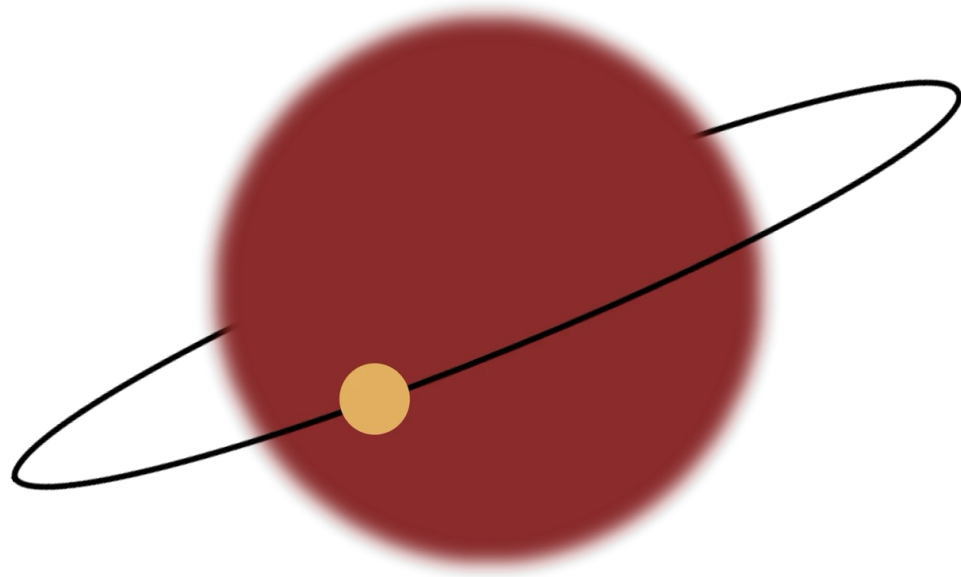
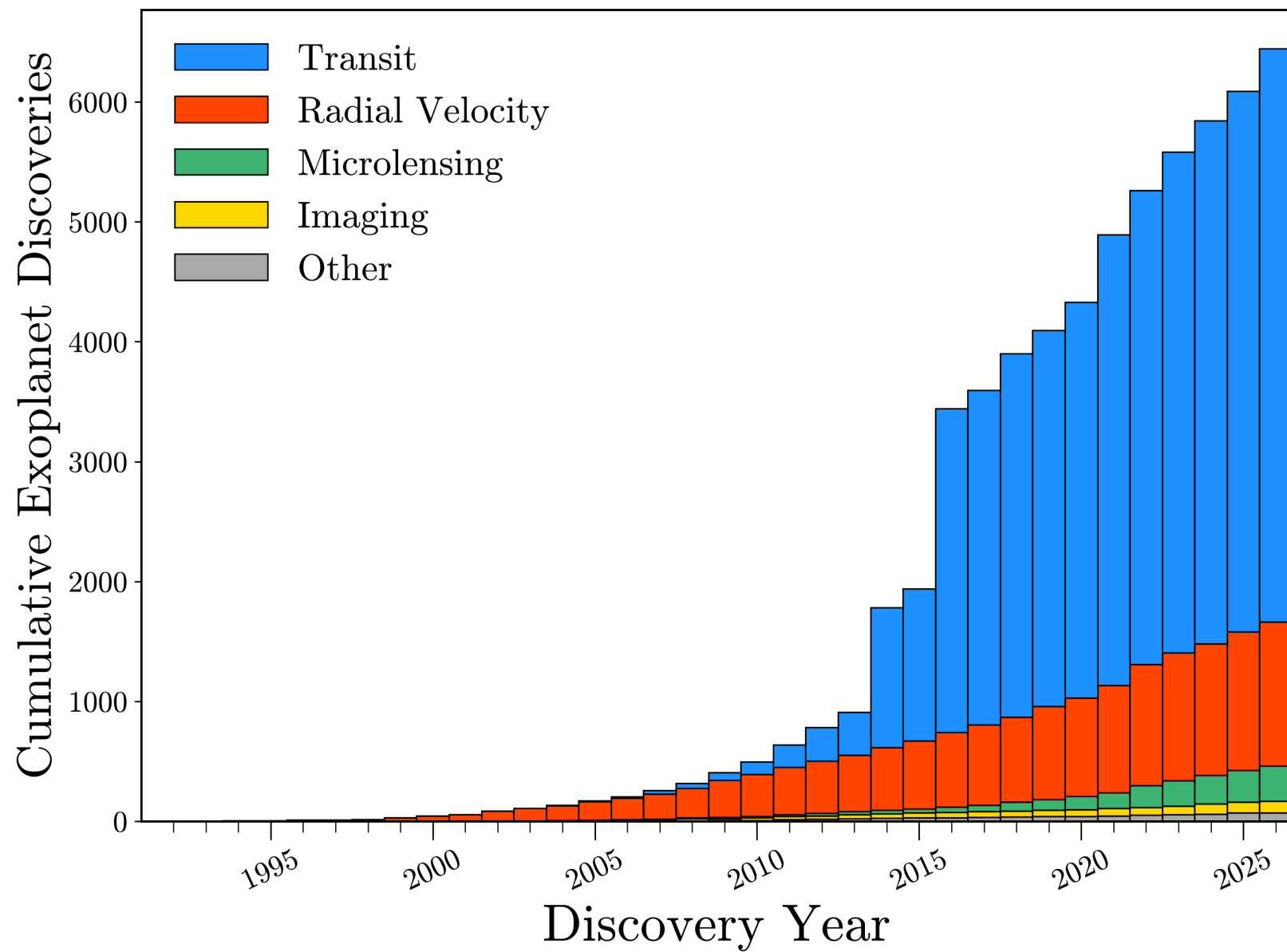




