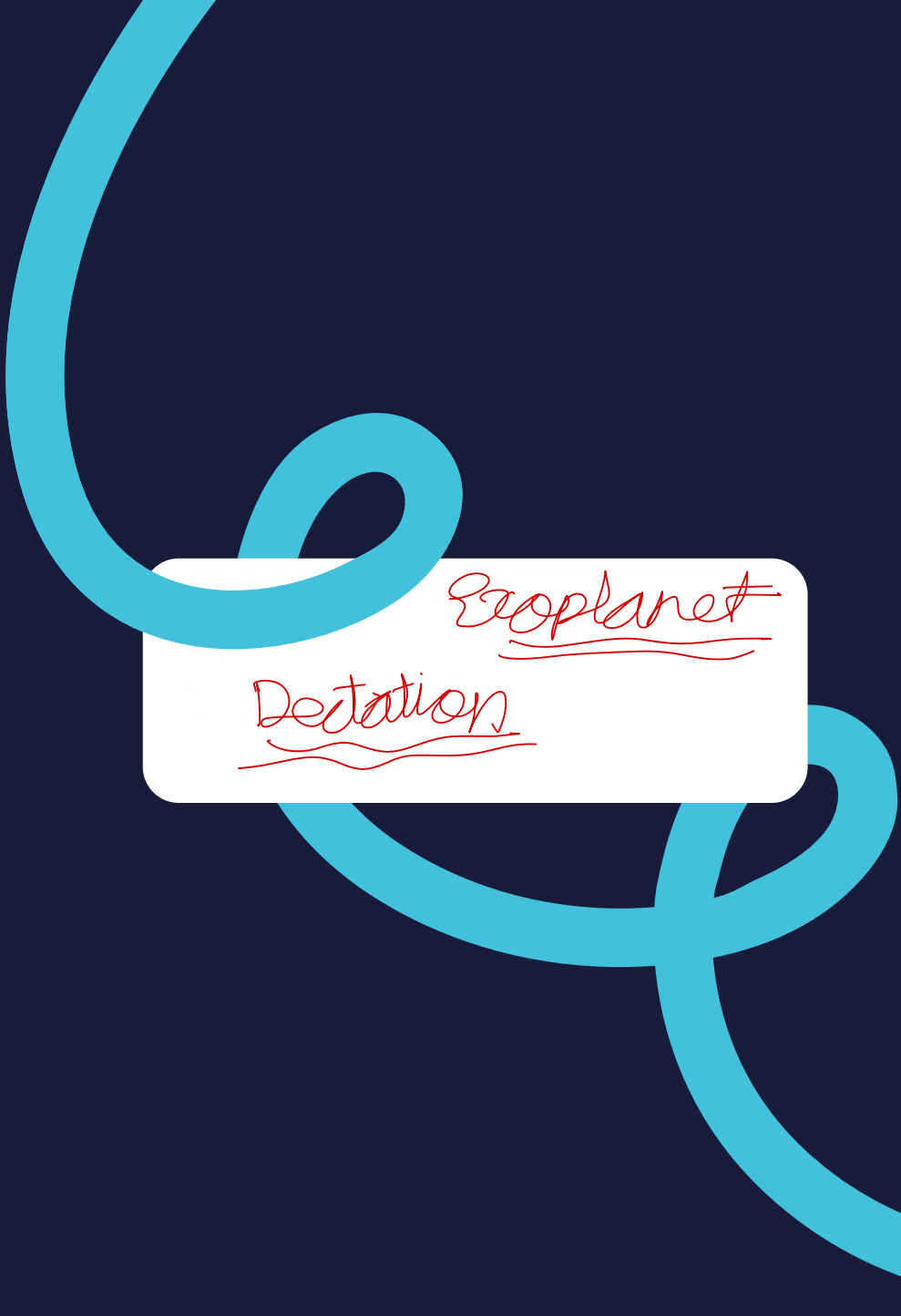
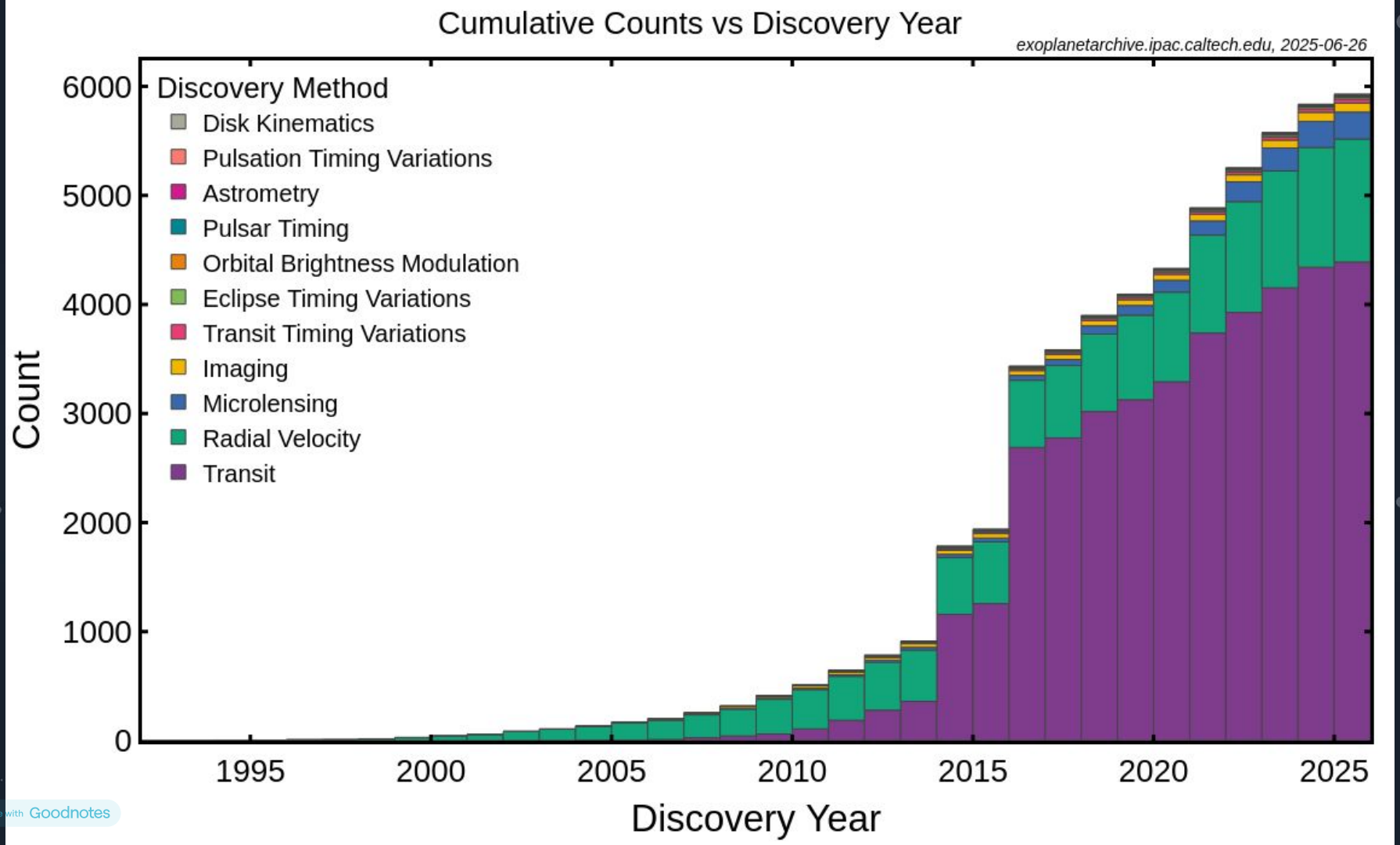
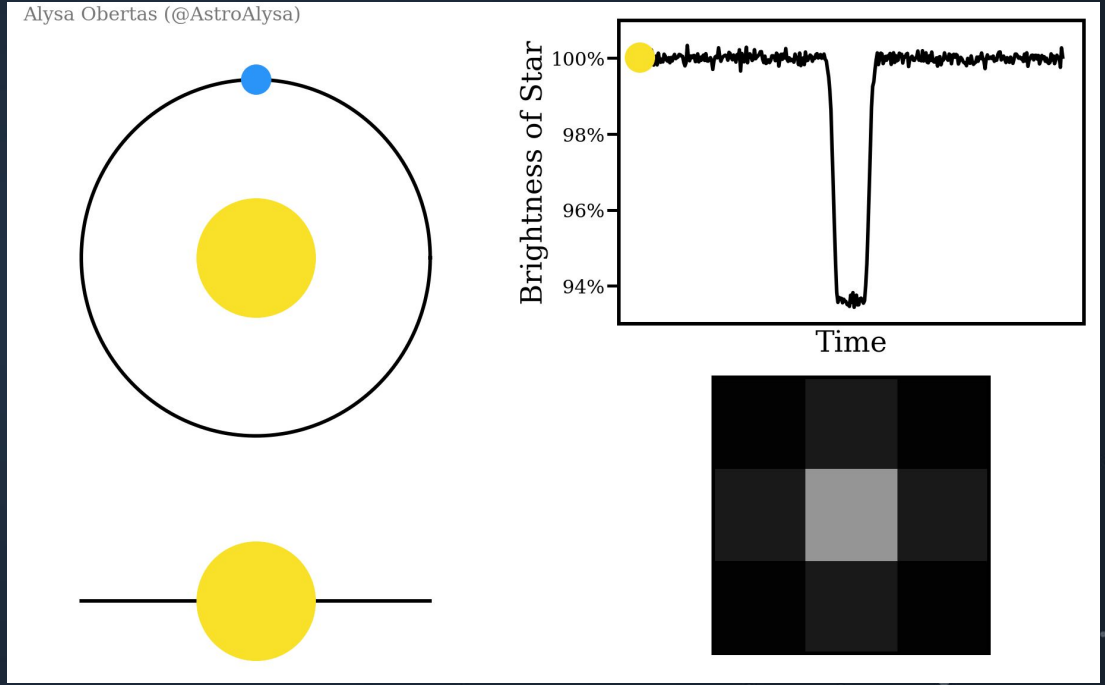


