

Hot Jupiters are not as Lonely as we thought

AAS 242 | 06.06.23

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underscored material = new
[bracketed material] = delete

1 HOUSE JOINT MEMORIAL 54
2 **48TH LEGISLATURE - STATE OF NEW MEXICO - FIRST SESSION, 2007**
3 INTRODUCED BY
4 Joni Marie Gutierrez
5
6
7
8
9
10 A JOINT MEMORIAL
11 DECLARING PLUTO A PLANET AND DECLARING MARCH 13, 2007, "PLUTO
12 PLANET DAY" AT THE LEGISLATURE.
13
14 WHEREAS, the state of New Mexico is a global center for
15 astronomy, astrophysics and planetary science; and
16 WHEREAS, New Mexico is home to world class astronomical
17 observing facilities, such as the Apache Point observatory,
18 the very large array, the Magdalena Ridge observatory and the
19 national solar observatory; and
20 WHEREAS, Apache Point observatory, operated by New Mexico
21 state university, houses the astrophysical research
22 consortium's three-and-one-half meter telescope, as well as
23 the unique two-and-one-half meter diameter Sloan digital sky
24 survey telescope; and
25 WHEREAS, New Mexico state university has the state's only
167359.1

underscored material = new
[bracketed material] = delete

1 independent, doctorate-granting astronomy department; and
2 WHEREAS, New Mexico state university and Dona Ana county
3 were the longtime home of Clyde Tombaugh, discoverer of Pluto;
4 and
5 WHEREAS, Pluto has been recognized as a planet for
6 seventy-five years; and
7 WHEREAS, Pluto's average orbit is three billion six
8 hundred ninety-five million nine hundred fifty thousand miles
9 from the sun, and its diameter is approximately one thousand
10 four hundred twenty-one miles; and
11 WHEREAS, Pluto has three moons known as Charon, Nix and
12 Hydra; and
13 WHEREAS, a spacecraft called new horizons was launched in
14 January 2006 to explore Pluto in the year 2015;
15 NOW, THEREFORE, BE IT RESOLVED BY THE LEGISLATURE OF THE
16 STATE OF NEW MEXICO that, as Pluto passes overhead through New
17 Mexico's excellent night skies, it be declared a planet and
18 that March 13, 2007 be declared "Pluto Planet Day" at the
19 legislature.
20 - 2 -
21
22
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25 167359.1

as Pluto passes overhead through New Mexico's excellent night skies, it be declared a planet