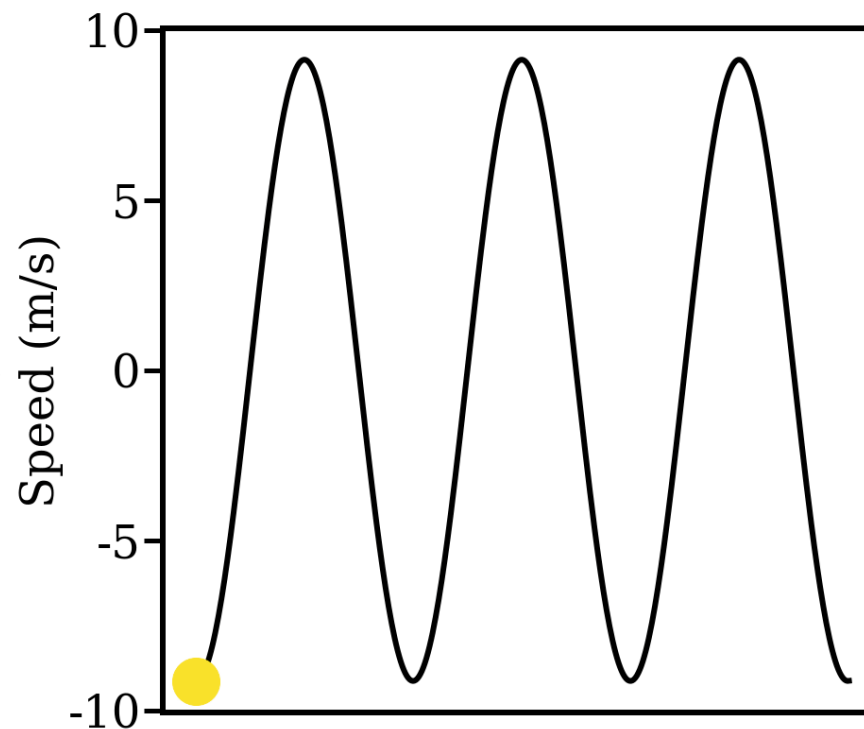
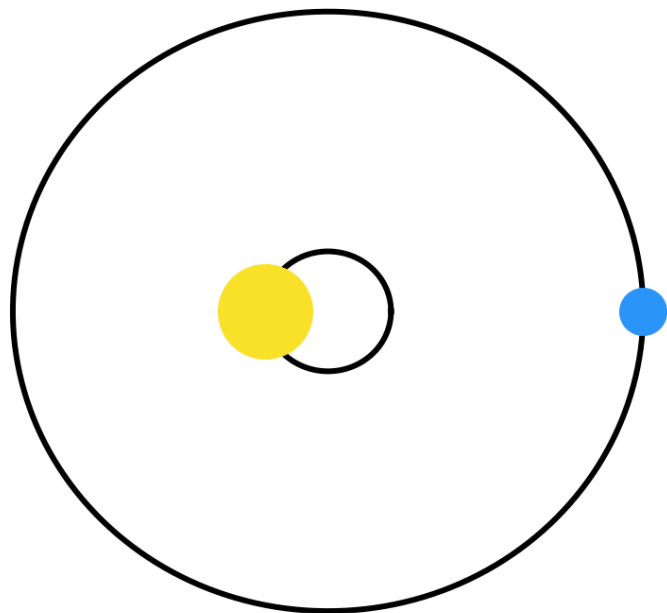
How to Find a Planet

