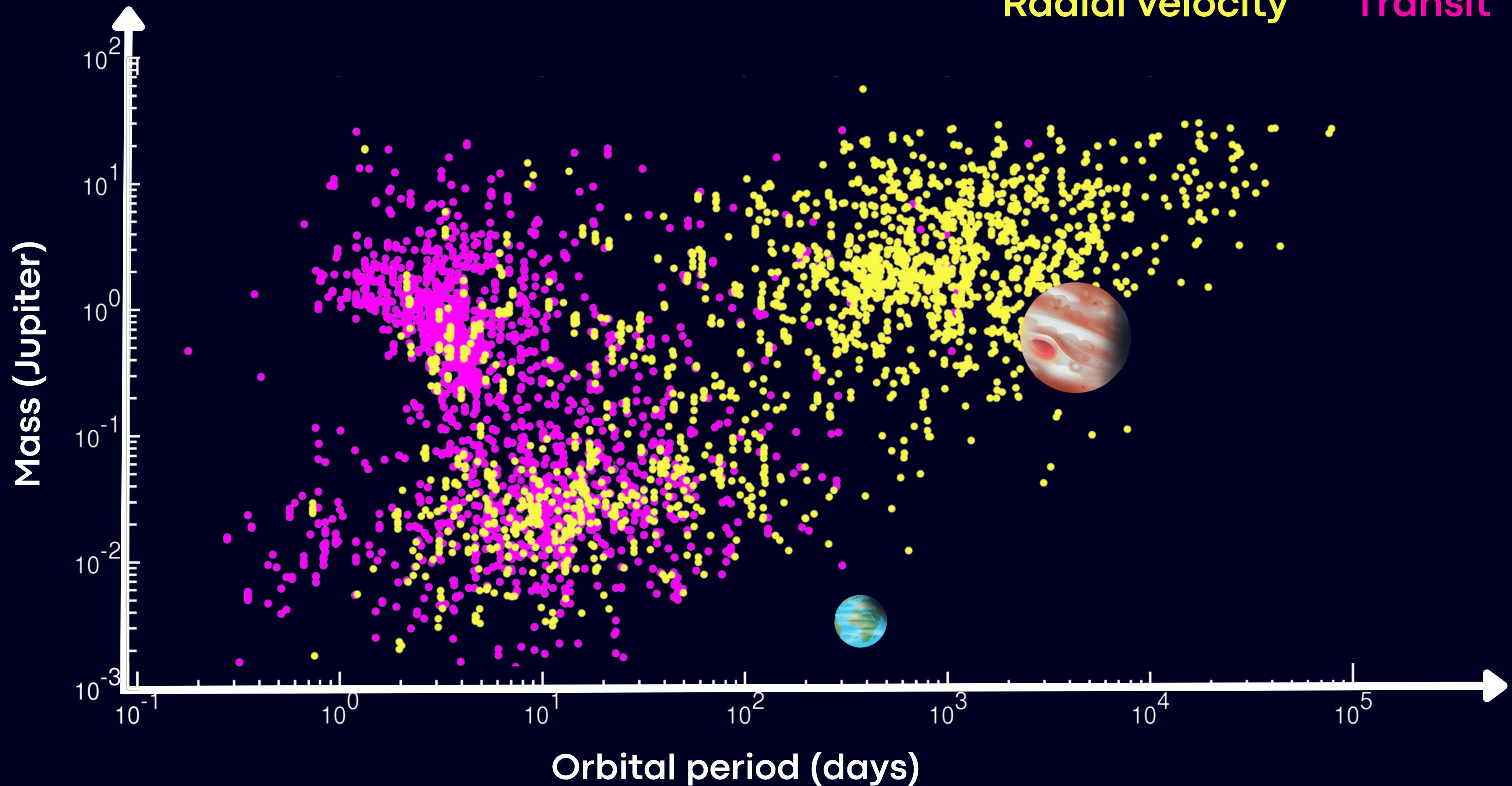
The Sun moves around the common centre of mass at a speed of 12.5 m/s due to Jupiter and 0.09 m/s due to Earth.