2023-06-06 20:15 UTC

The Sky ^{LIVE}

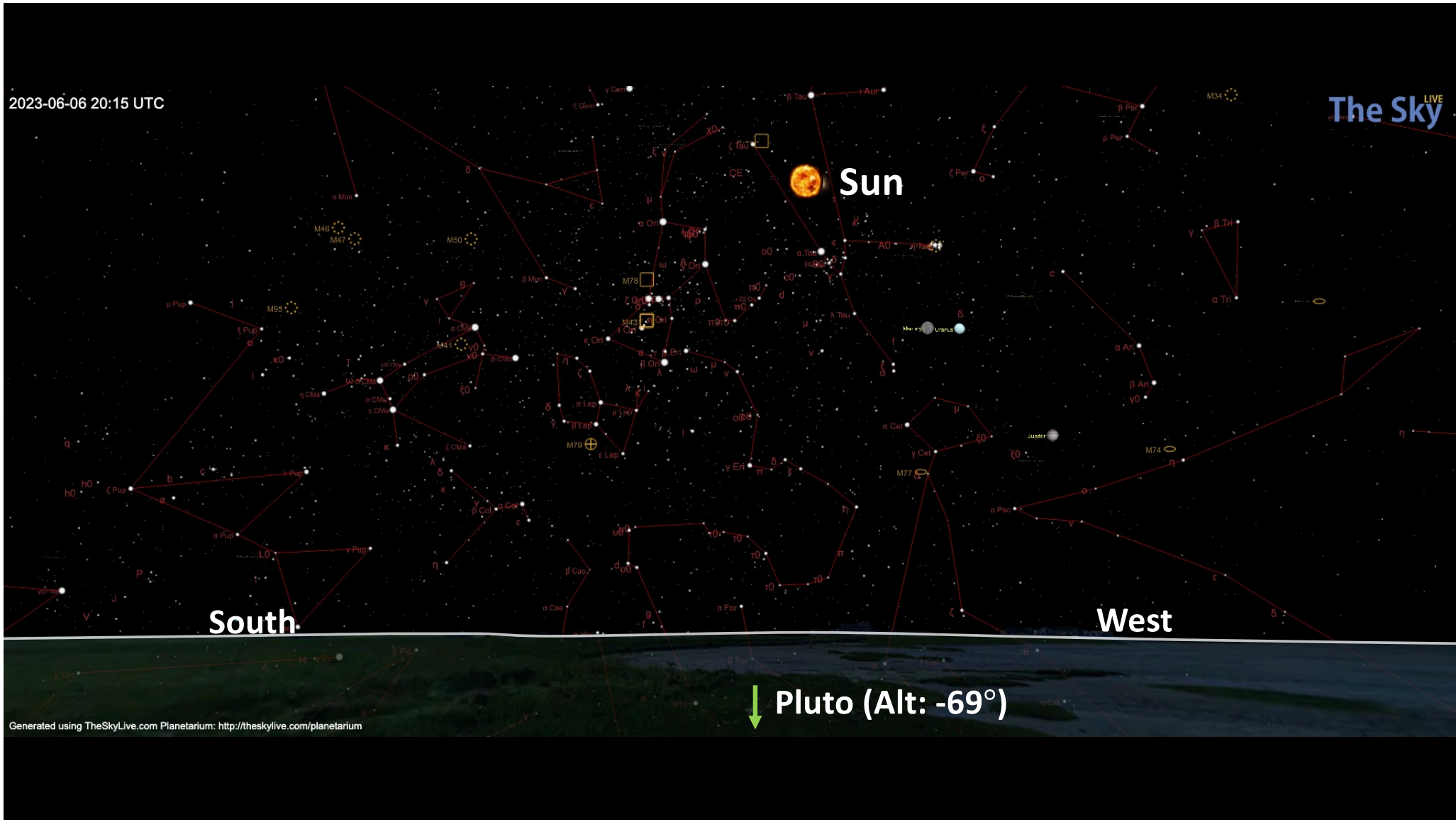
Sun

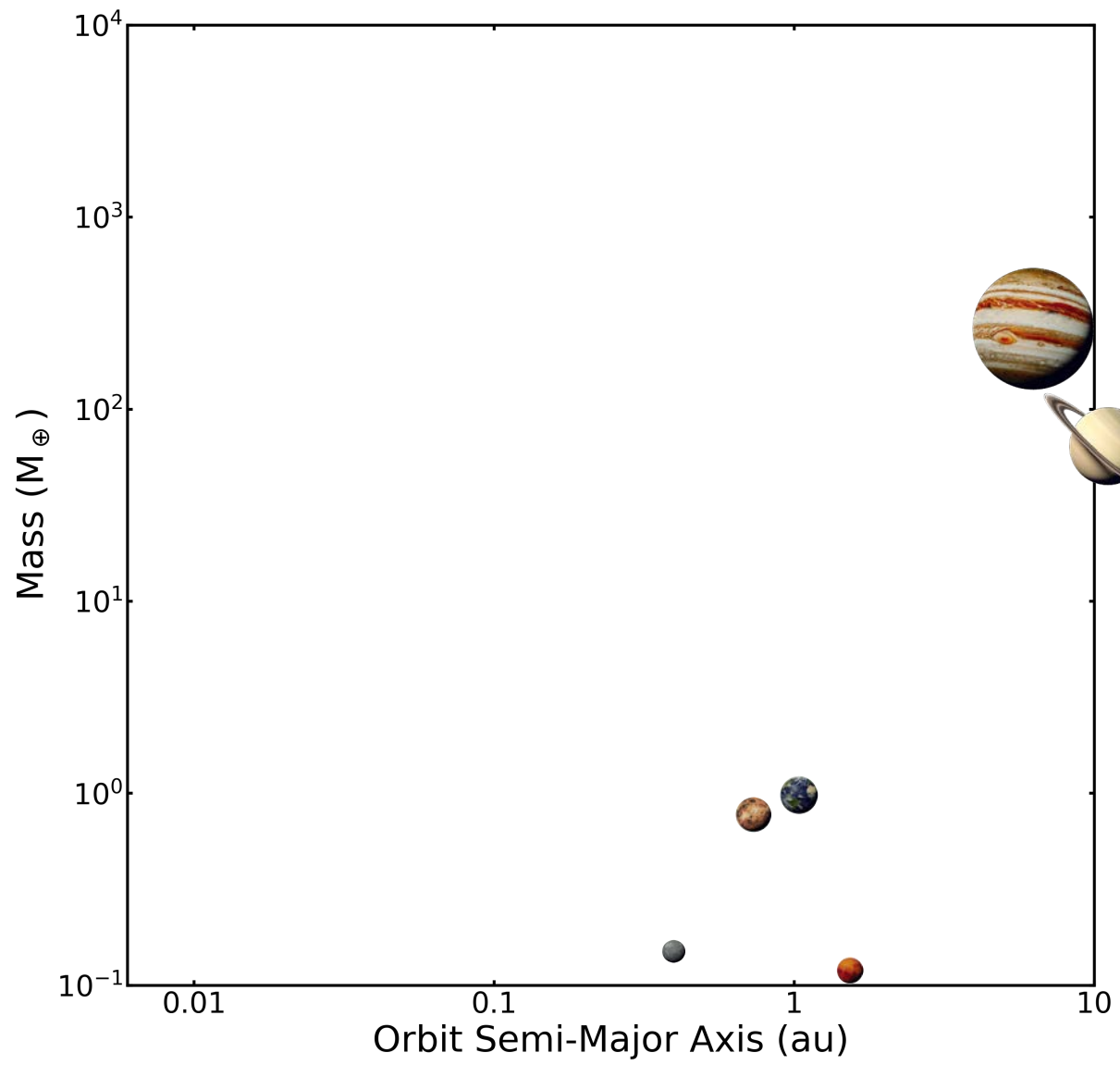
South

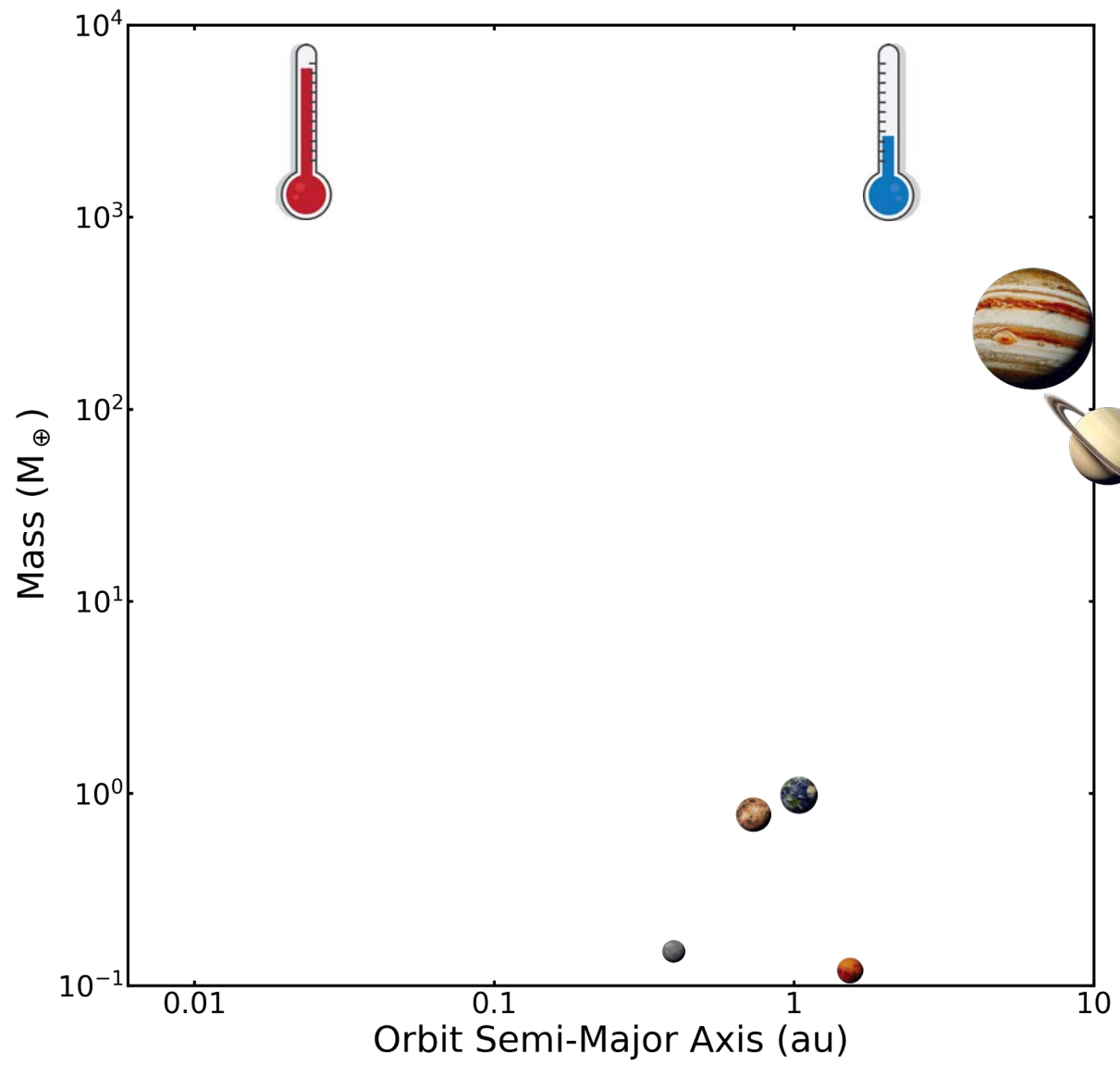
West

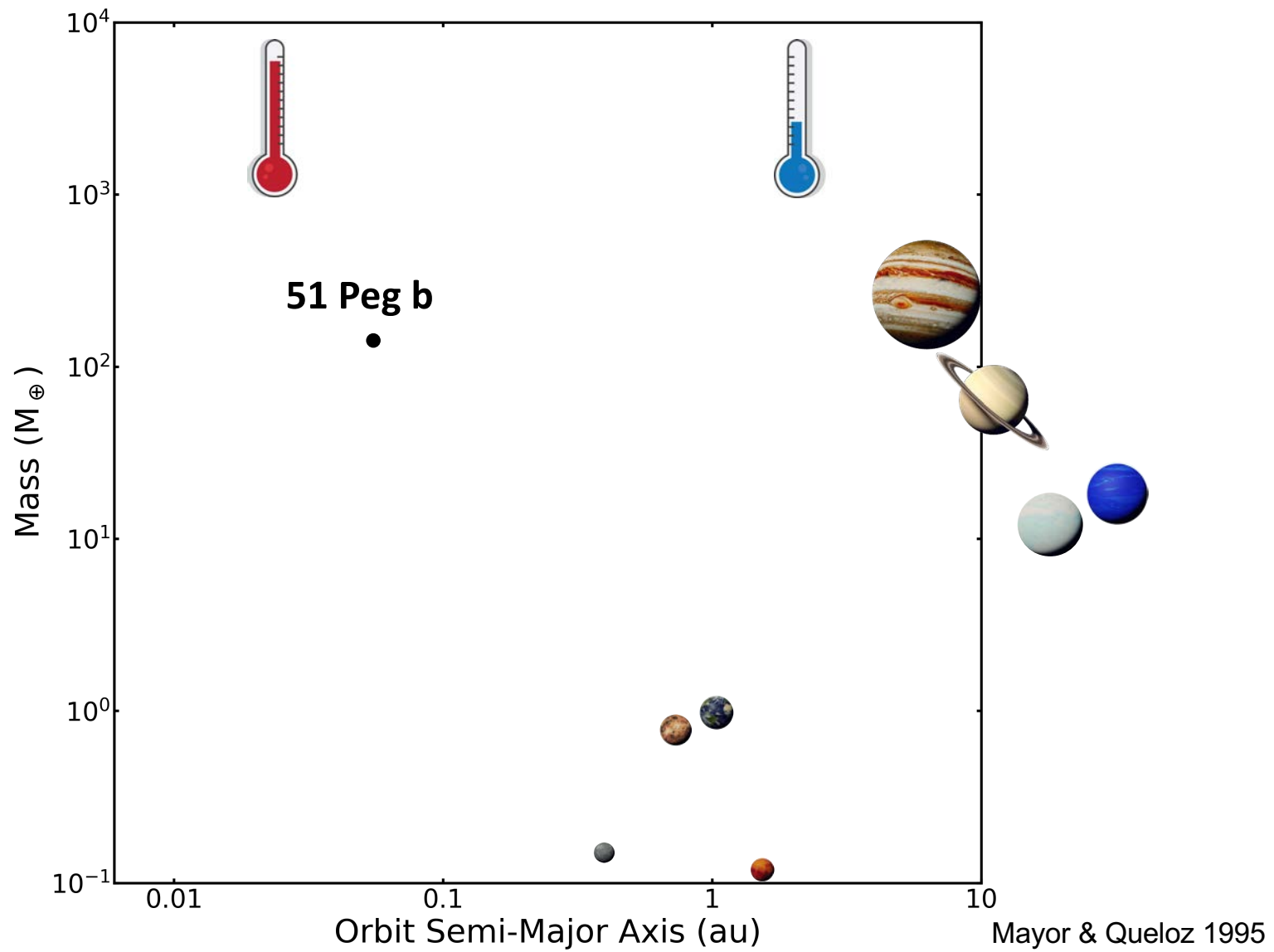
↓ Pluto (Alt: -69°)