Dr. Nicholas Saunders
ASTR 2550, Yale University
16 October 2026

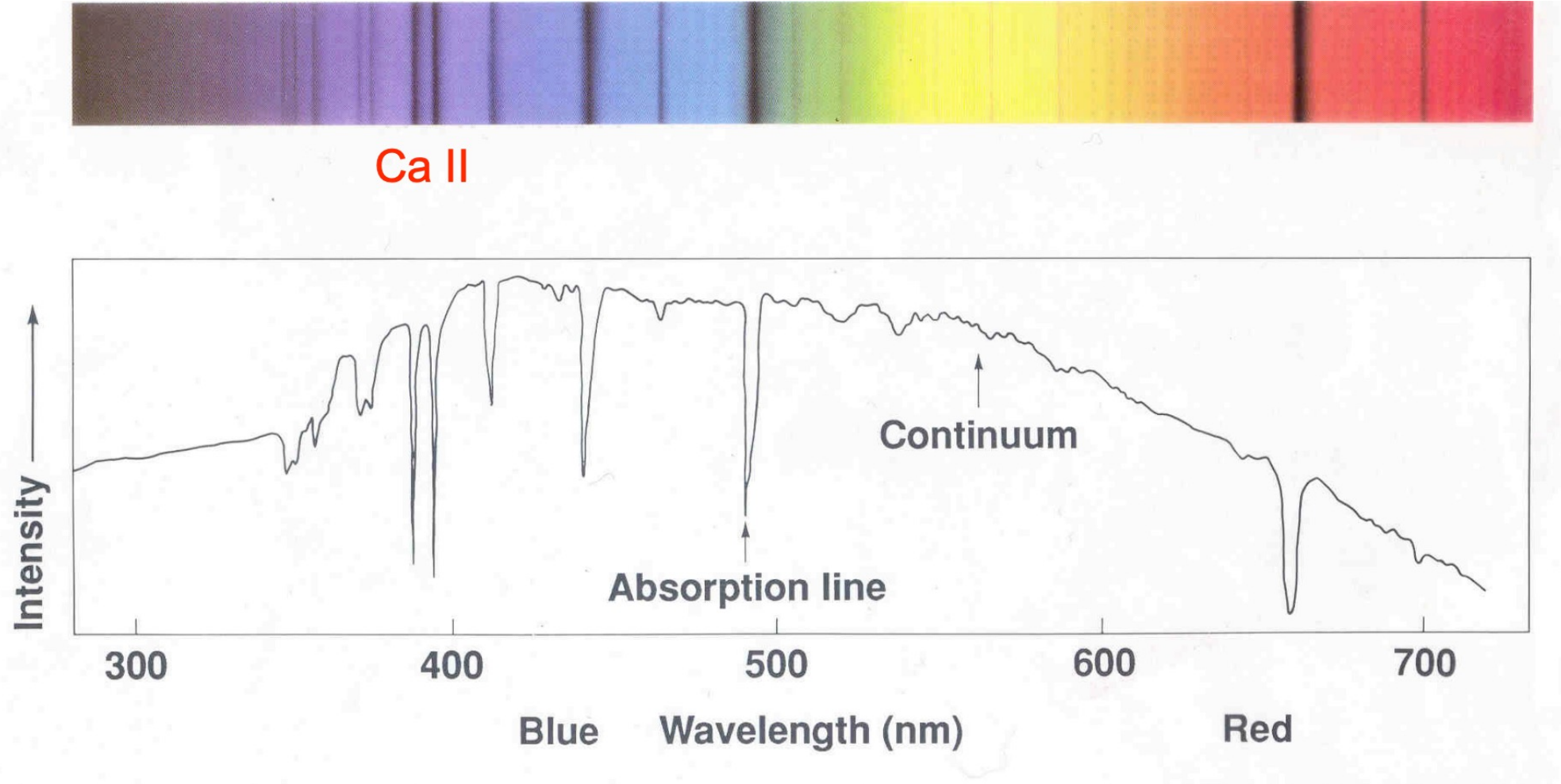


The Radial Velocity Method

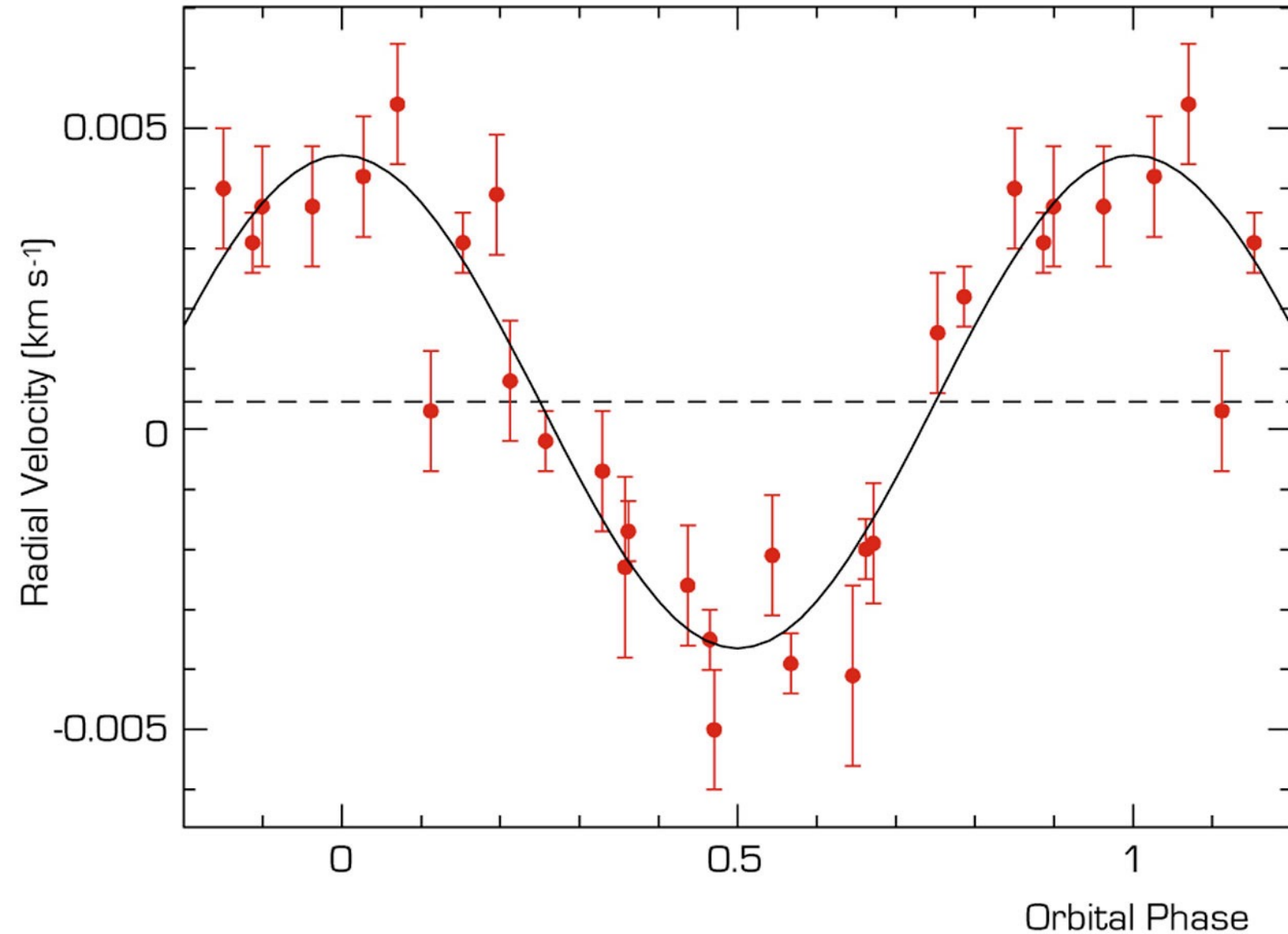
Alysa Obertas (@AstroAlysa)



The Radial Velocity Method



The Radial Velocity Method



$$K = \left(\frac{2\pi G}{M_{\star}^2 P} \right)^{1/3} \frac{1}{\sqrt{1-e^2}} M_p \sin i$$

- K — RV semi-amplitude
- G — gravitational constant
- $M_{\star}$ — stellar mass
- P — orbital period
- e — eccentricity
- M_p — planet mass
- i — orbital inclination

The Radial Velocity Method

measuring shifts of spectral lines due to the star
wobbling as the planet orbits

$$K = \left(\frac{2\pi G}{M_{\star}^2 P} \right)^{1/3} \frac{1}{\sqrt{1 - e^2}} M_p \sin i$$