EXOPLANET DETECTION METHODS



METHOD I: THE TRANSIT METHOD

- We can see planets **transit** their stars
- This makes the stars appear fainter for a time!
- We can see this by looking at **light curves** -- time-resolved photometry measurements



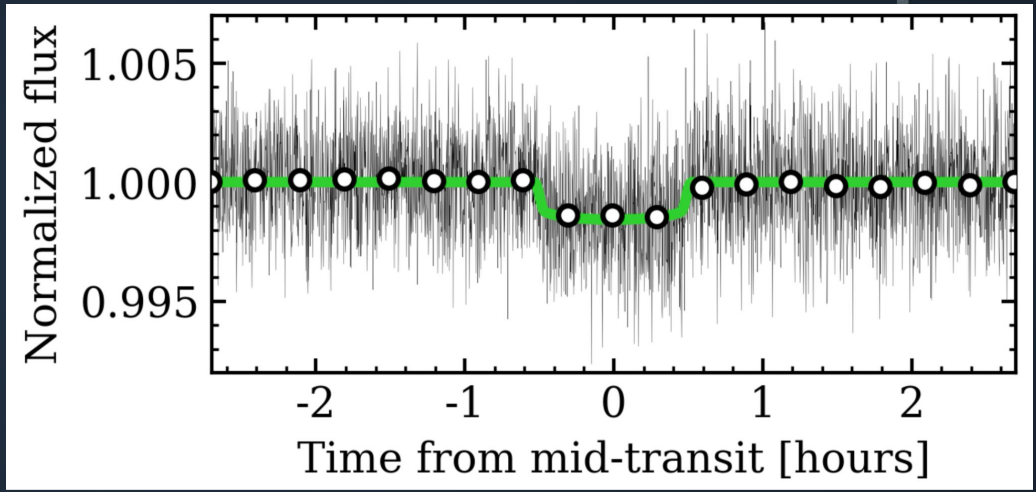
METHOD I: THE TRANSIT METHOD

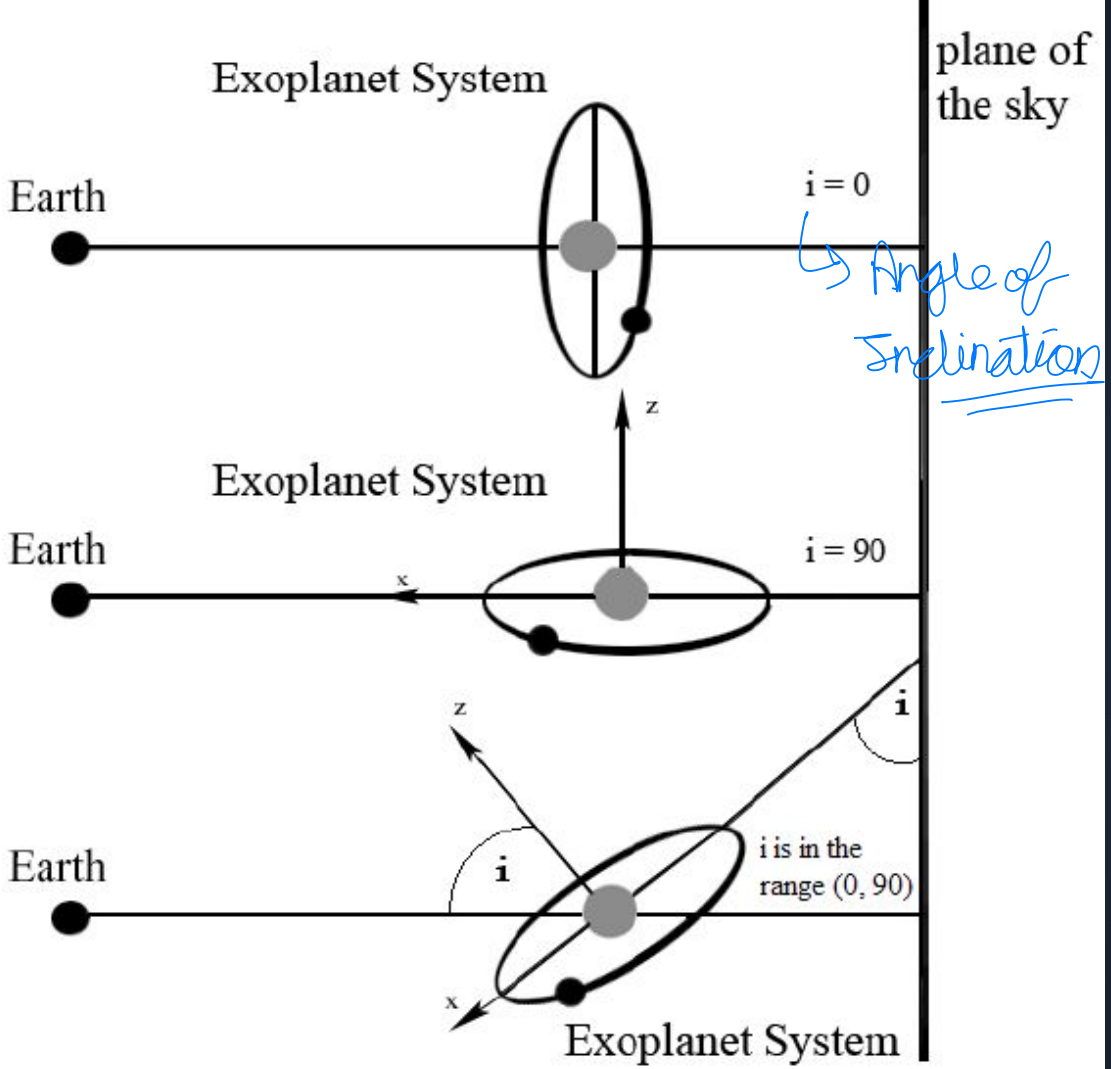
- **Transit depth:**

$$Z = (R_p/R_*)^2$$

(R_p: Radius of Planet; R_*: Radius of star (sun))

- ~1% for Jupiter-sized planets, ~0.01% for Earth-sized planets!
- Can measure planet's period, inclination, and radius