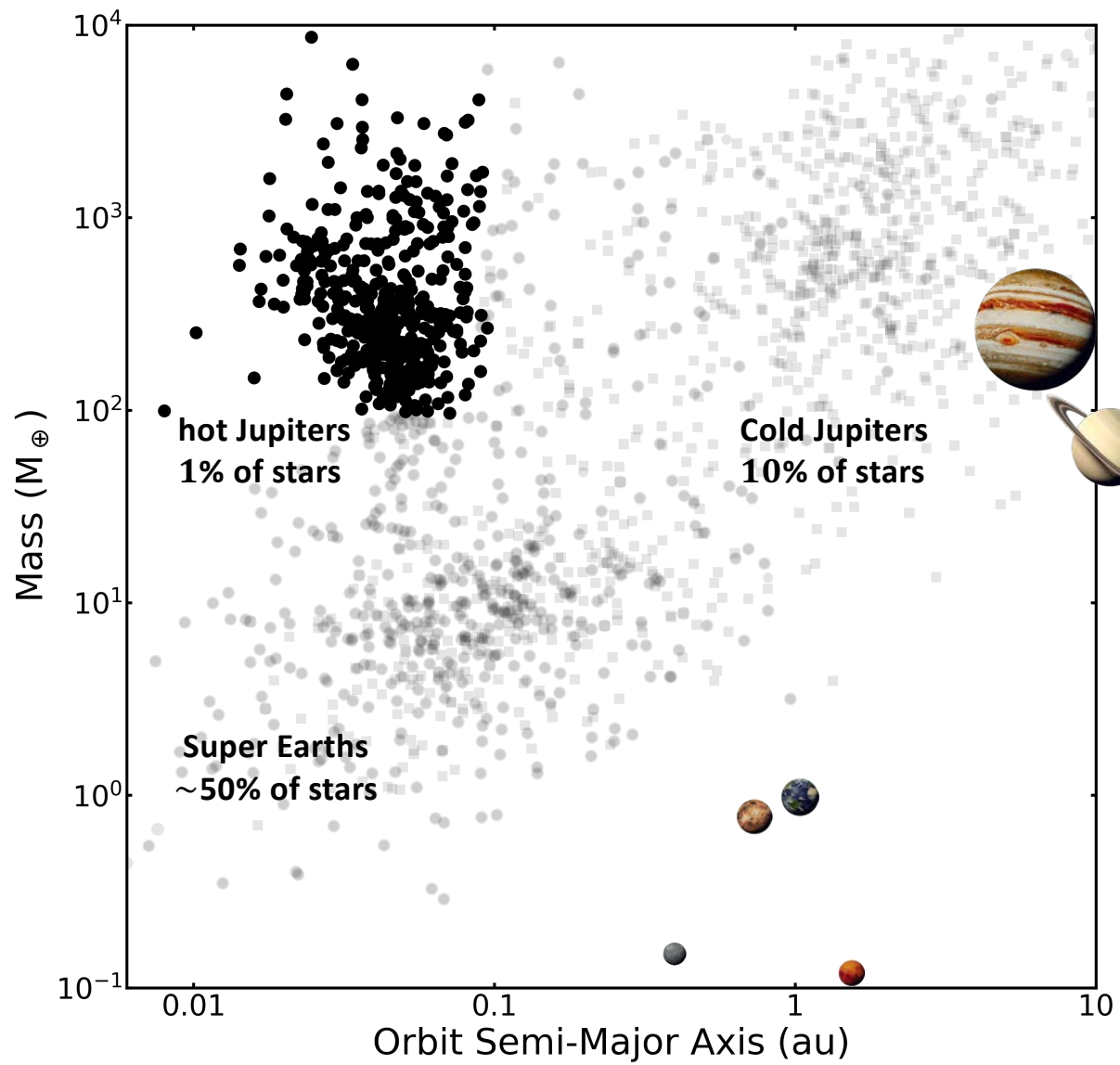
Generated using TheSkyLive.com Planetarium: <http://theskylive.com/planetarium>





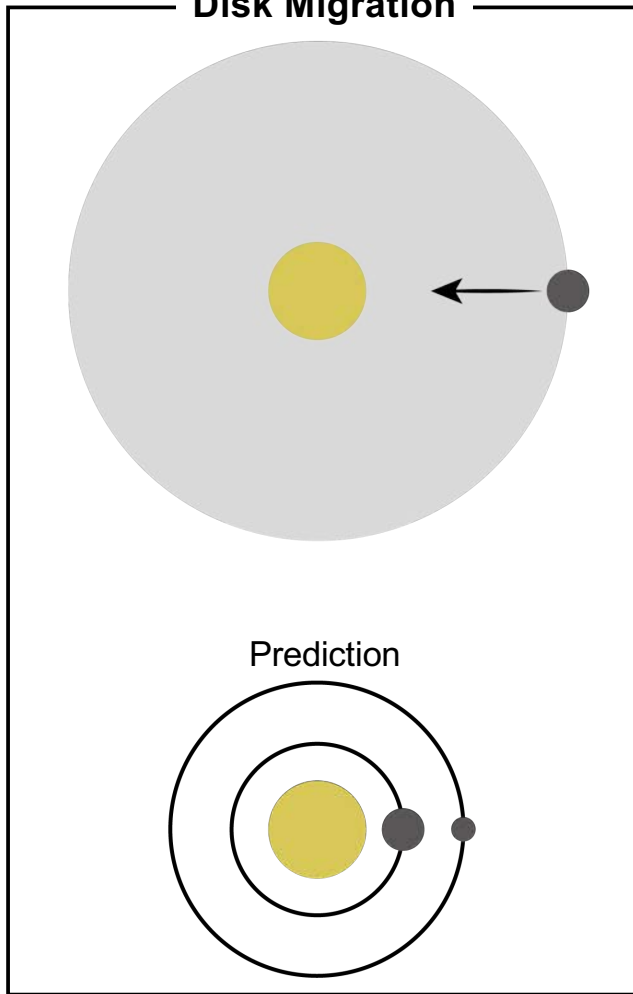




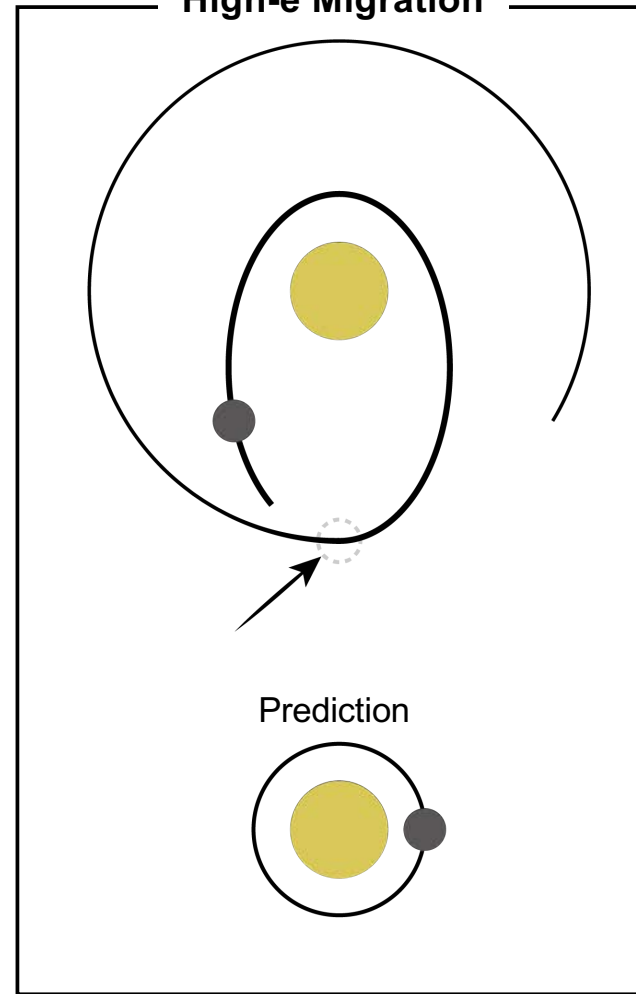


Competing Formation Mechanisms

Disk Migration



High-e Migration



Celebrate Math Awareness Month [Shop Now](#)