best at finding

small
(terrestrial) or **large**
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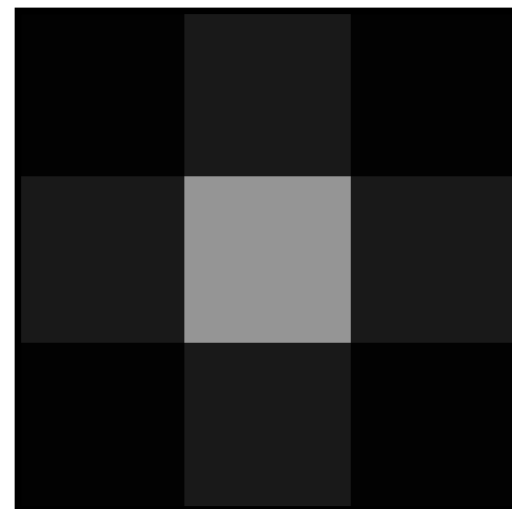
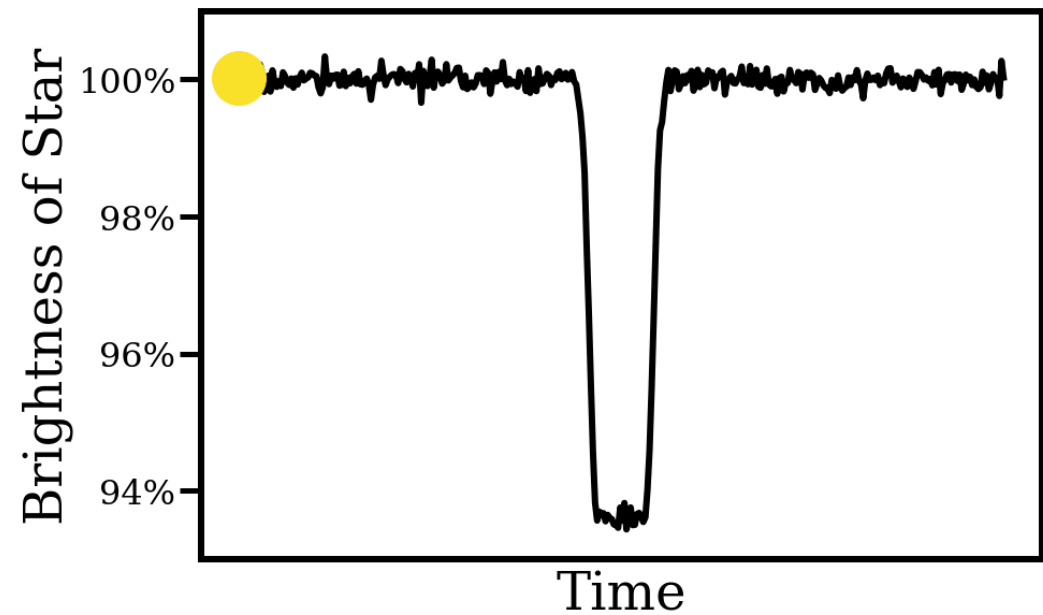
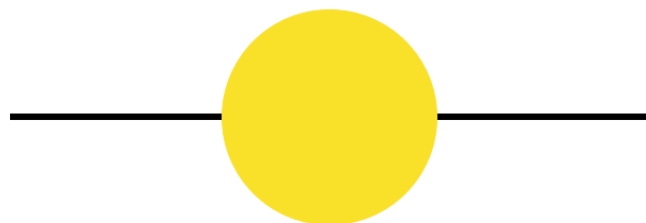
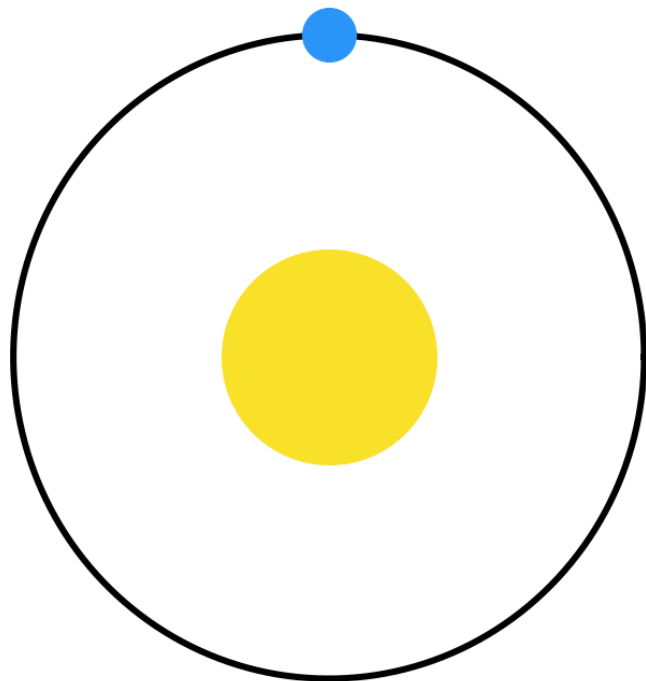
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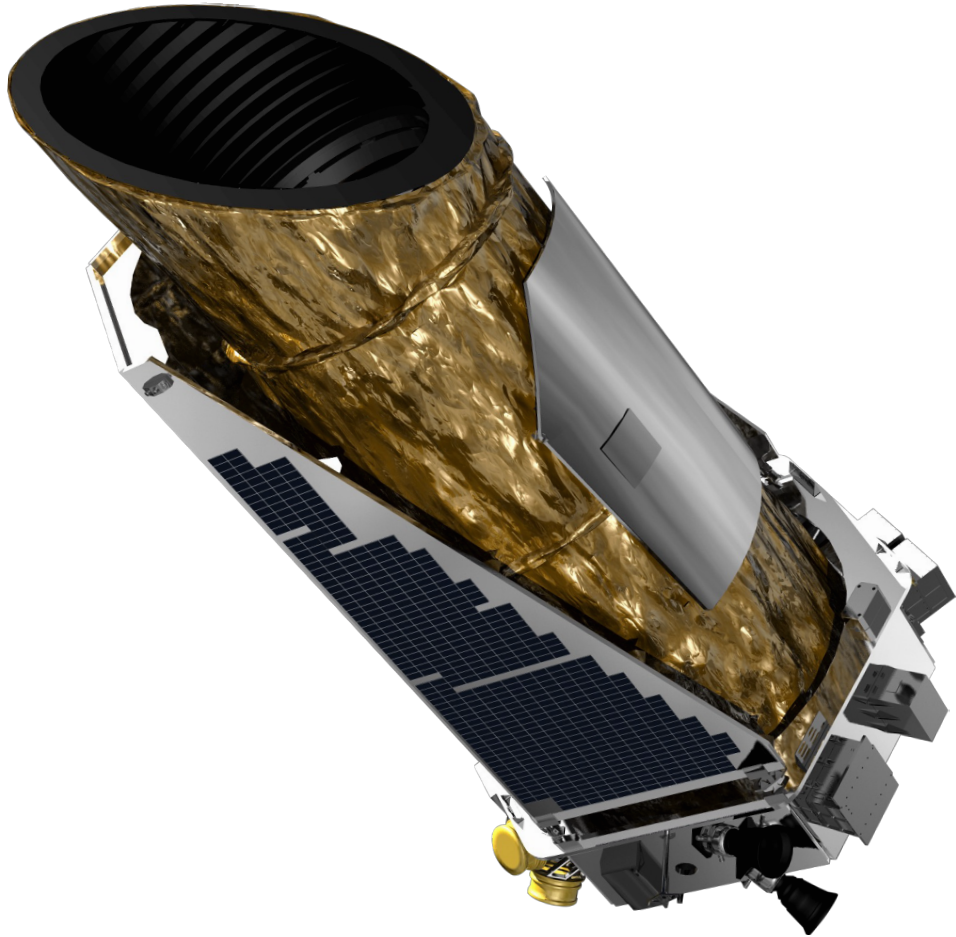
The Transit Method

Alysa Obertas (@AstroAlysa)