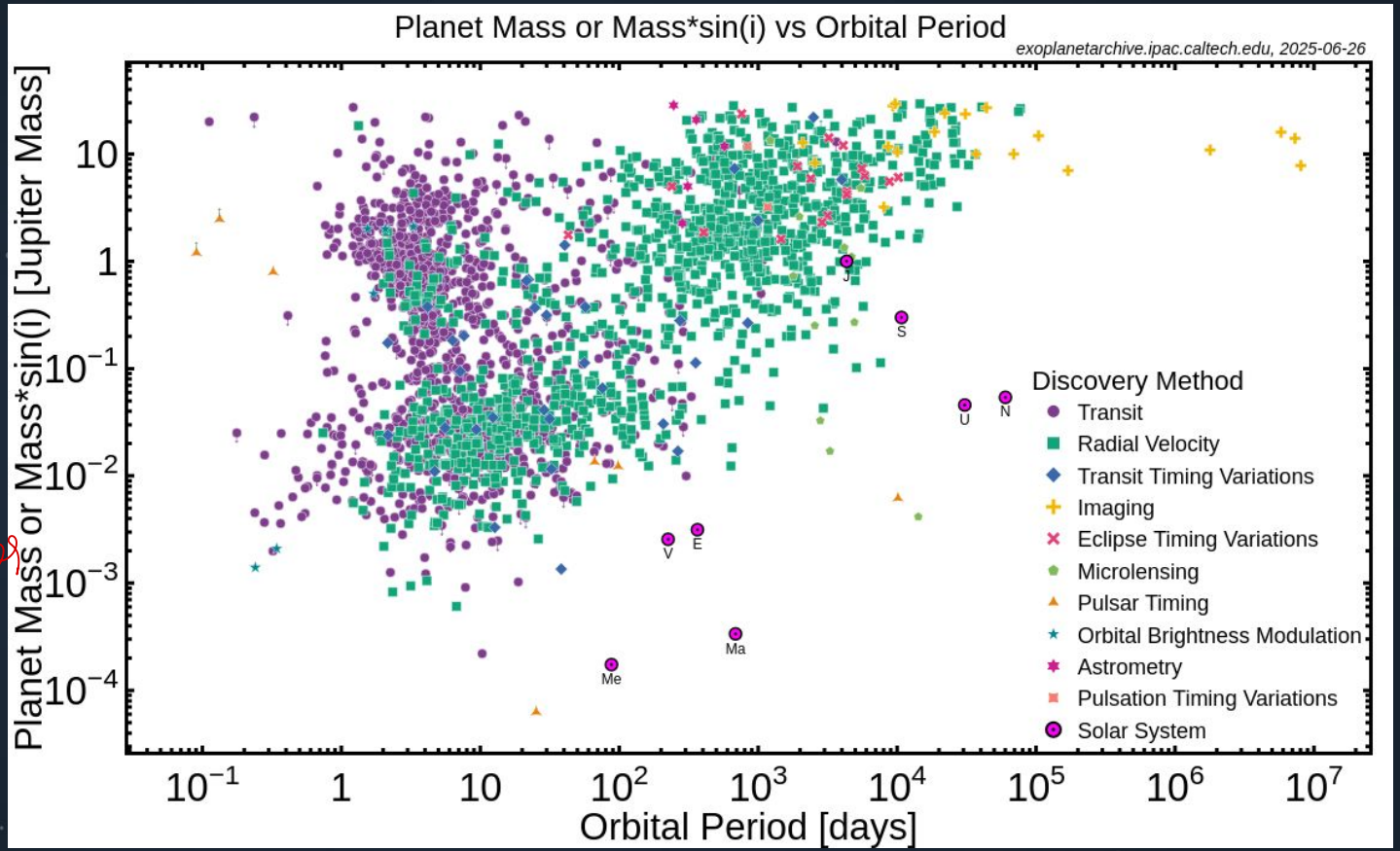


Probability of Planet transit.

$P_{tr} \sim R_*/a$

Radius of star

Semi major axis of Planet or Avg dist Between star and Planet.



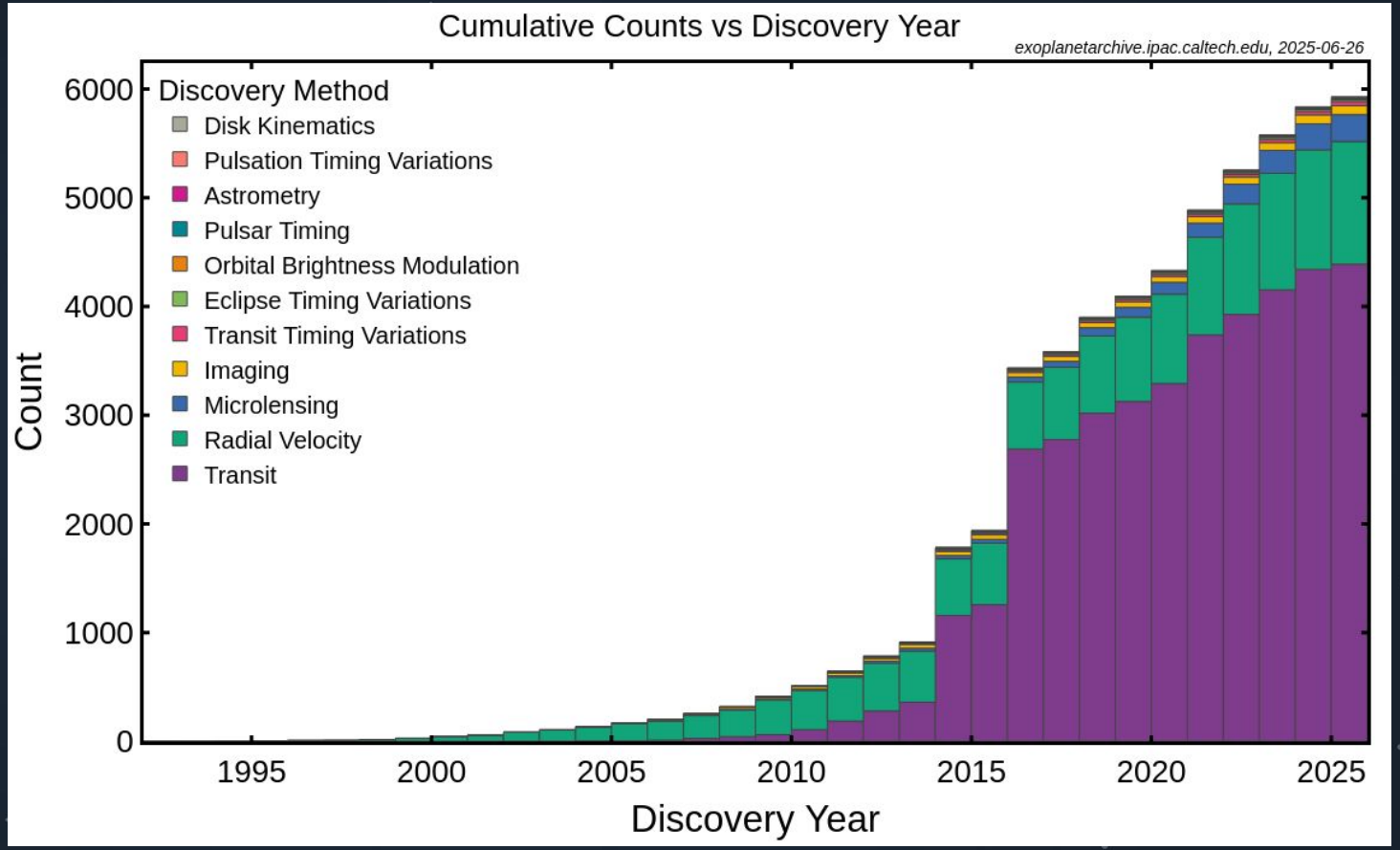
although this method is good but it only effective when the orbit period is low. as you clearly see in the graph. most planets found by transit has less period of time. also its not as efficient for longer period of time.

Telescopes

Kepler ⇒ first telescope sent into space. (2009] ⟶ 2018

TESS → launch in 2018 (able to observe entire sky not just one section like Kepler)

Kepler (and K2) and TESS caused those two jumps!