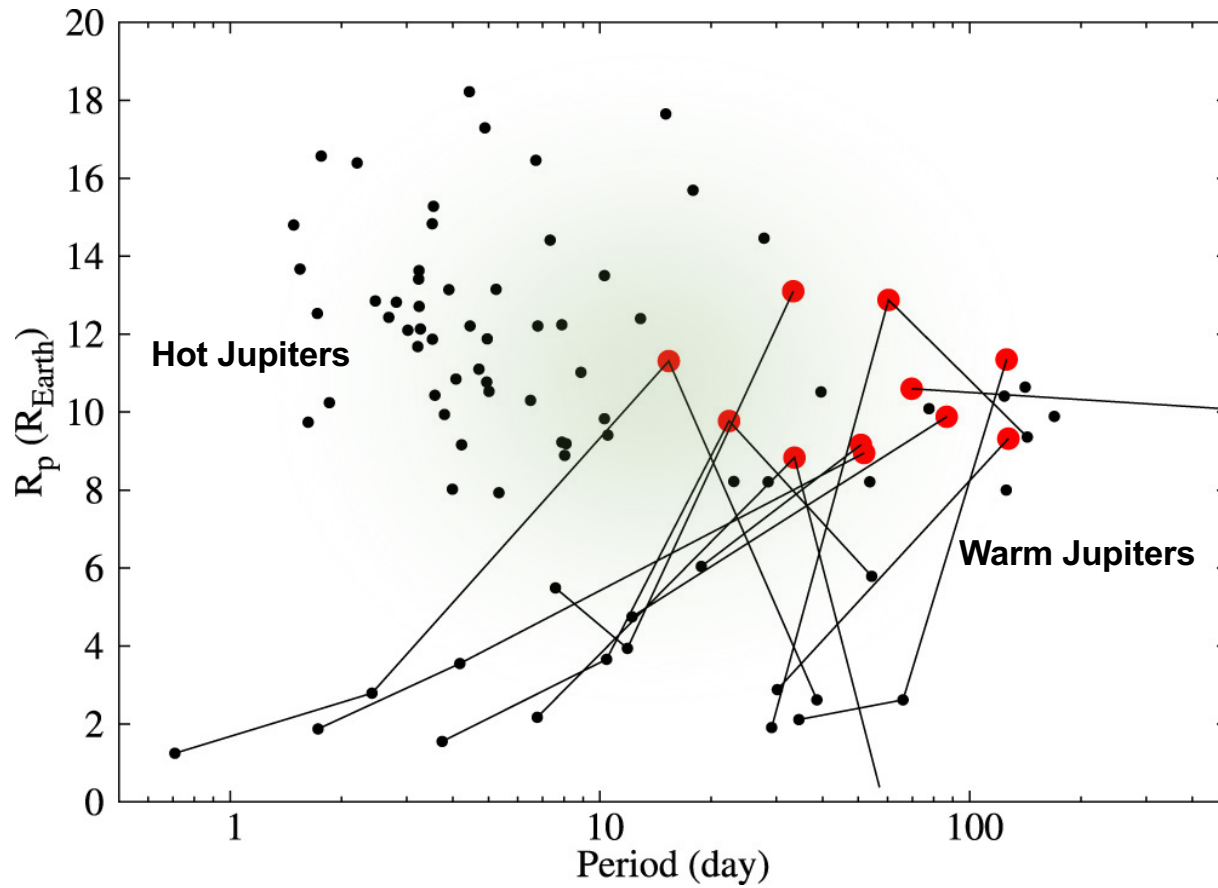
Lonely Planets: Hot Jupiters Are Isolated

By Caleb A. Scharf on May 7, 2012

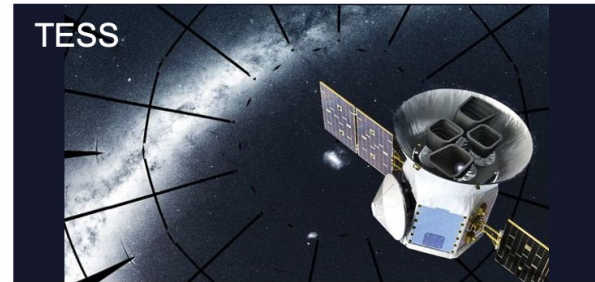
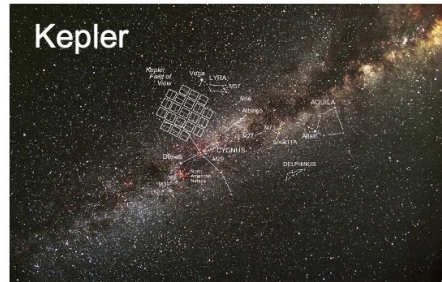
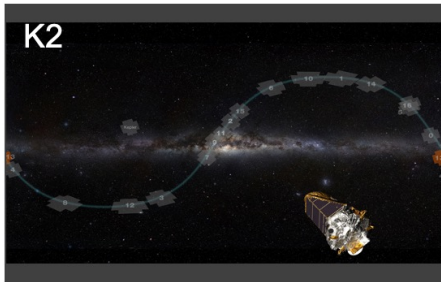
Hot Jupiters are special beasts in the exoplanetary menagerie. These giant worlds orbit their parent stars incredibly tightly, sometimes zipping around in barely a day or two, and so close that they can disturb the stellar atmosphere itself - as well as throwing themselves at the mercy of gravitational tides and scorching radiation.

They were also the very first type of exoplanets to be

Confirmation of Hot Jupiters' Isolation



First Exceptions

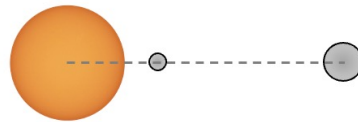


Wasp-47



Becker et al. 2015

Kepler-730

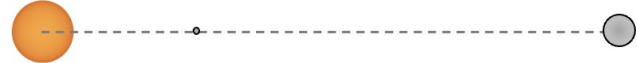


Canas, **Wang S.** et al. 2018

TOI-1130



WASP-132













Huang et al. 2020

Hord et al. 2022

Tess Survey: Hot Jupiters Are Still Lonely

A Uniform Search for Nearby Planetary Companions to Hot Jupiters in TESS Data Reveals Hot Jupiters Are Still Lonely

Benjamin J. Hord^{1,2,3} , Knicole D. Colón^{2,3} , Veselin Kostov^{2,3} ,
Brianna Galgano^{2,4} , George R. Ricker⁵ , Roland Vanderspek⁵ ,
S. Seager^{5,6,7} , Joshua N. Winn⁸ , Jon M. Jenkins⁹ , Thomas Barclay^{2,10} 

[+ Show full author list](#)

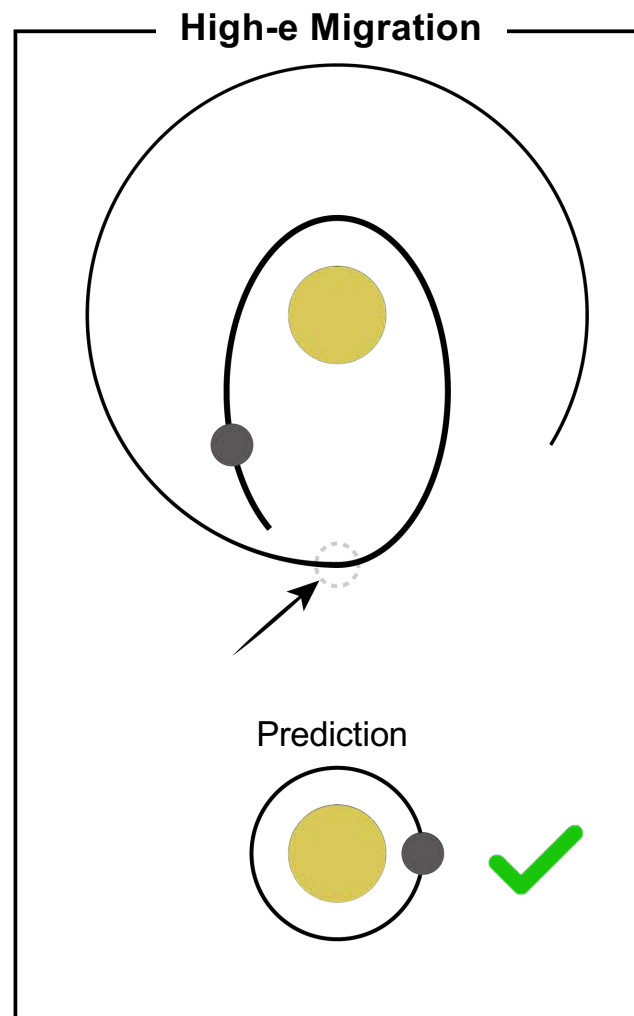
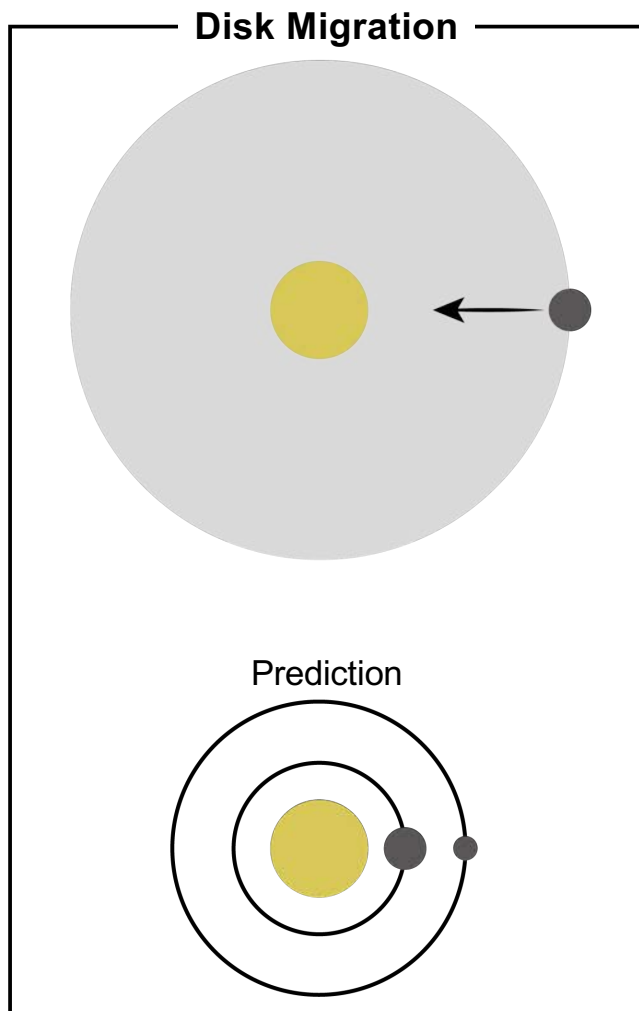
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[The Astronomical Journal](#), [Volume 162](#), [Number 6](#)