Kepler

2009 – 2018

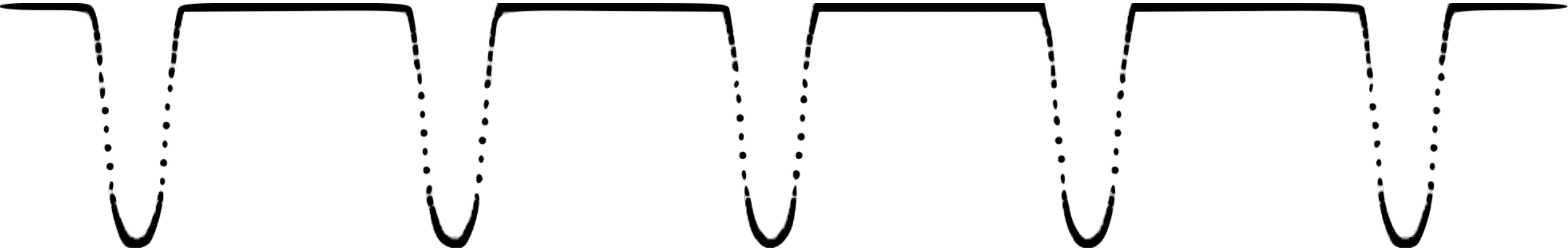


TESS

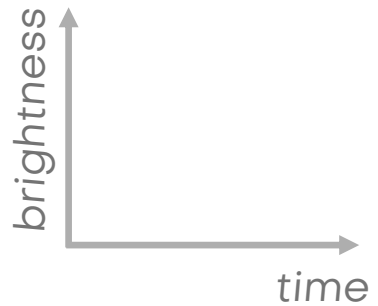
2018 – present



The Transit Method

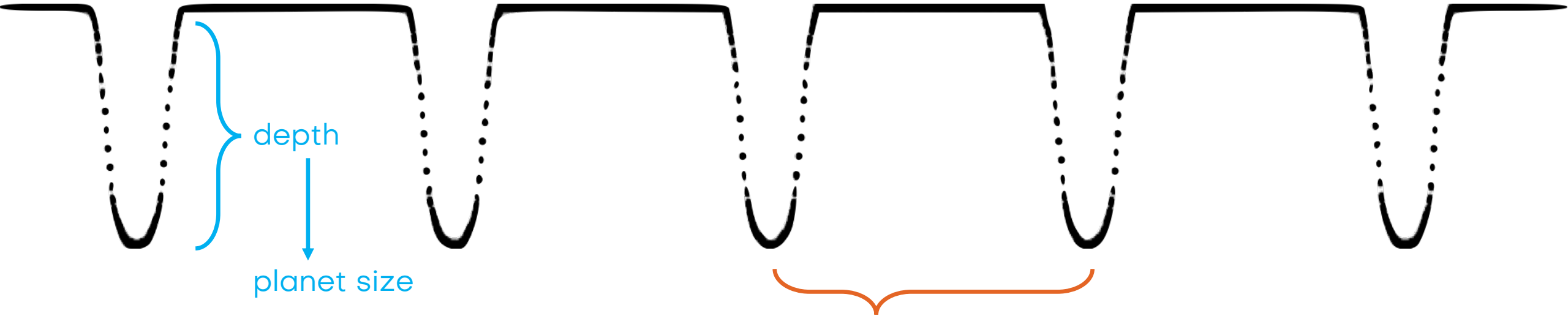


if you watch a star for a long time, you'll see multiple dips

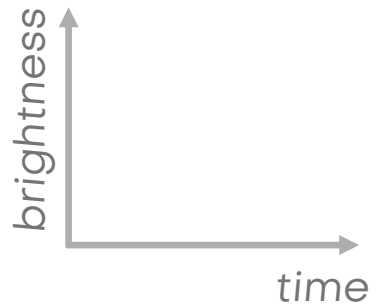


The Transit Method

$$\text{depth} = \left(\frac{R_p}{R_\star} \right)^2$$



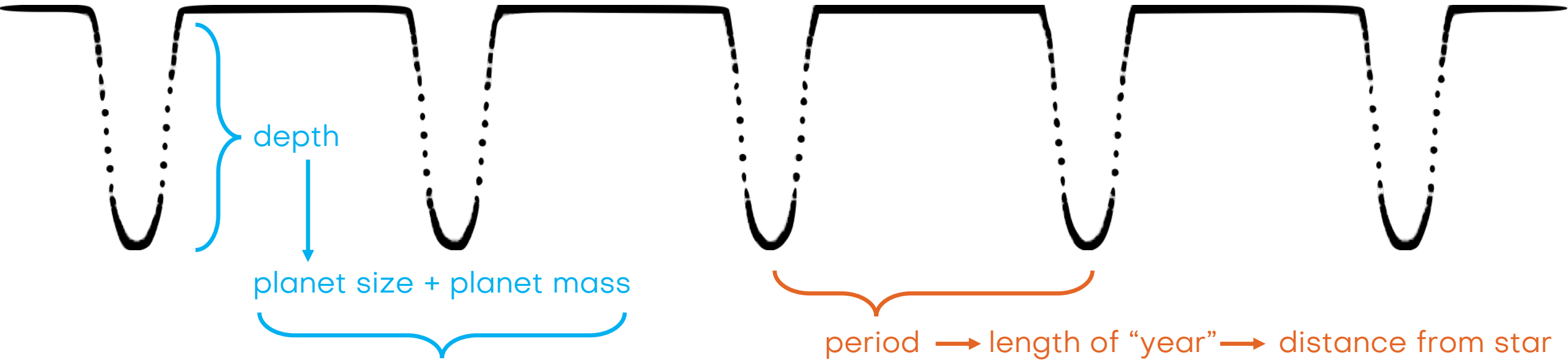
period → length of “year” → distance from star



$$P^2 = \left(\frac{4\pi^2}{GM} \right) a^3$$

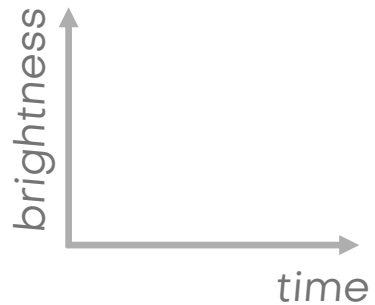
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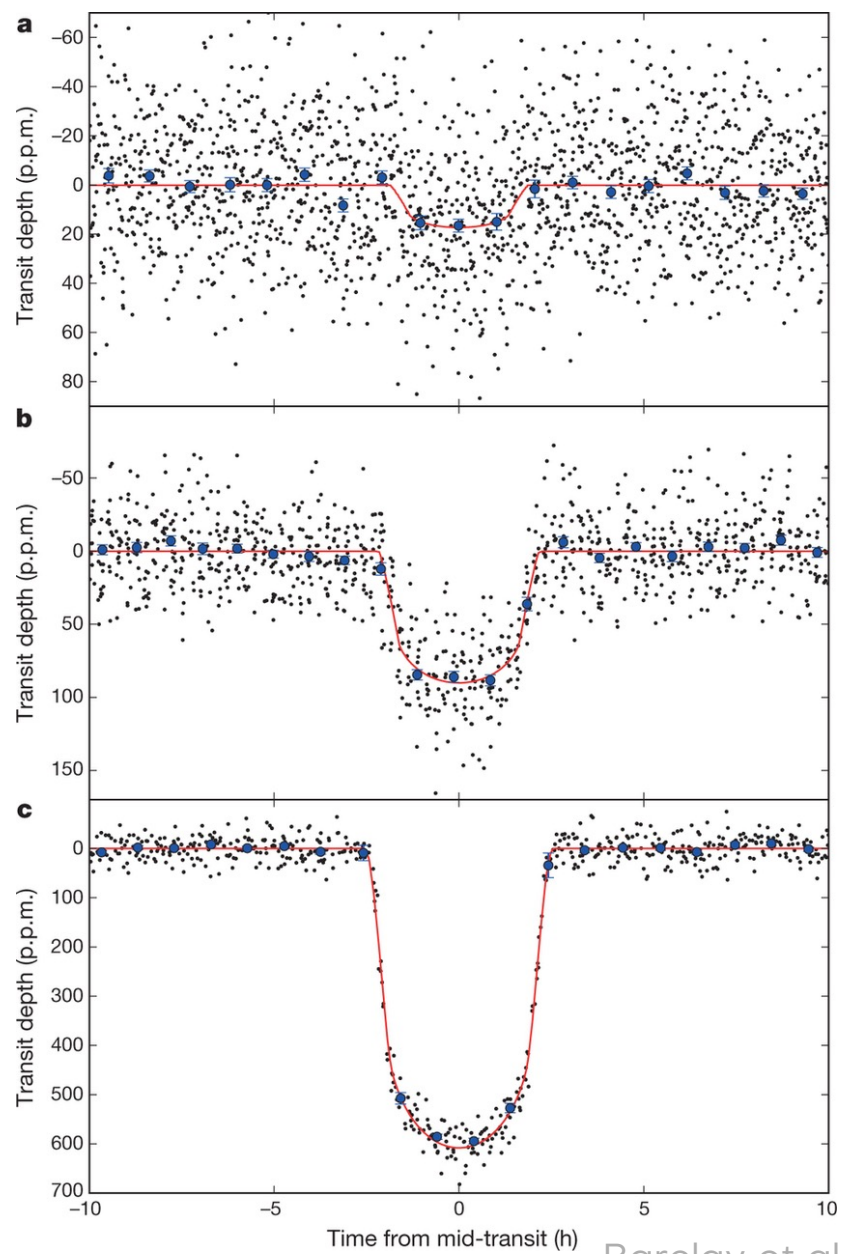
planet density