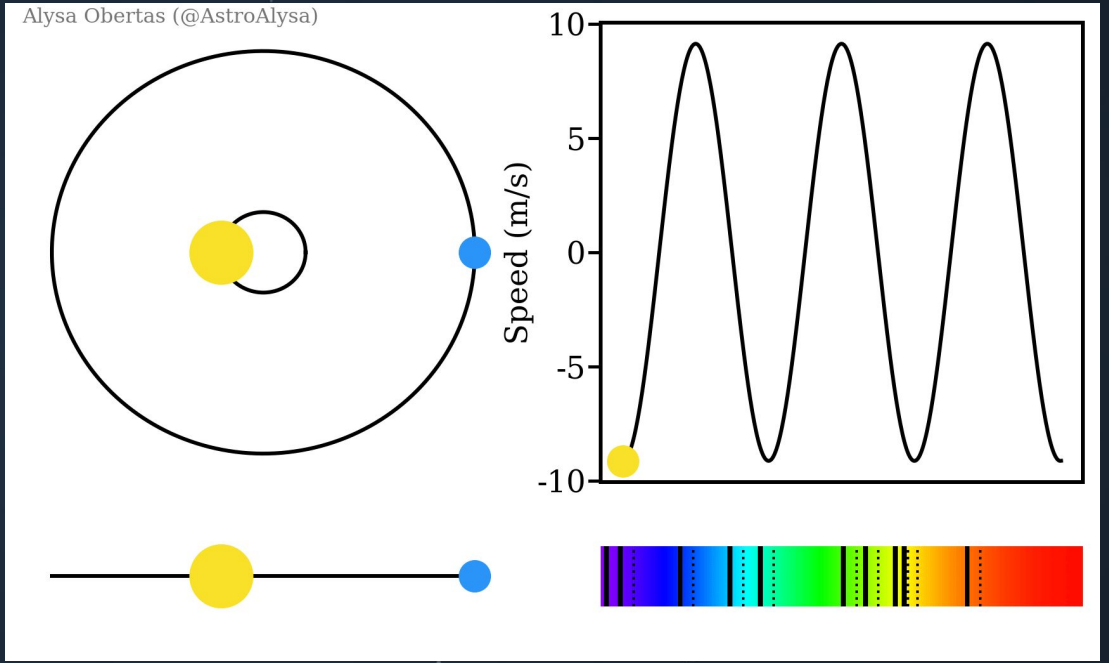


METHOD 2: RADIAL VELOCITIES

- Time-resolved spectroscopy to measure a planet's **Doppler shift**

$$\lambda' = \lambda * \frac{\sqrt{1 + v/c}}{\sqrt{1 - v/c}}$$

- Can measure planet's period, eccentricity, and ***minimum* mass**



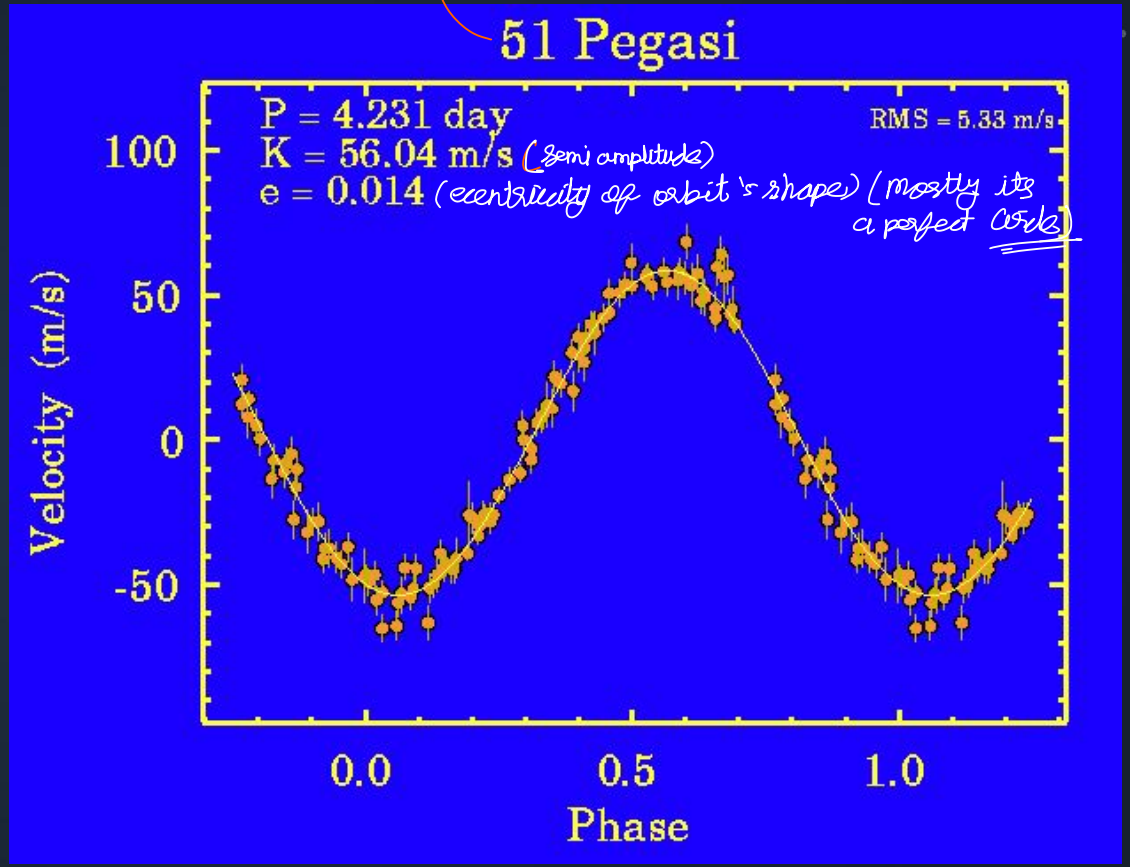
Doplar Effect :-> If a source of light is moving away from observer the light emmiting is Red

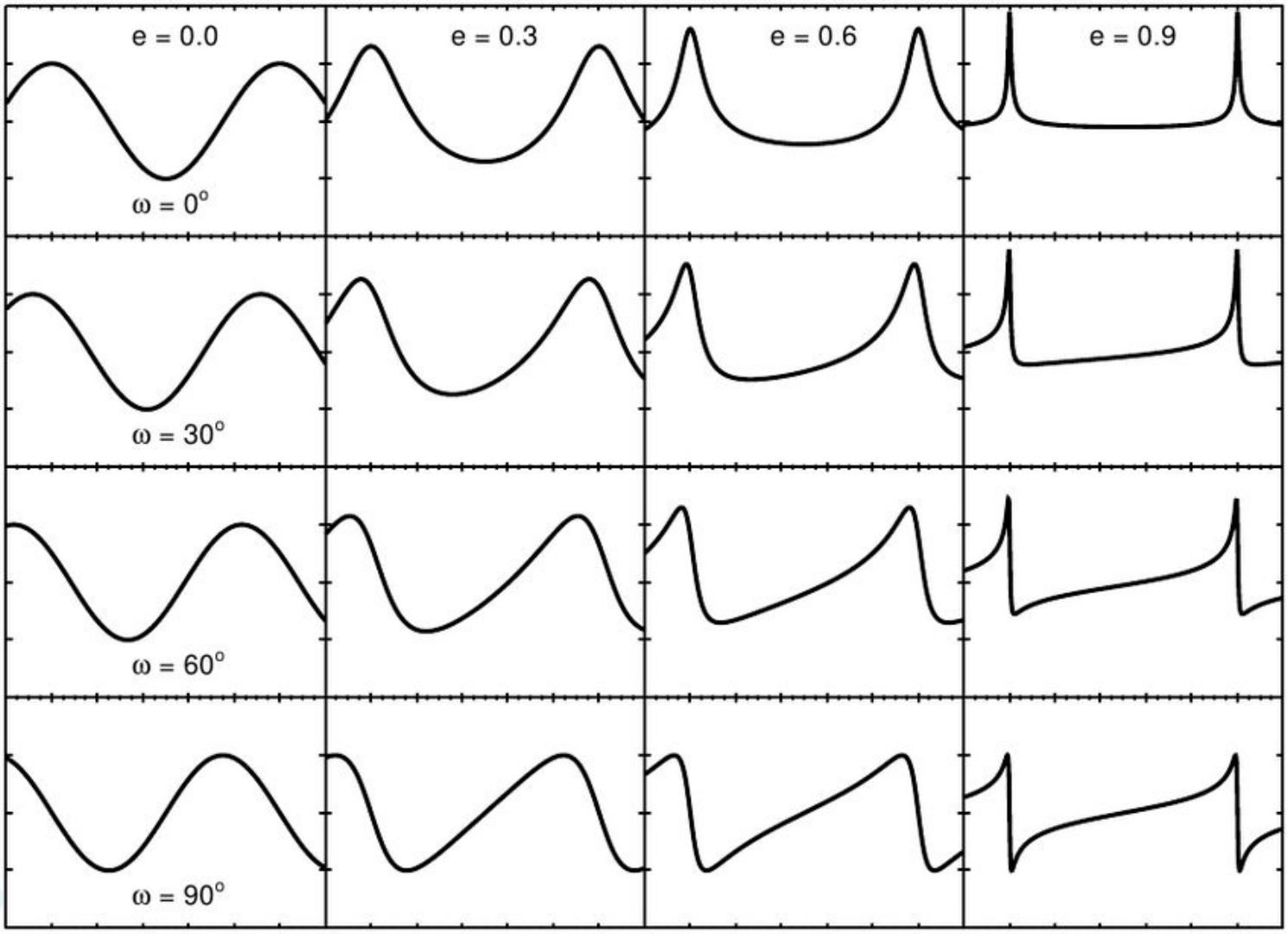
If it is moving towards the observed, the light emmiting is Blue

So In Radial Velocity Method

We measure weather a star is getting slightly redder of Blues. as a planet orbiting around the star, causes the star to wobble back and forth.