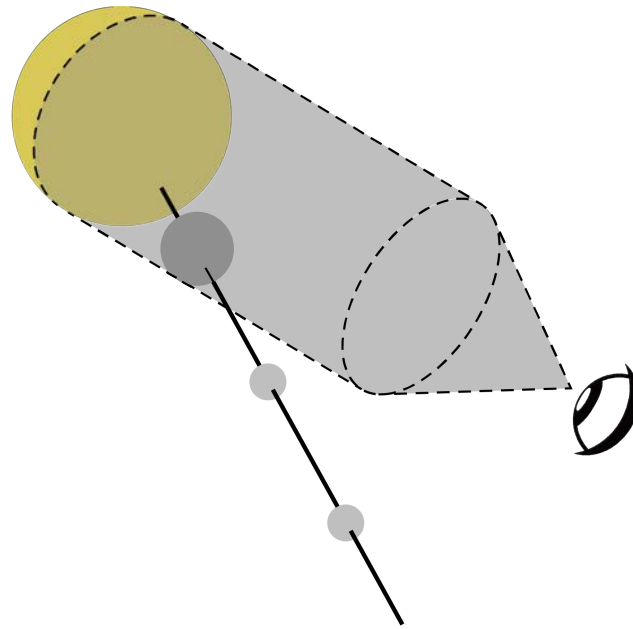
Citation Benjamin J. Hord *et al* 2021 *AJ* **162** 263

Hord et al. 2021

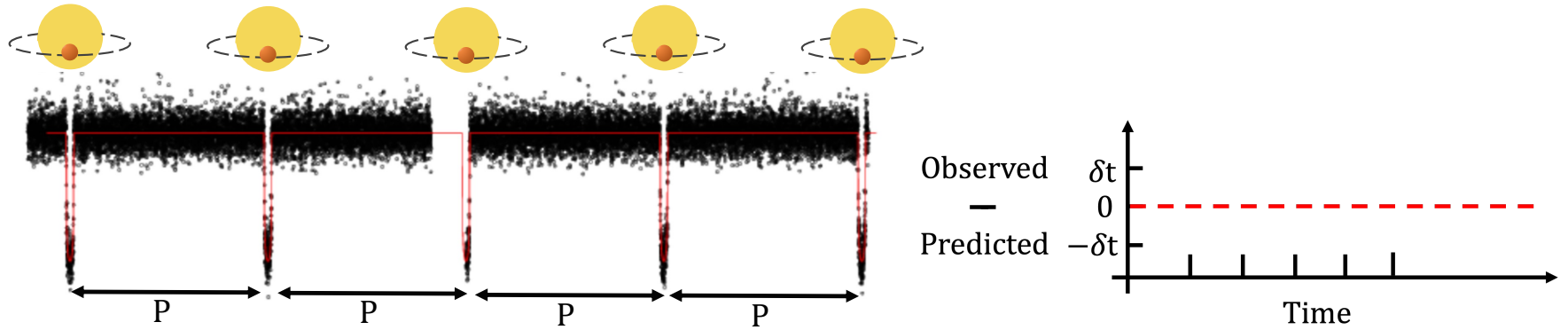
Support High-e Migration



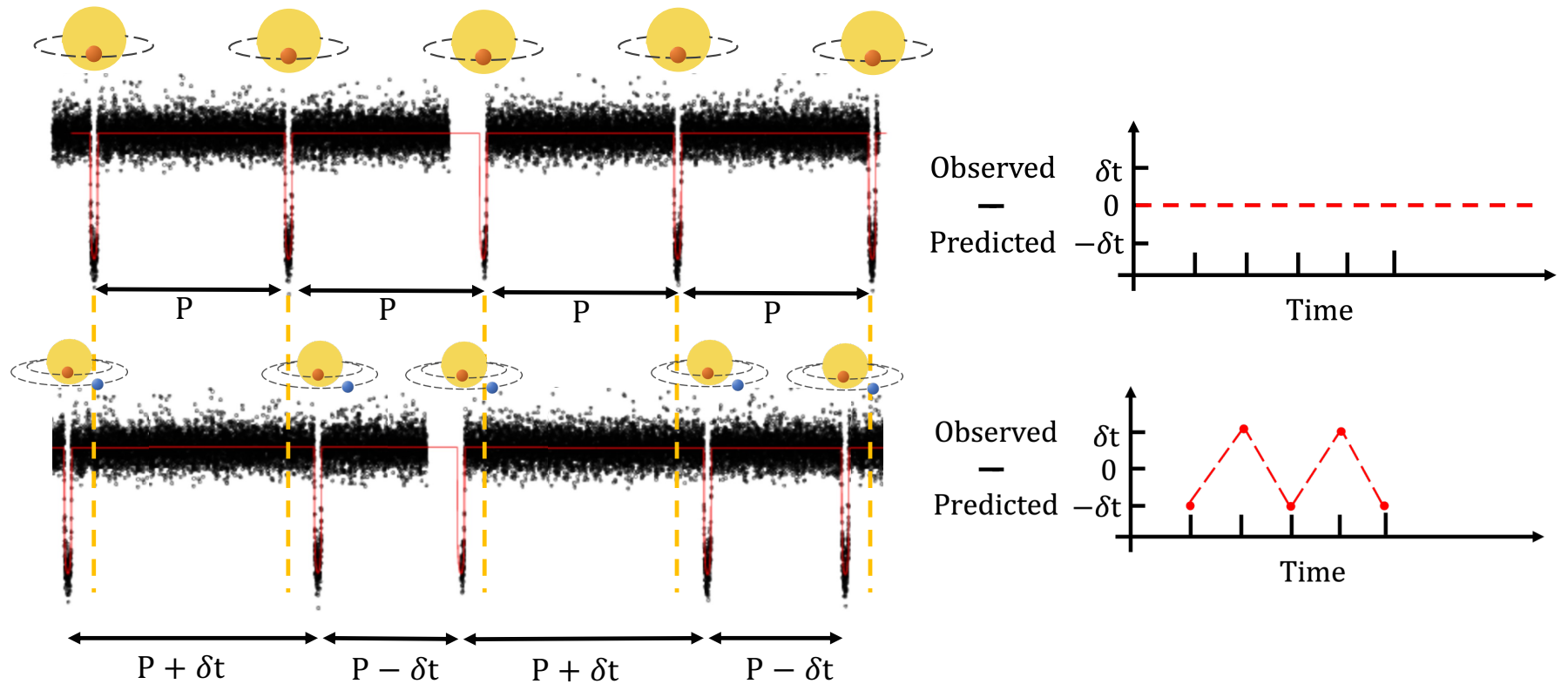
Hard to detect longer period/inclined companion



Transit Timing Variation (TTV)



Transit Timing Variation (TTV)