$$\rho_p = \frac{3M_p}{4\pi R_p^3}$$

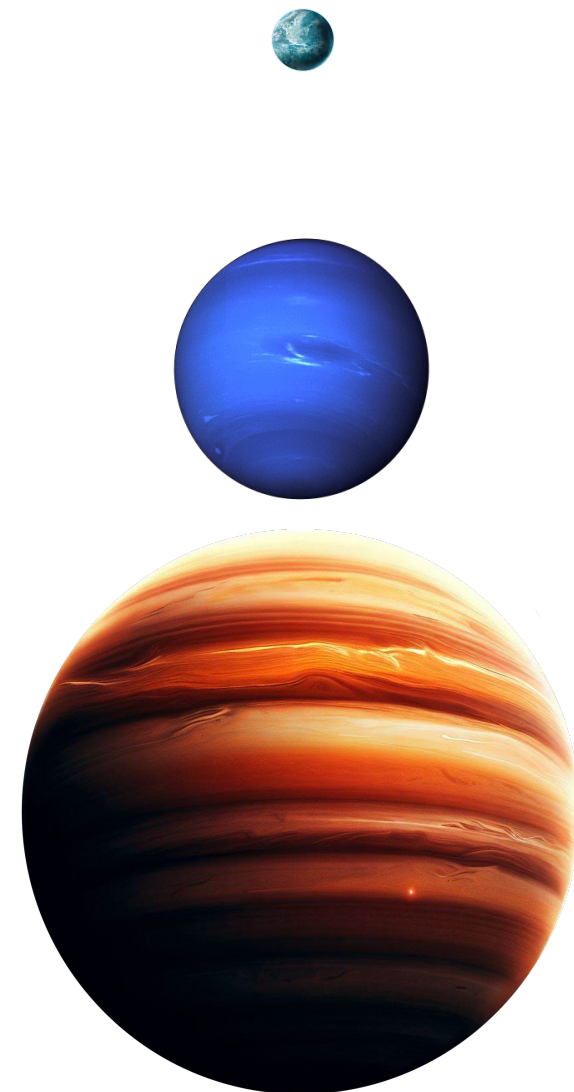


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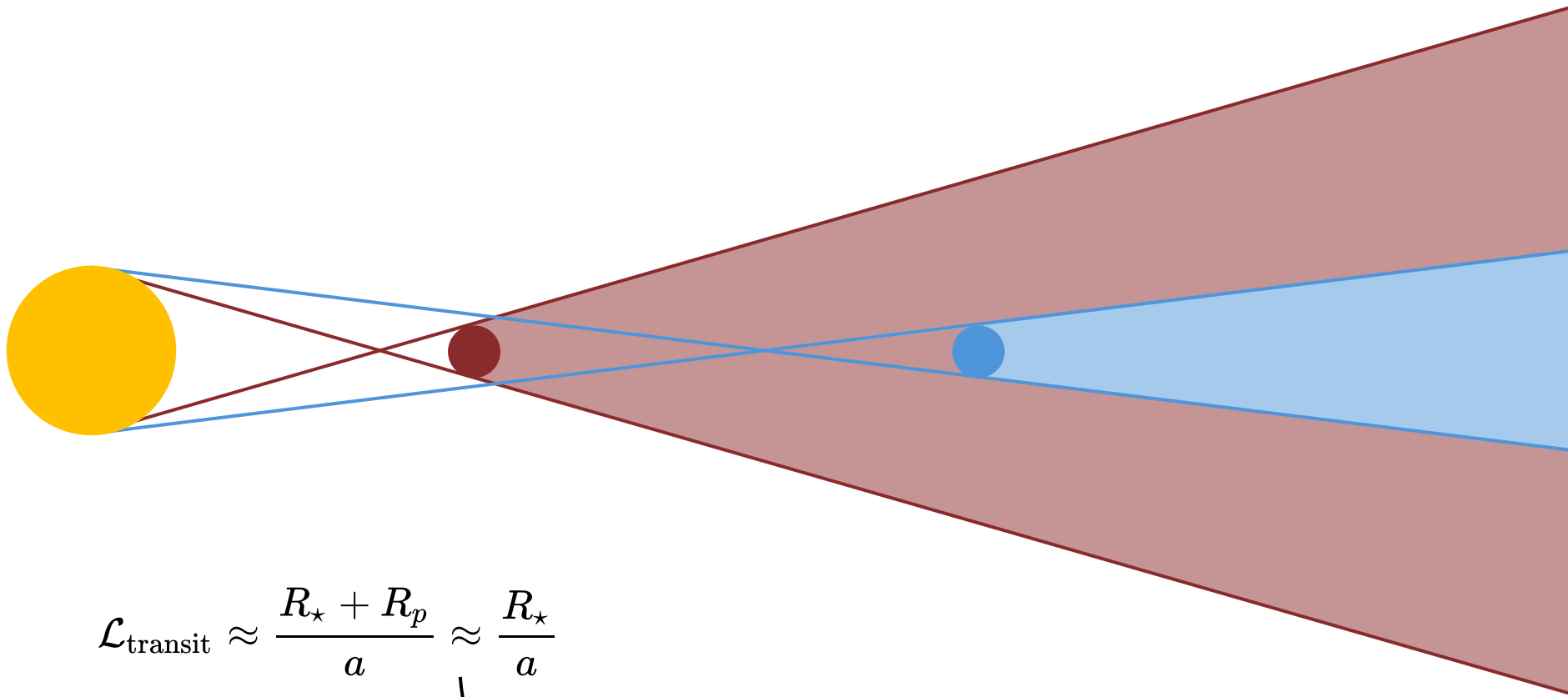
The Transit Method



Barclay et al. (2013)