- Best instruments in the world (HARPS, NIRPS, MAROON-X, ESPRESSO, etc.) can reach precision of 1 m/s or lower!
- Instruments being built right now will reach precision of 10 cm/s





Semi amplitude

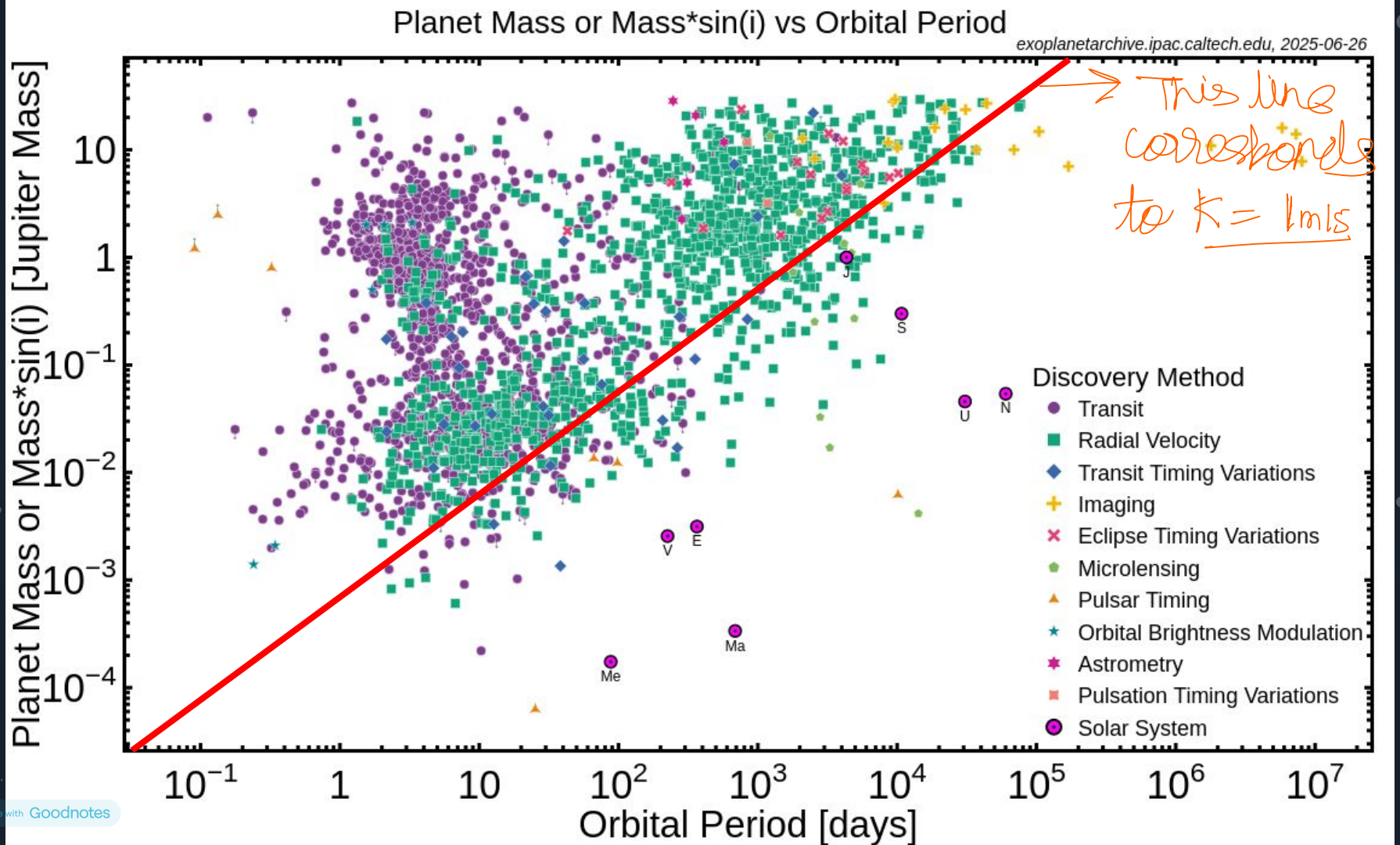
Inclination

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

Min. mass of Planet

Planet Period

Stellar Mass (mass of star)