Limitation for Previous TTV Search



Q1-6



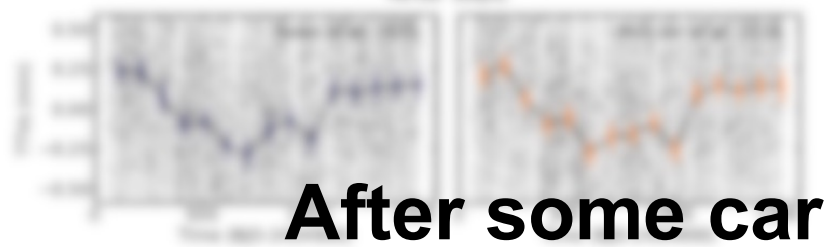
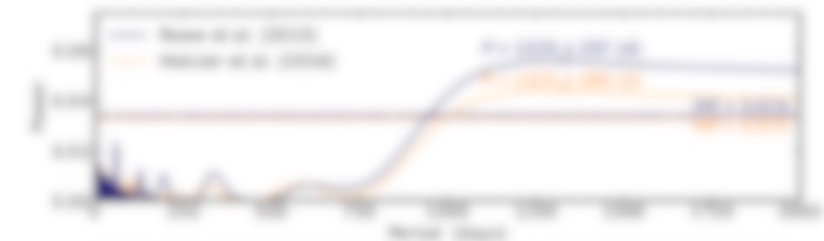
Steffen et al. 2012



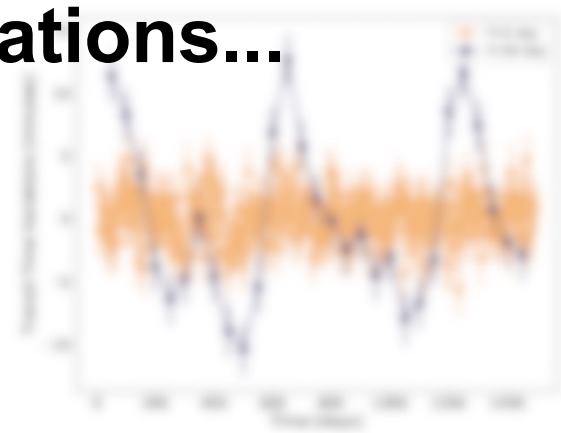
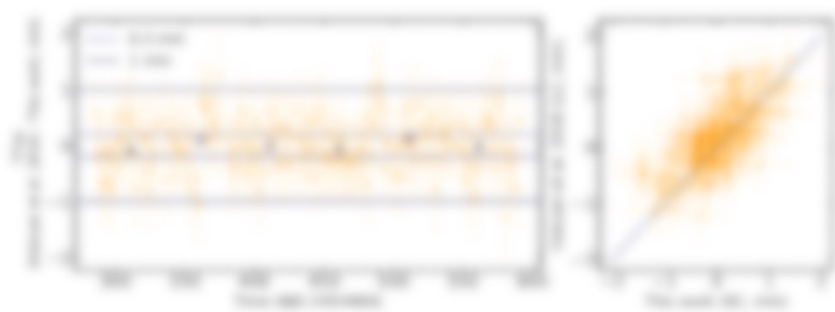
Q1-17



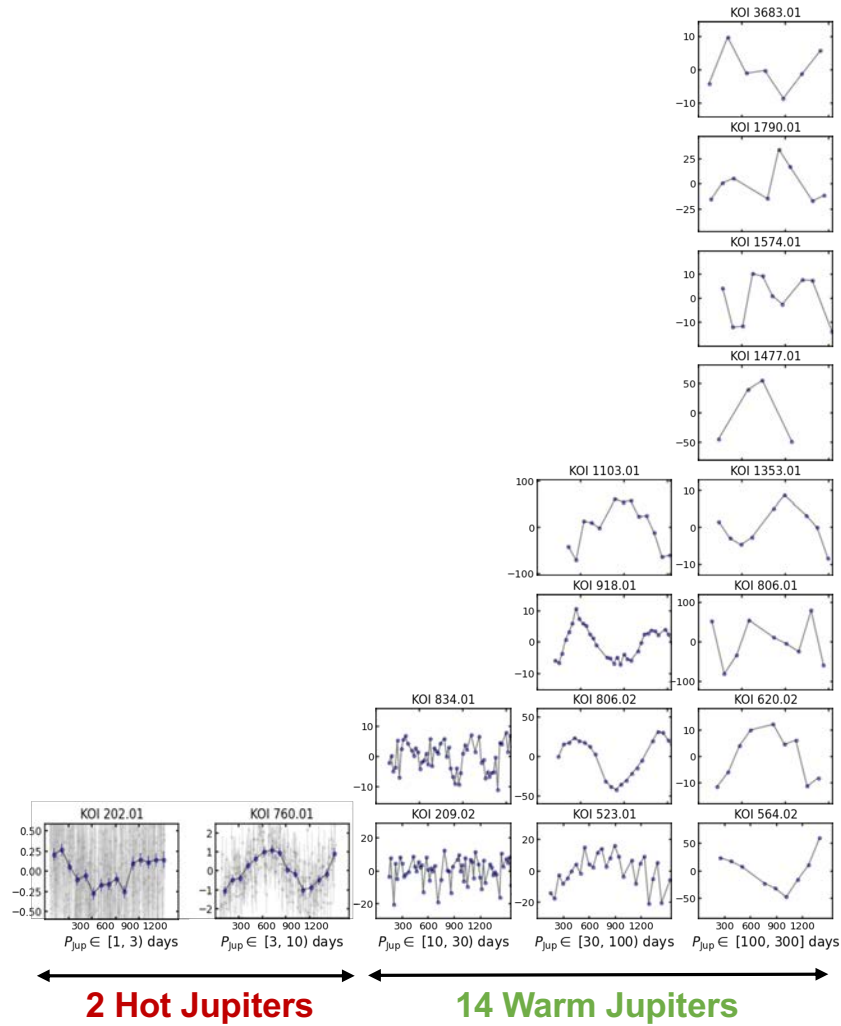
This work



After some careful searches and rigorous validations...