Mayor & Queloz, 1995

Radial velocity

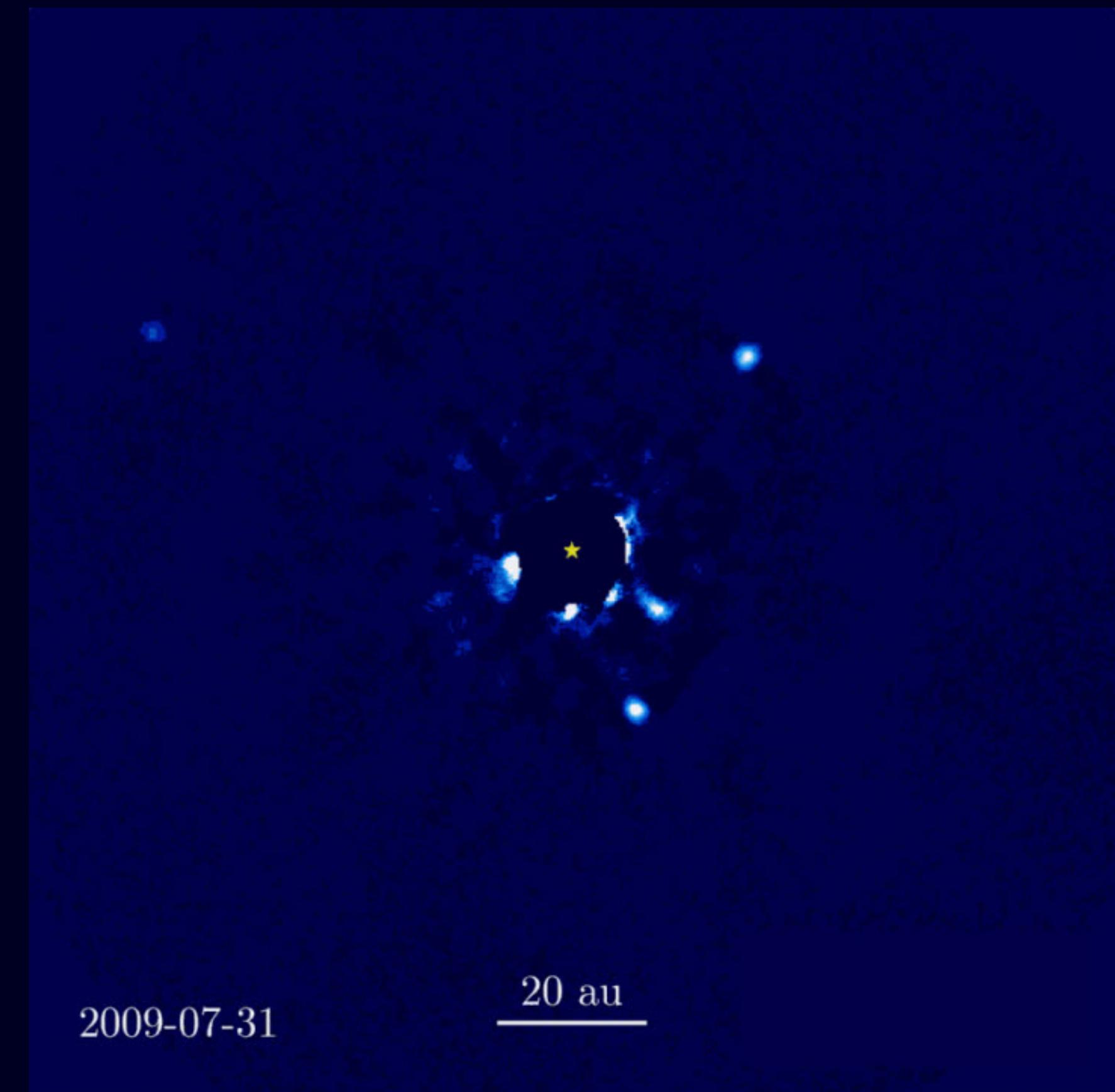
Transit



Direct Imaging

What do we know about this planet?