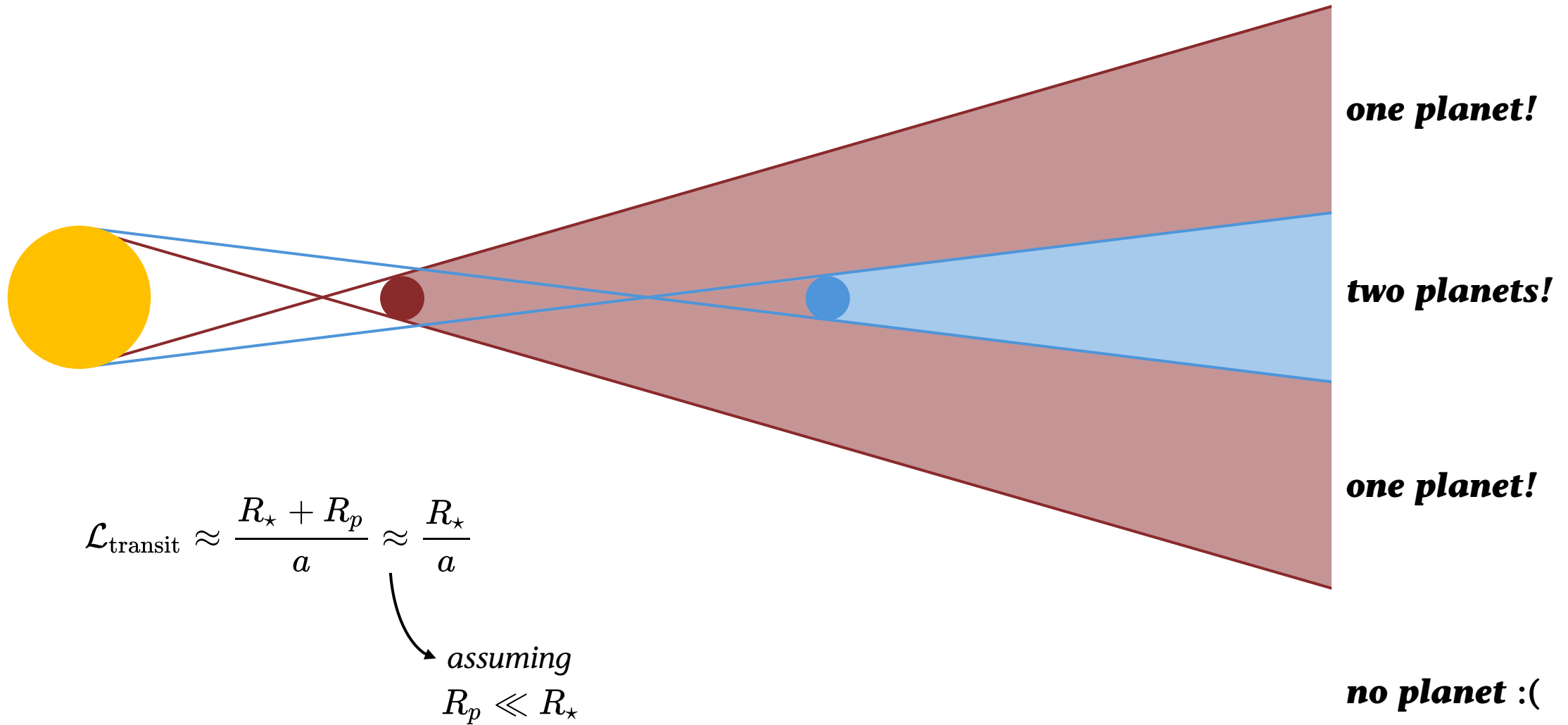
Geometric Transit Likelihood



$$\mathcal{L}_{\text{transit}} \approx \frac{R_{\star} + R_p}{a} \approx \frac{R_{\star}}{a}$$

assuming
 $R_p \ll R_{\star}$

Geometric Transit Likelihood



The Transit Method

searching for periodic dips in the brightness of stars
caused by a planet blocking light once per orbit

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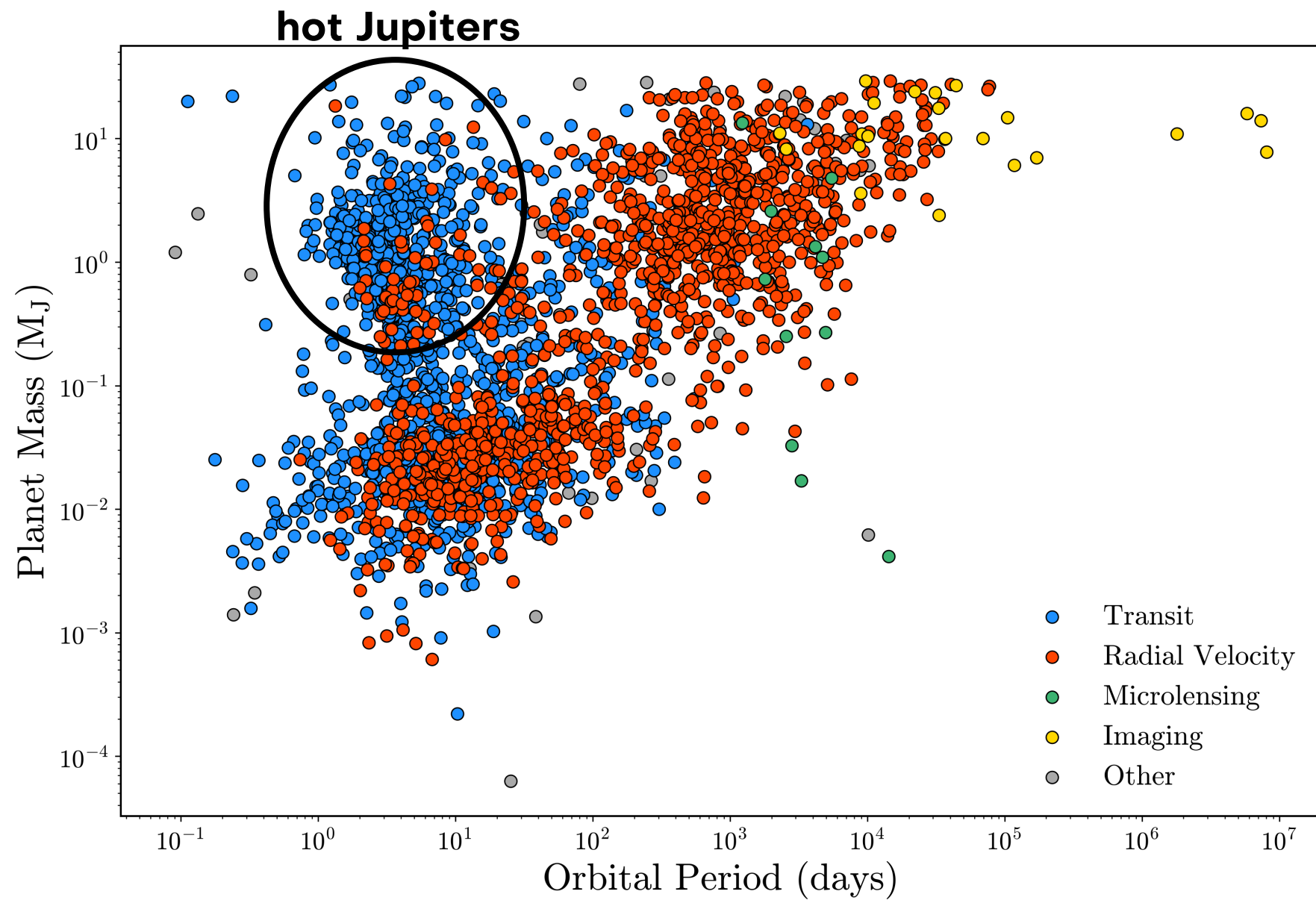
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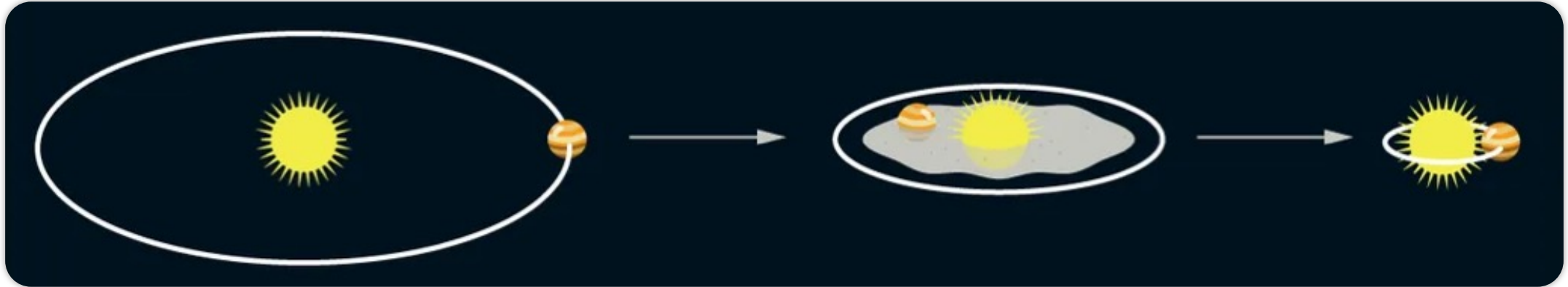
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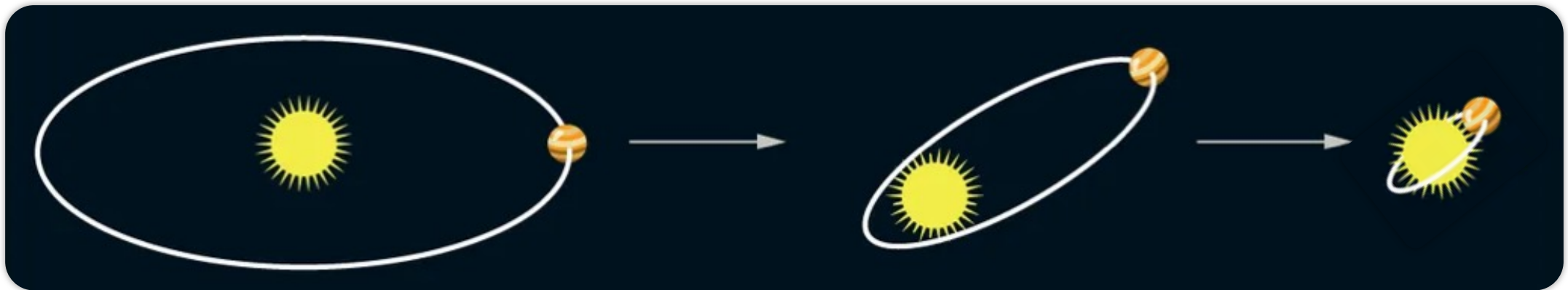