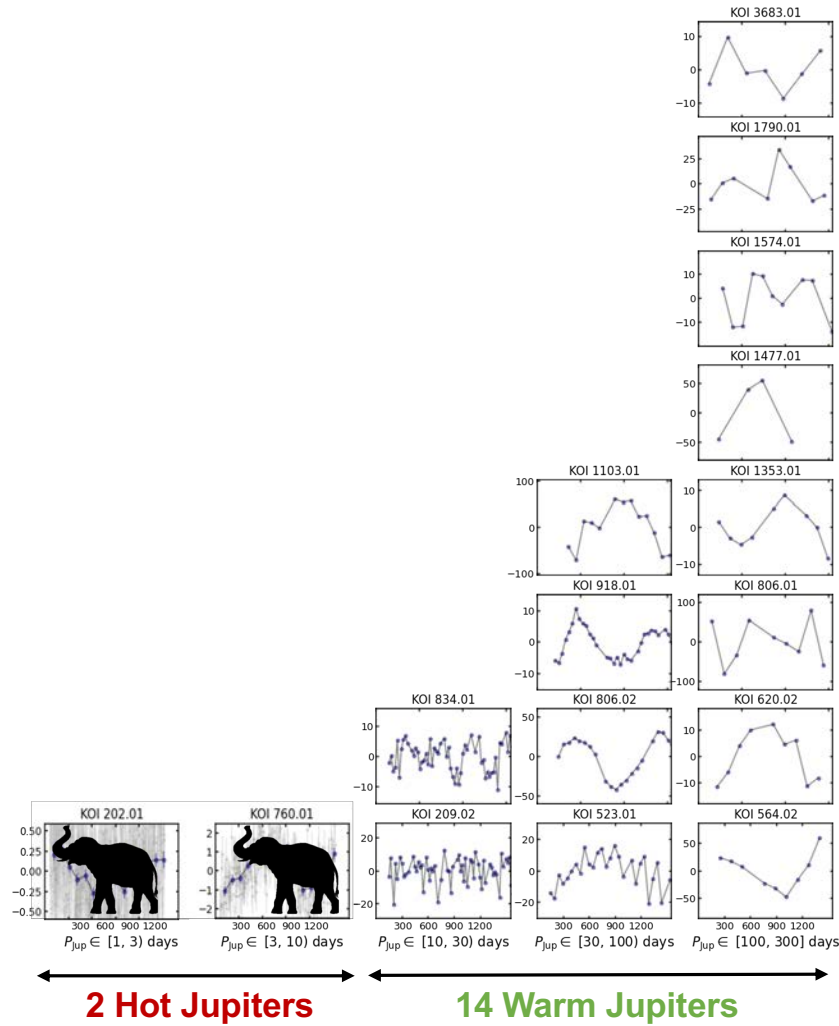


16 Validated Detections



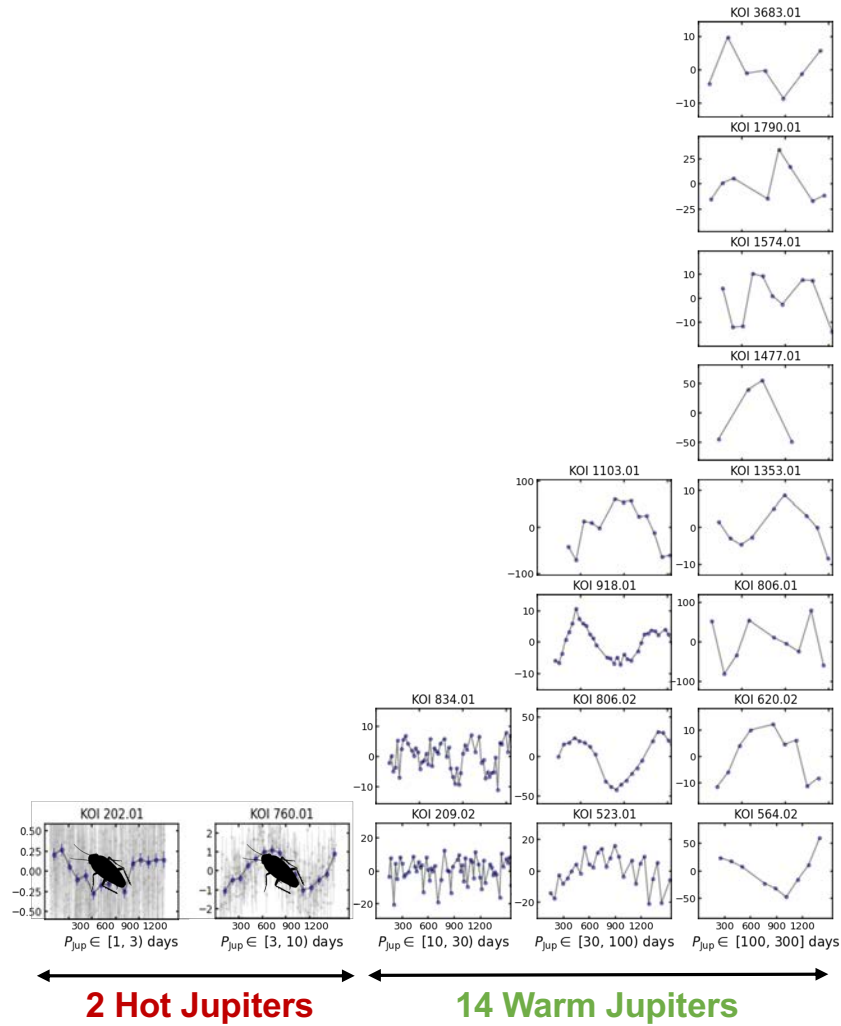
Wu, Rice, & Wang S. 2023

16 Validated Detections



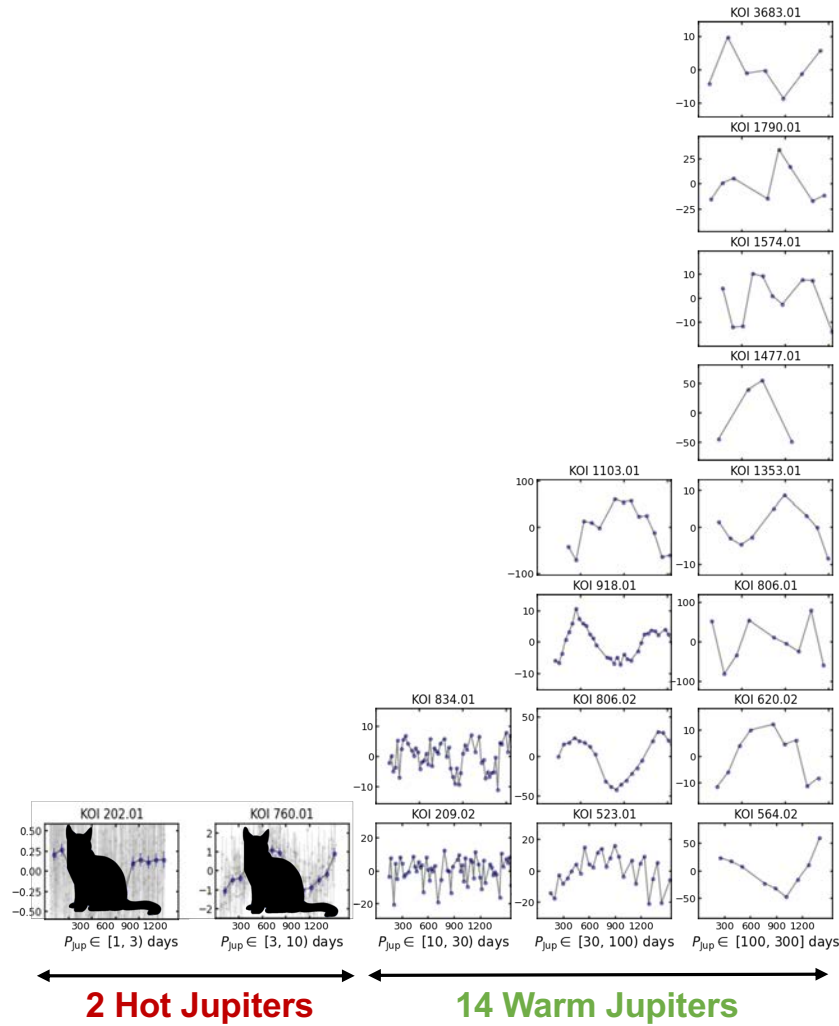
Wu, Rice, & Wang S. 2023

16 Validated Detections



Wu, Rice, & Wang S. 2023

16 Validated Detections



Wu, Rice, & Wang S. 2023

probability a hypothesis is true given the evidence

probability a hypothesis is true (before any evidence is present)

probability of seeing the evidence if the hypothesis is true

probability of observing the evidence

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$

Or the extended alternative:

$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B|A) \cdot P(A) + P(B|\bar{A}) \cdot P(\bar{A})}$$

where \bar{A} must be understood as not A

$$P(H/E) = \frac{P(H) P(E/H)}{P(E)}$$

$$P(H/E) = \frac{P(H) P(E/H)}{P(H) P(E/H) + P(\bar{H}) P(E/\bar{H})}$$

After some statistical calculations...

Formula For Bayes' Theorem

$$P(A|B) = \frac{P(A \cap B)}{P(B)} = \frac{P(A) \cdot P(B|A)}{P(B)}$$

where:

$P(A)$ = The probability of A occurring

$P(B)$ = The probability of B occurring

$P(A|B)$ = The probability of A given B

$P(B|A)$ = The probability of B given A

$P(A \cap B)$ = The probability of both A and B occurring

$$P(Y|X) = \frac{P(X, Y)}{P(X)}$$

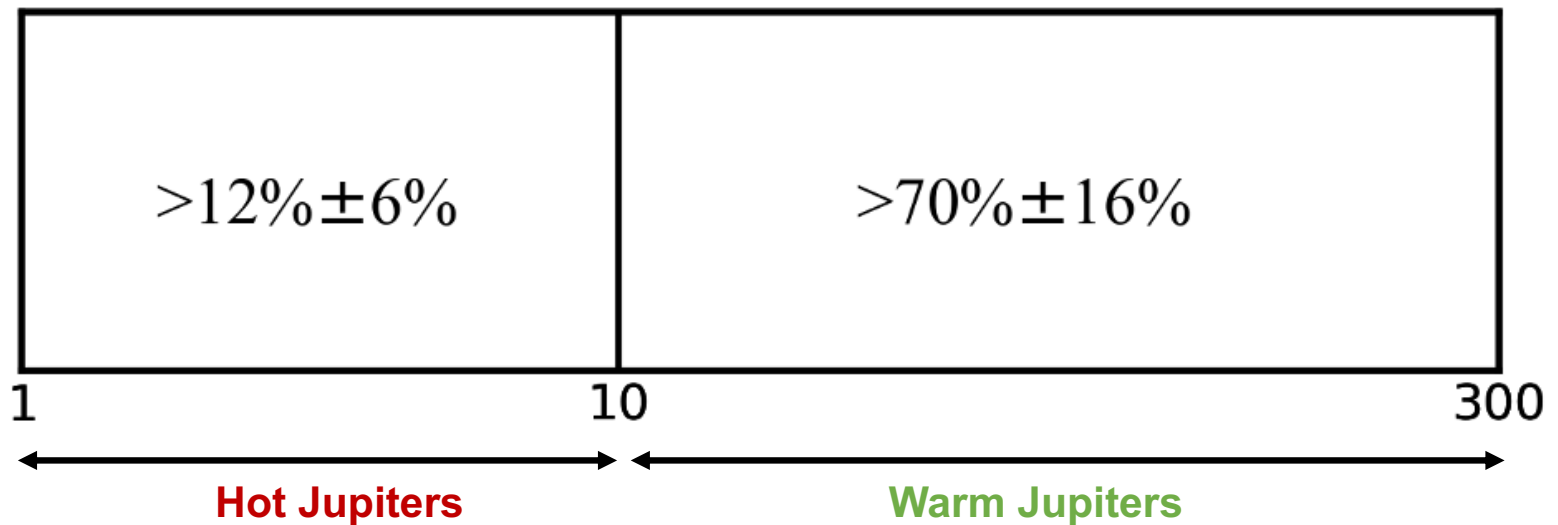
$$P(Y|X) = \frac{P(X|Y)P(Y)}{\sum_i P(X, Y)}$$