- Basically everything!



2009-07-31

20 au

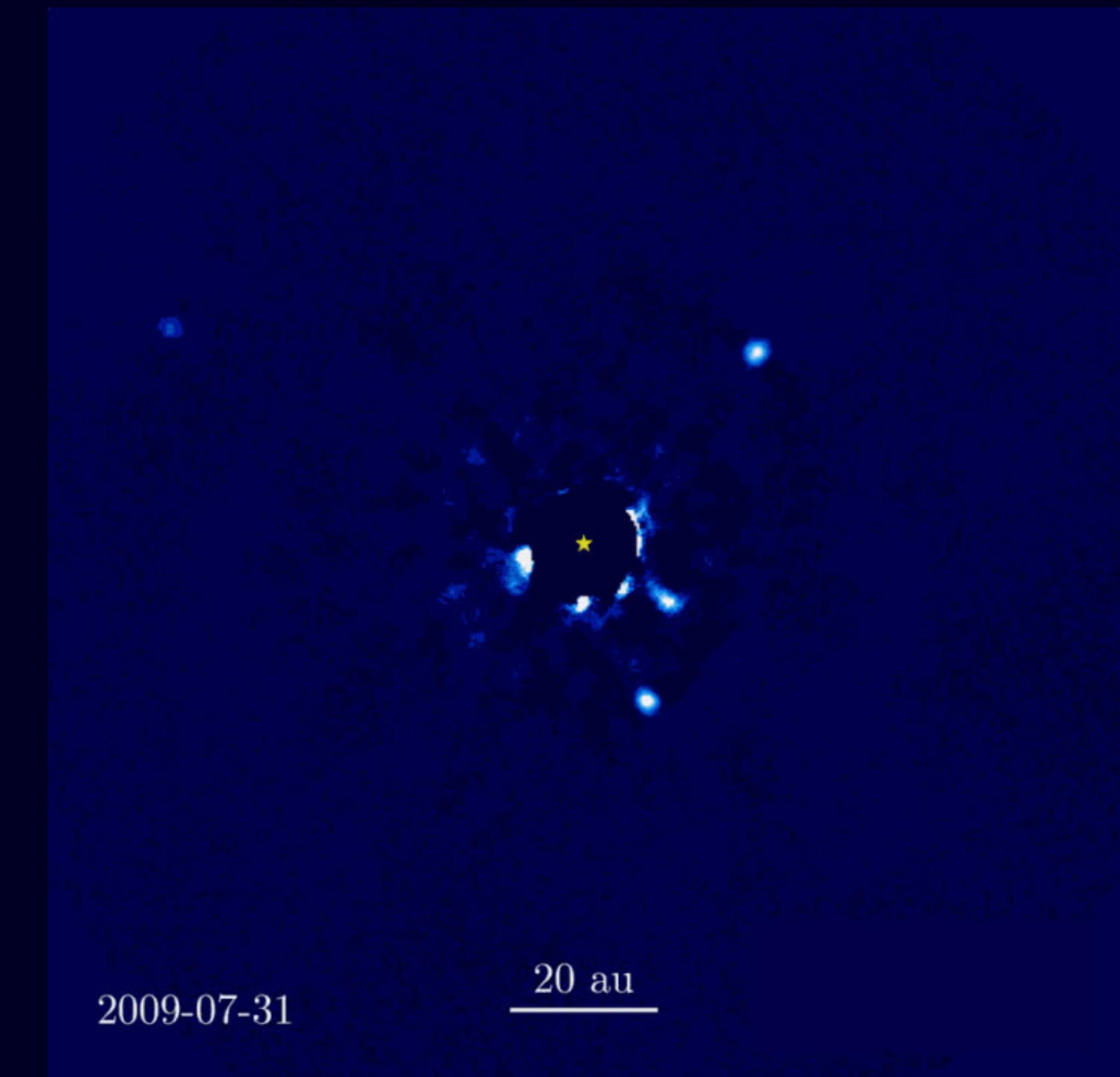
Jason Wang / Christian Marois

Direct Imaging

What do we know about this planet?