Planet Mass or Mass*sin(i) vs Orbital Period
exoplanetarchive.ipac.caltech.edu, 2025-06-26
This line corresponds to K = 1m/s
Planet Mass or Mass*sin(i) [Jupiter Mass]
Orbital Period [days]
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Astrometry
Pulsation Timing Variations
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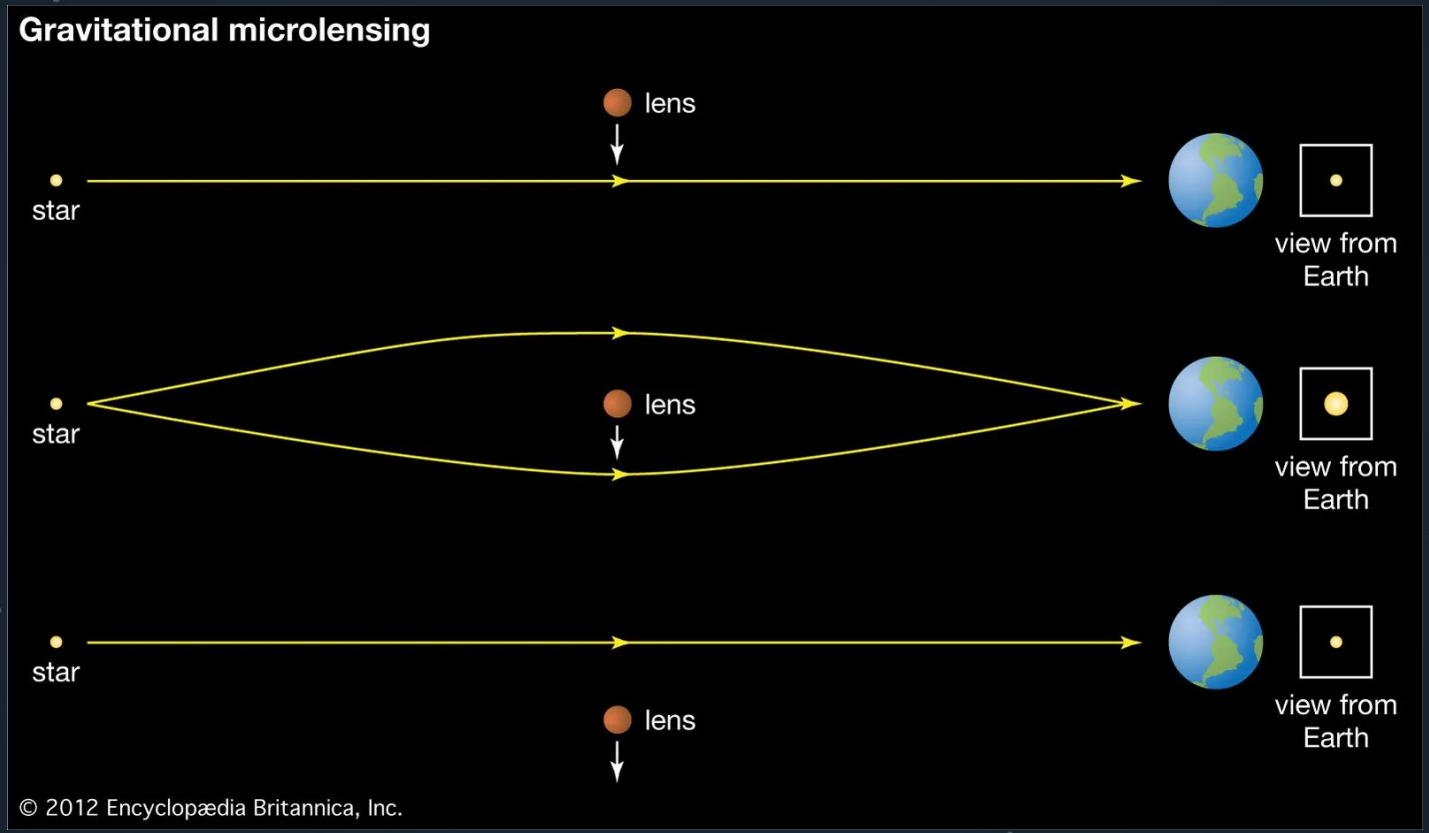
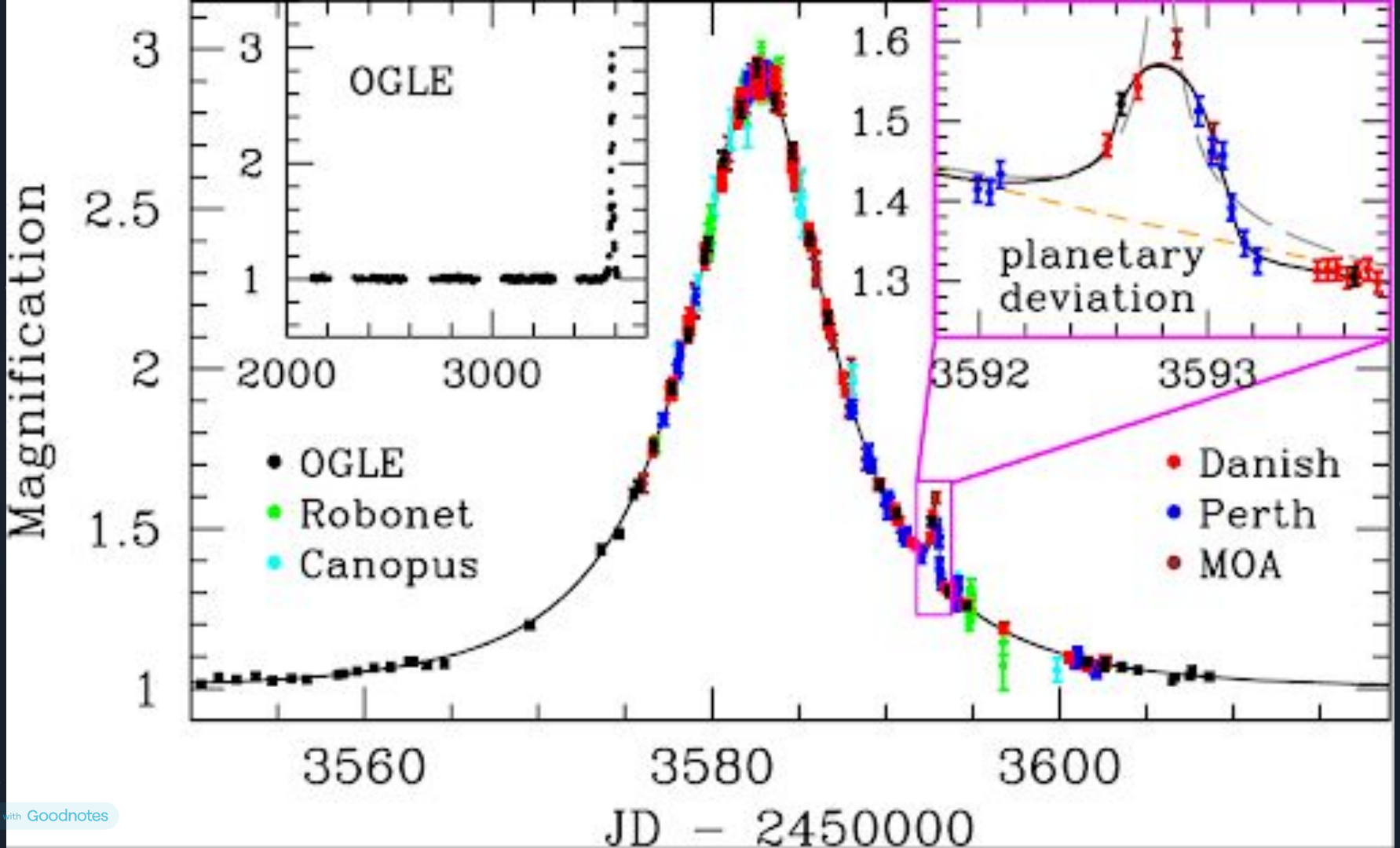
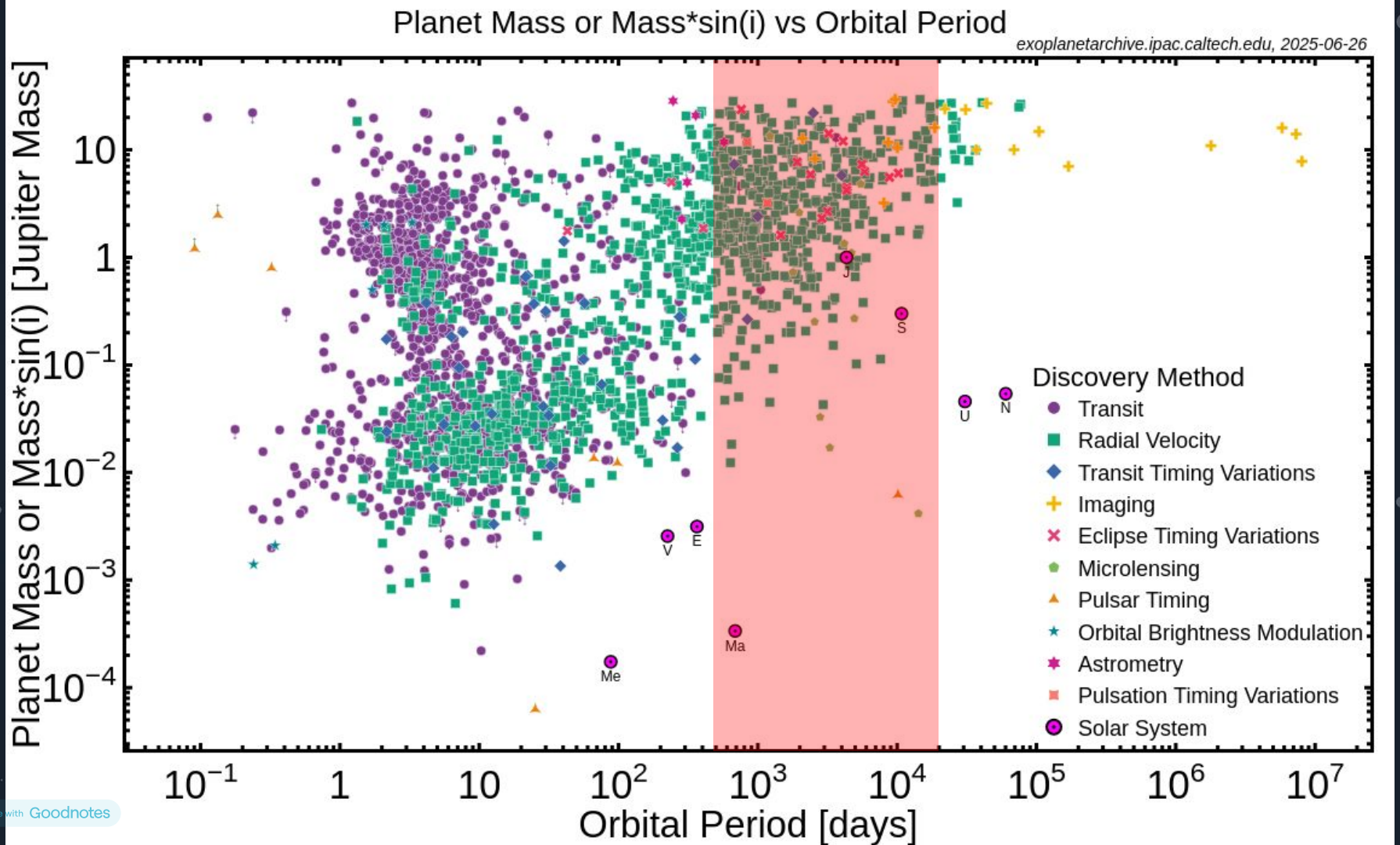
OTHER METHODS