$$P(Y|X) = \frac{P(X|Y)P(Y)}{P(X|Y)P(Y) + P(X|\bar{Y})P(\bar{Y})}$$

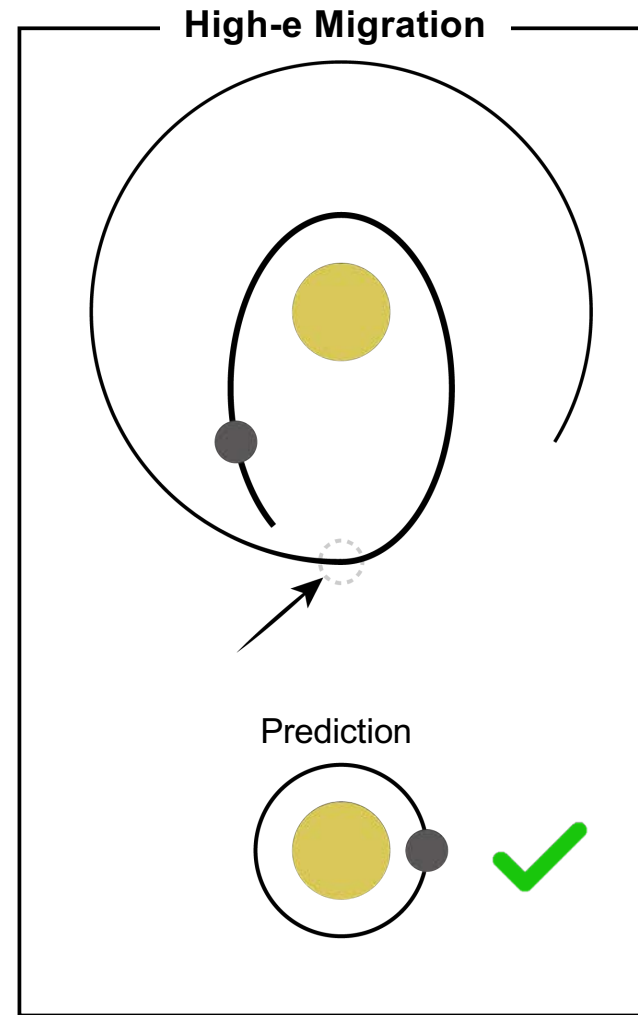
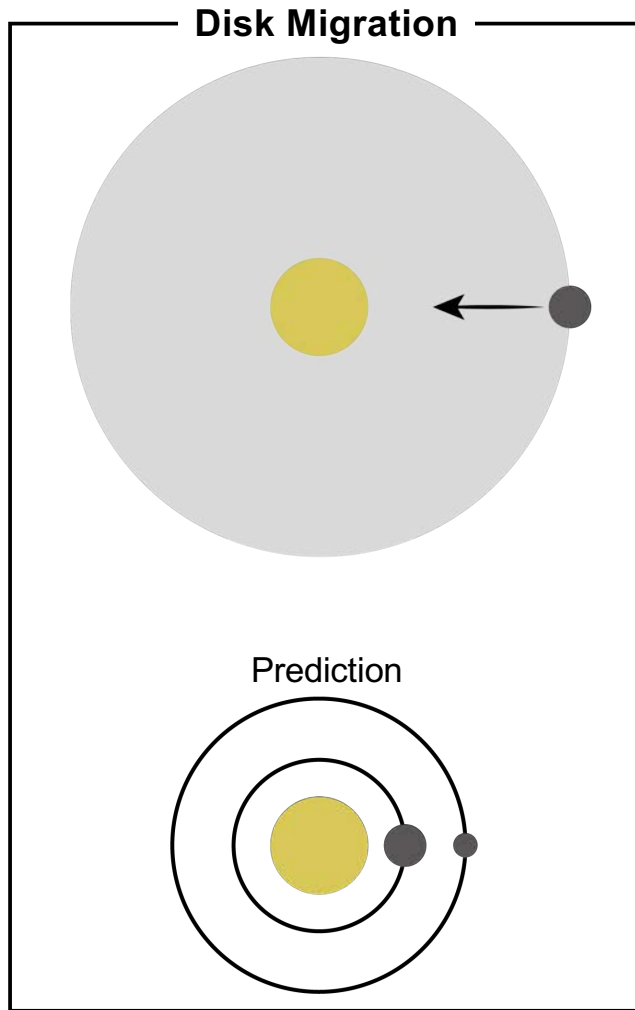
Credit: gaussianwaves.com

Intrinsic fraction of Jupiters with nearby companion

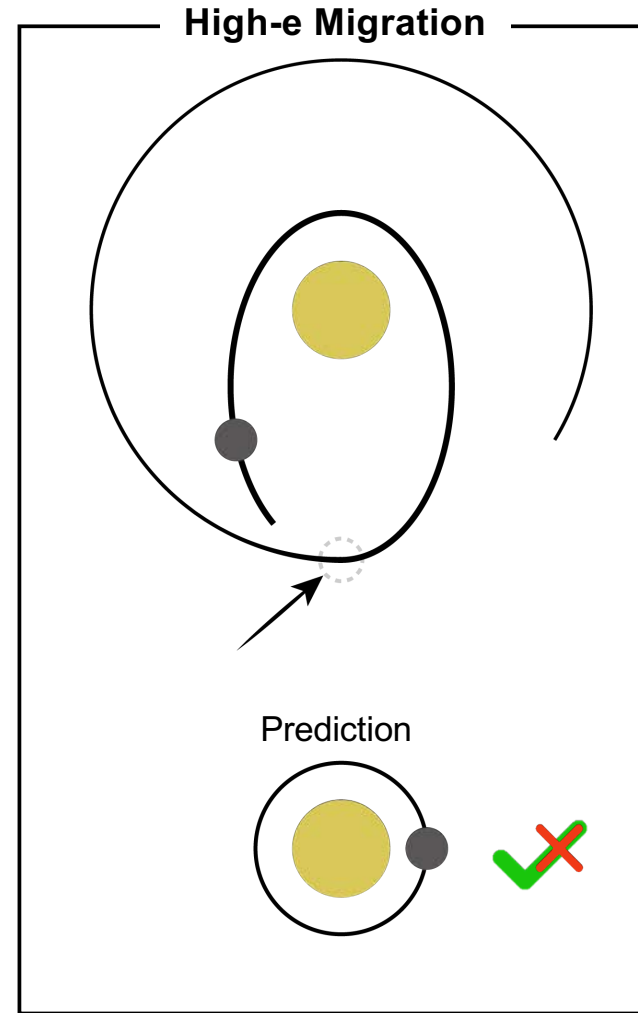
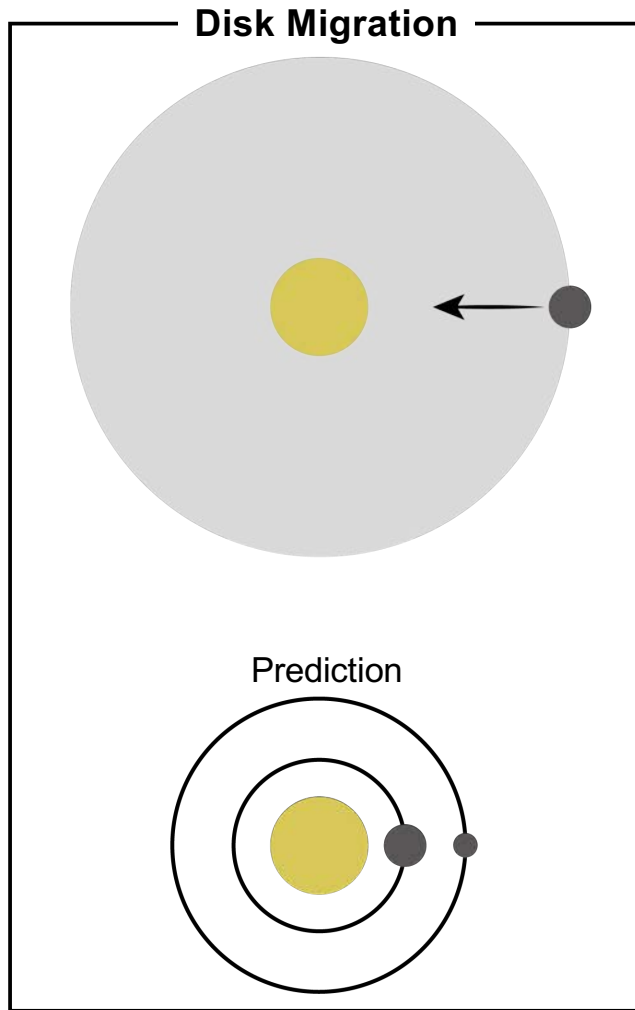
Key result



Competing Formation Mechanisms



Not all from High-e Migration





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Prof. Malena Rice/Yale

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