Hot Jupiter Formation Pathways

Disk-driven migration



High-eccentricity migration



Adapted from Dawson & Johnson (2018)

hot Jupiters are unlike
anything we see in
our solar system



hot Jupiters are unlike
anything we see in
our solar system

**...so why do we find
so many of them?**



Are hot Jupiters common?

there are many in our galaxy, but they're not as common as they appear on this plot

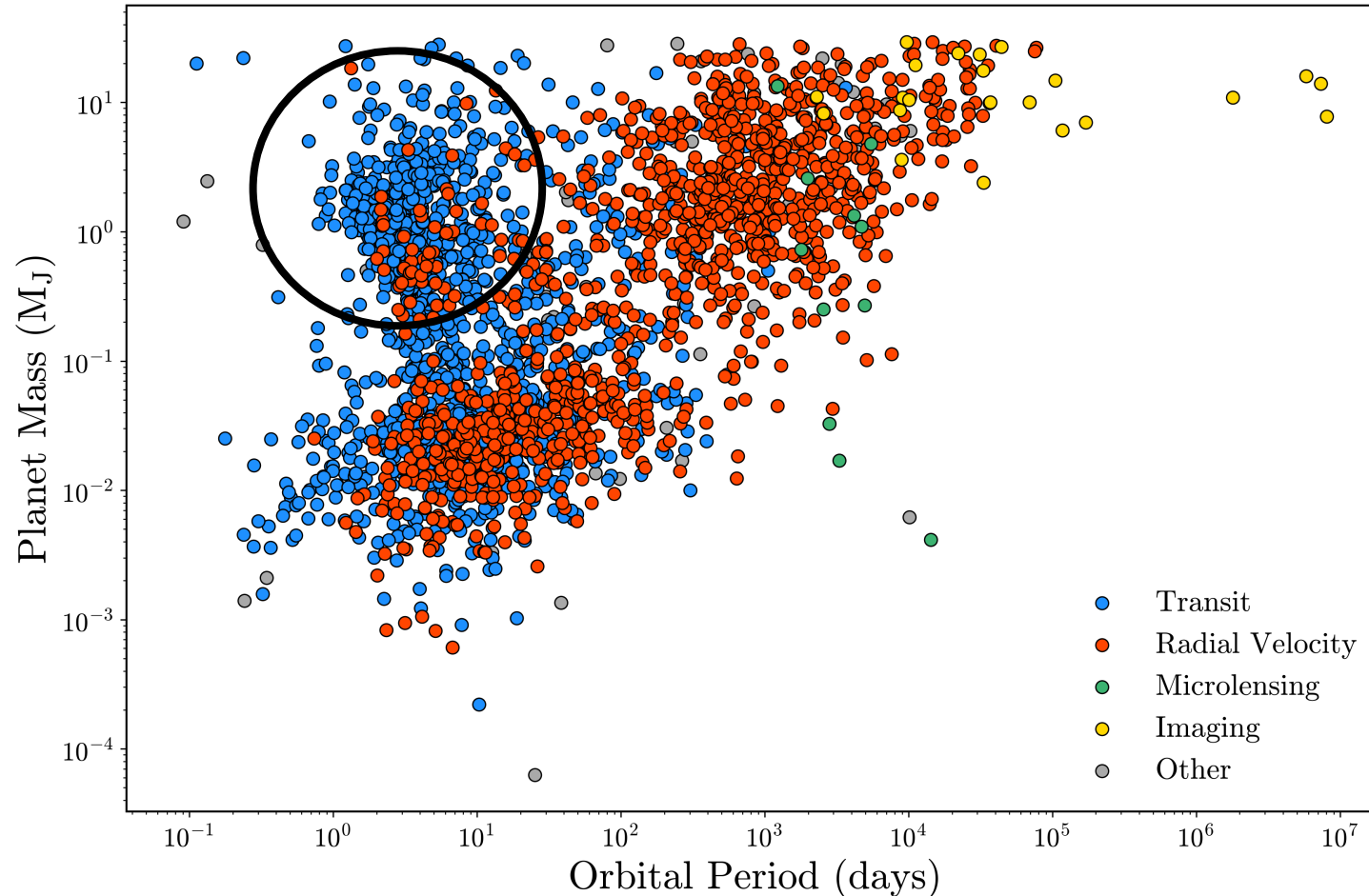


Image: P. Schmidt (Terranaut)

Tutorial: *Recovering a transiting planet in TESS data*

Step 0:

→ Install lightcurve & plot a sample light curve

Step 1:

→ Explore the NASA Exoplanet Archive, then make cuts to choose your planet

→ Download & plot its TESS light curve

Step 2:

→ Find the orbital period using a Box Least Squares periodogram

→ Fold the light curve to this period & plot

Step 3:

→ Tune the transit depth parameter to estimate the planet radius*

**Requires the star's radius! Look it up on the archive*

Step 4:

→ Compare your period & radius to the Exoplanet Archive values

→ Plot your planet in context, then submit your results to the class plot

Link: ***nksaunders.space/tutorials***

Make sure to click File → Save a copy in Drive