- Basically everything!

The planet is very faint in comparison to the star, so this only works for far-out planets.



Jason Wang / Christian Marois

Mass (Jupiter)

10^2

10^1

10^0

10^{-1}

10^{-2}

10^{-3}

Direct imaging

Radial velocity

Transit

Orbital period (days)

10^{-1}

10^0

10^1

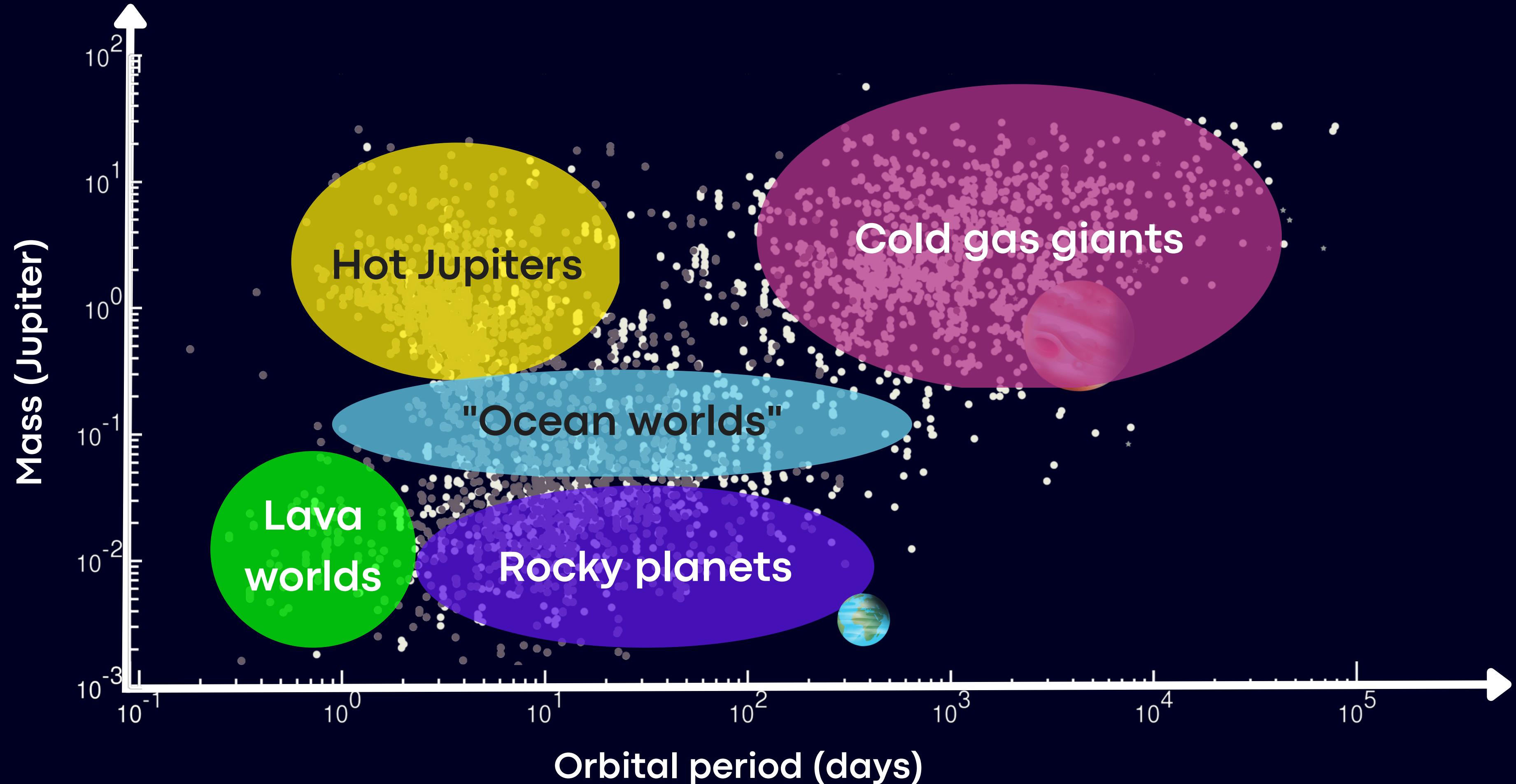
10^2

10^3

10^4

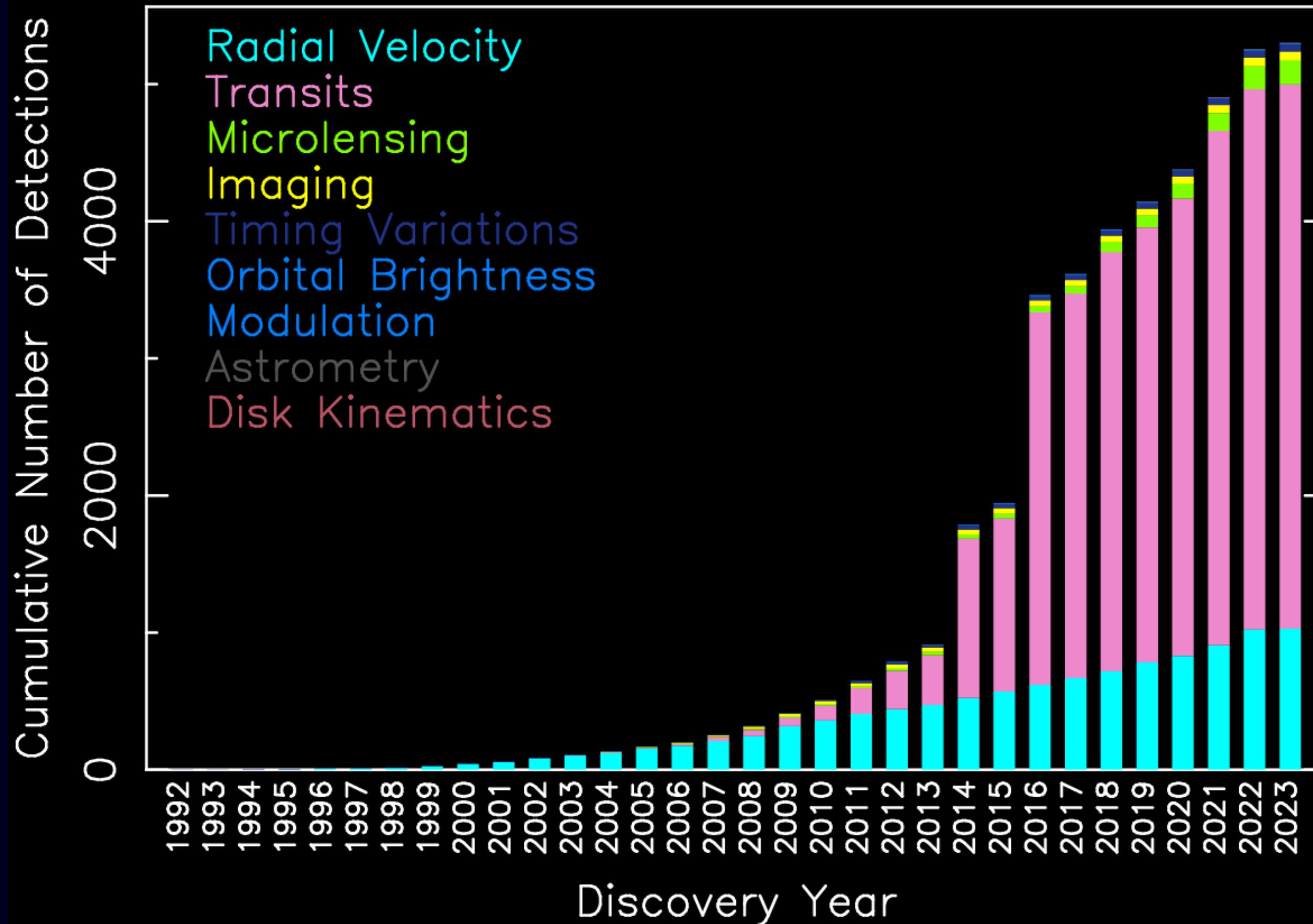
10^5





Cumulative Detections Per Year

07 Mar 2023
exoplanetarchive.ipac.caltech.edu

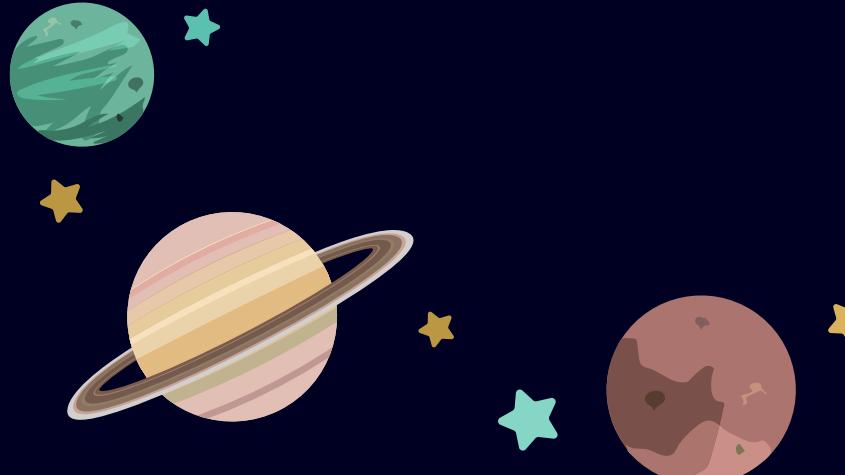


Naming exoplanets

HD stands for Henry Draper Catalogue, an astronomical star catalogue published between 1918 and 1924 containing a spectroscopic classification of over 200,000 stars.

b is the letter for our exoplanet. The first planet found in a system is referred to by the letter b (a is used to refer to the host star).