METHOD 3: MICROLENSING



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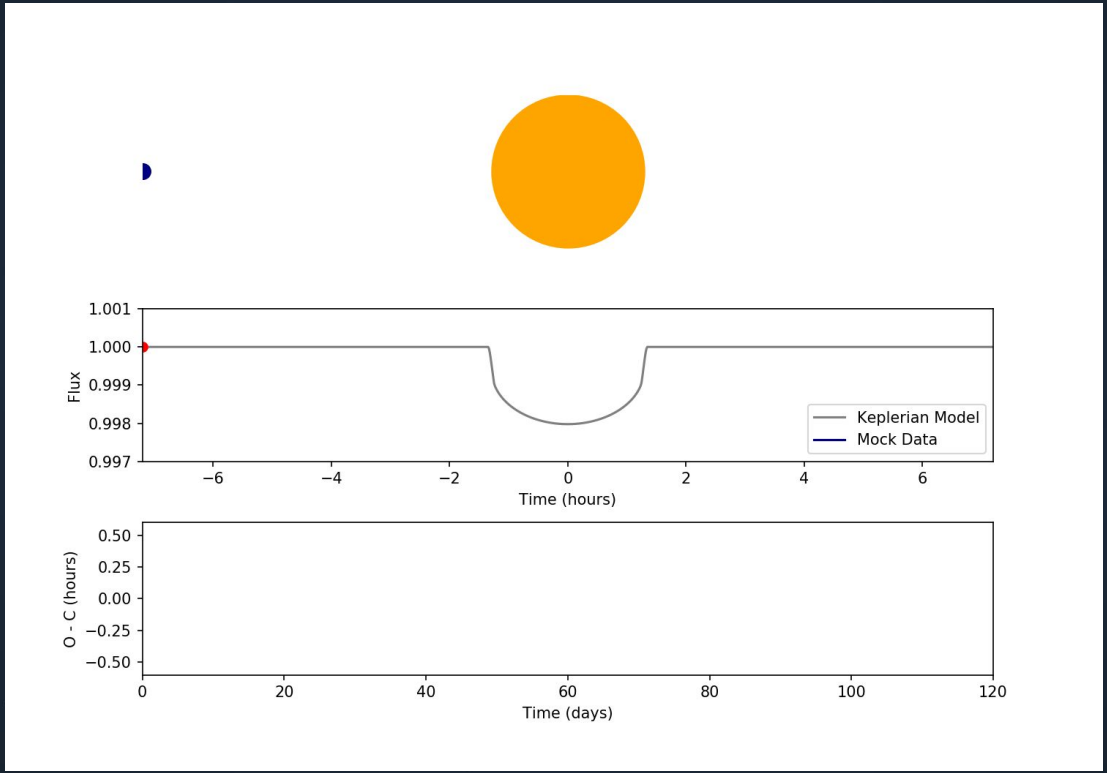
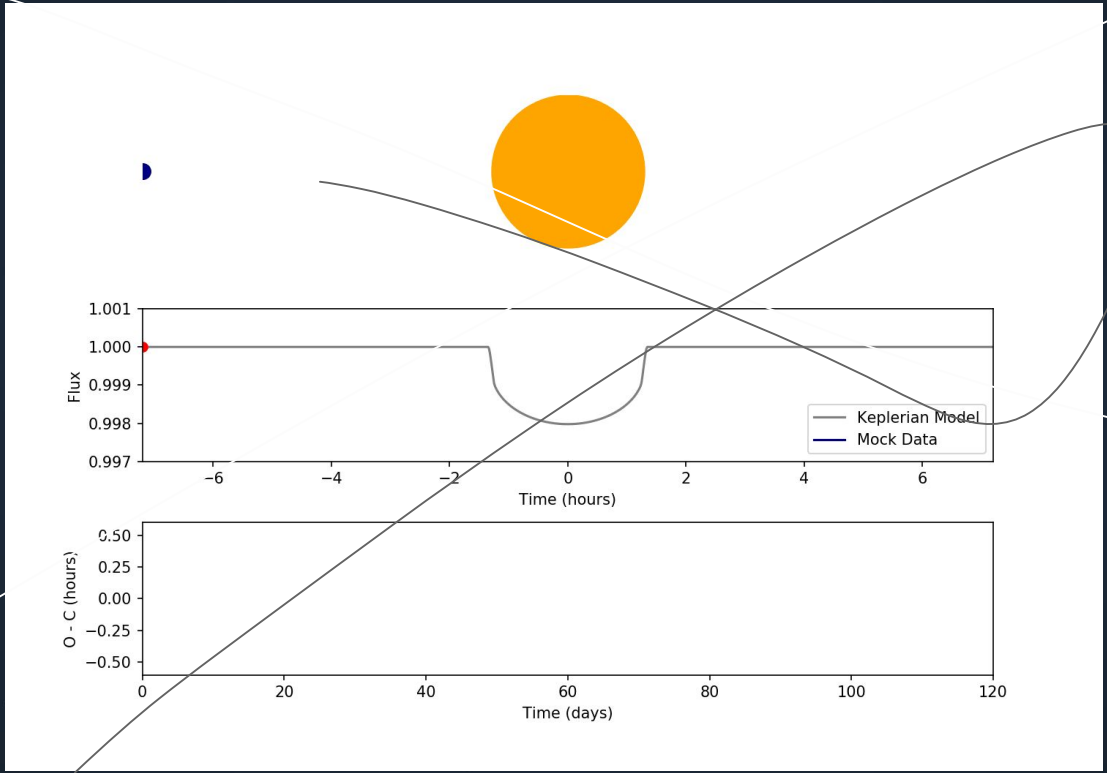
METHOD 4: TRANSIT TIMING VARIATIONS



Animations: Juliette Becker

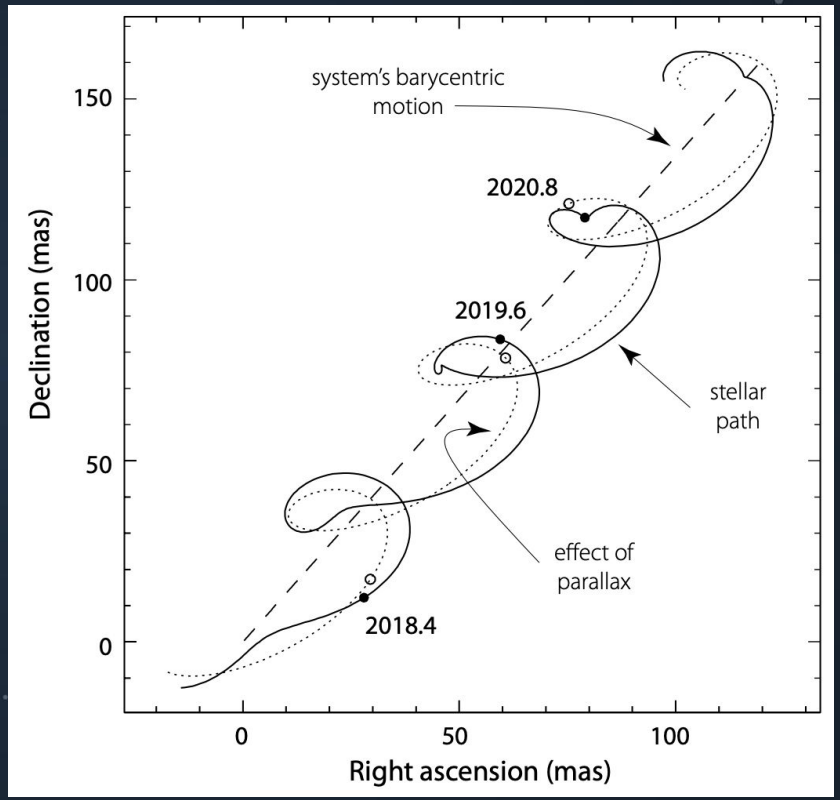
METHOD 4: TRANSIT TIMING VARIATIONS

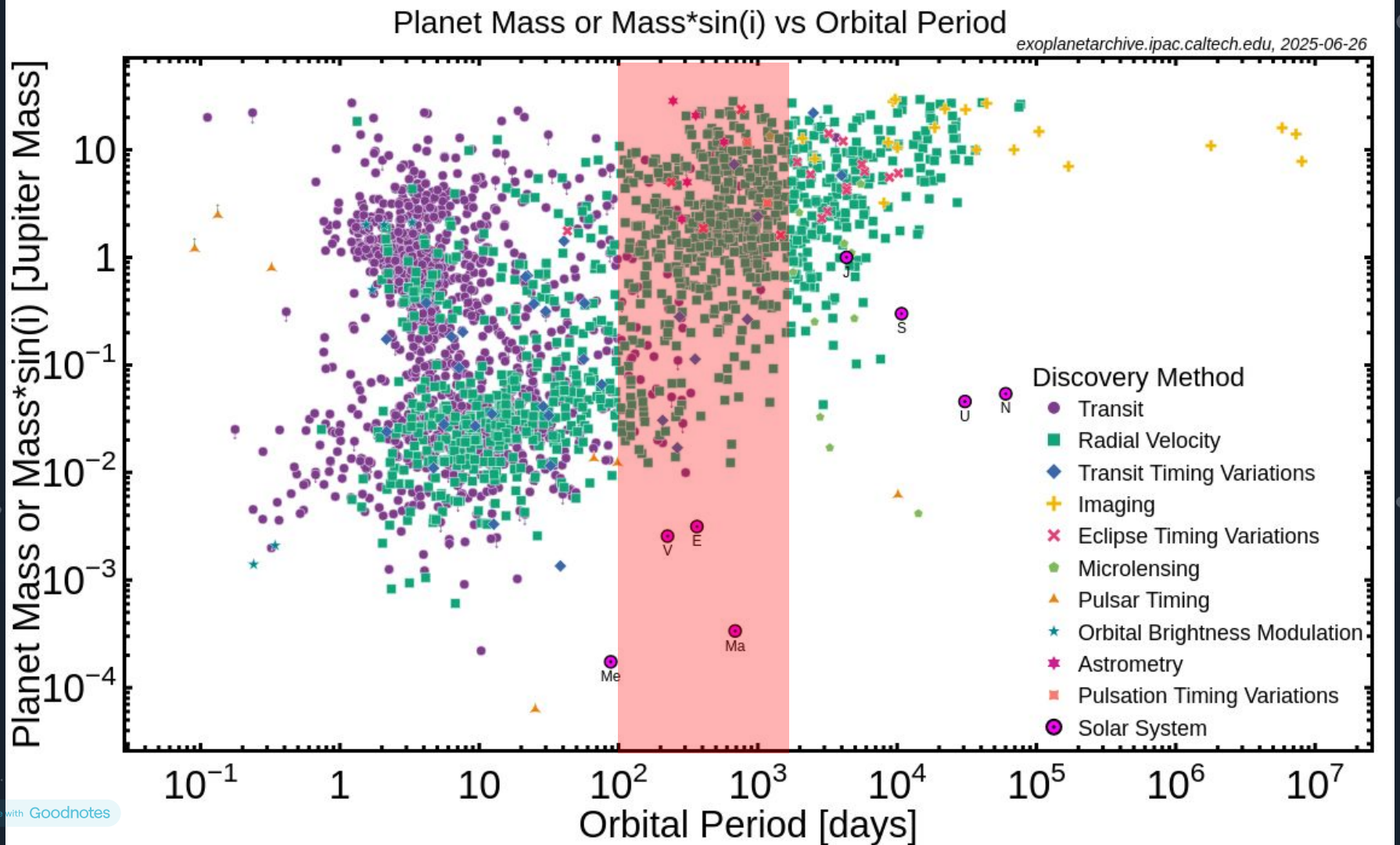


Animations: Juliette Becker

METHOD 5: ASTROMETRY (Brother of radial velocity)

- Observe change in location of star due to planet motion
- REALLY hard to do, because stars barely move! Especially relative to motion of Earth around Sun or star's proper motion
- Final data from *Gaia* coming next year, should increase number of planets detected this way from 5 to ~many thousands
- Can tell period, eccentricity, minimum mass

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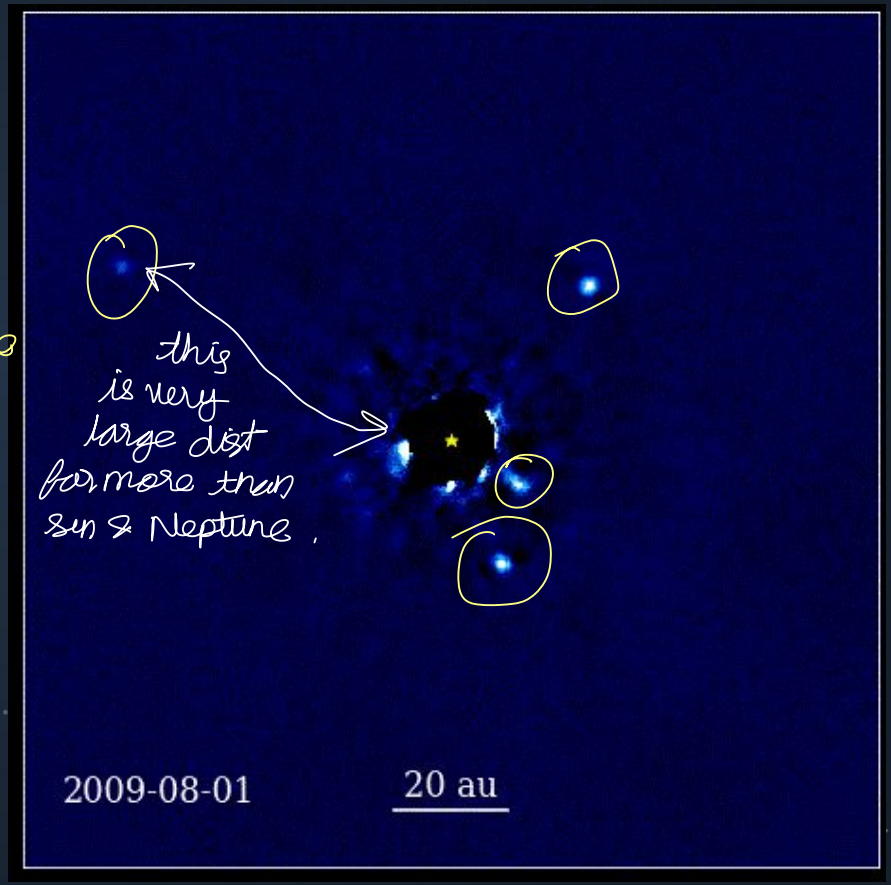
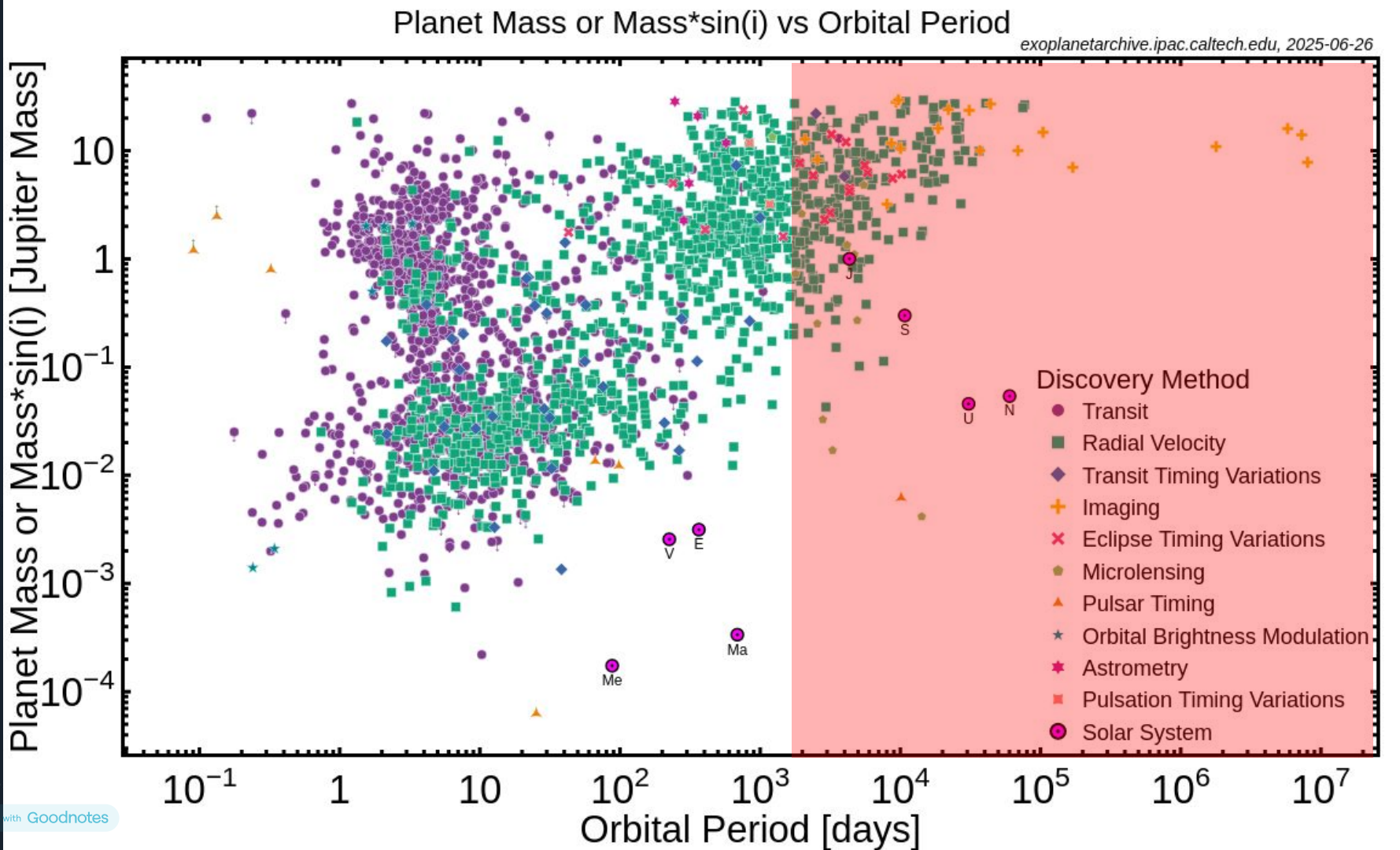
METHOD 6: DIRECT IMAGING

- See planets directly with big telescopes!
- Block out star with a **coronagraph** → a big metal disk which Blocks out the star.
- Only works on *big*, young planets really far away!
- Can tell planet period, eccentricity, rough idea of planet mass/size from brightness

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