HD 189733 b

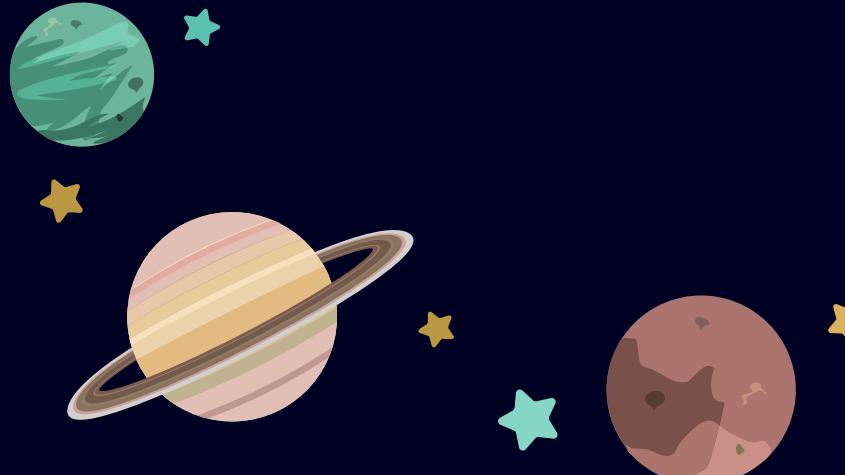
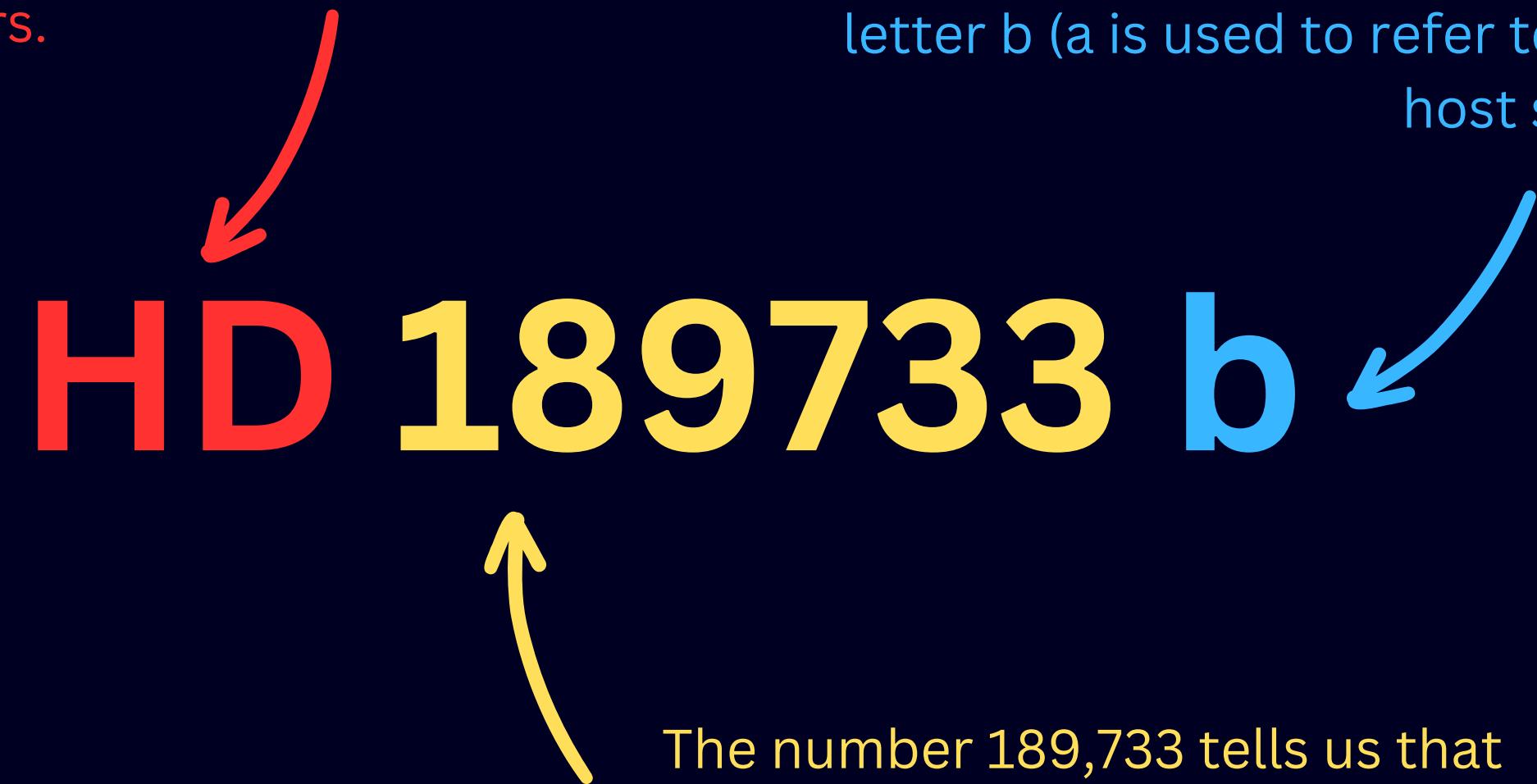


The number 189,733 tells us that this was the 189,733rd star in this catalogue. Crazy, isn't it?

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