

Does Realistic Photometric Noise Affect Our Ability to Find Moons of Transiting Planets?

A Case Study: Photometric Transit Timing

Karen Lewis

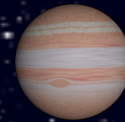
Supervisor: Dr. Rosemary Mardling

What are Transiting Planets?

- 1) An extrasolar planet

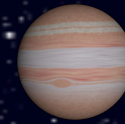
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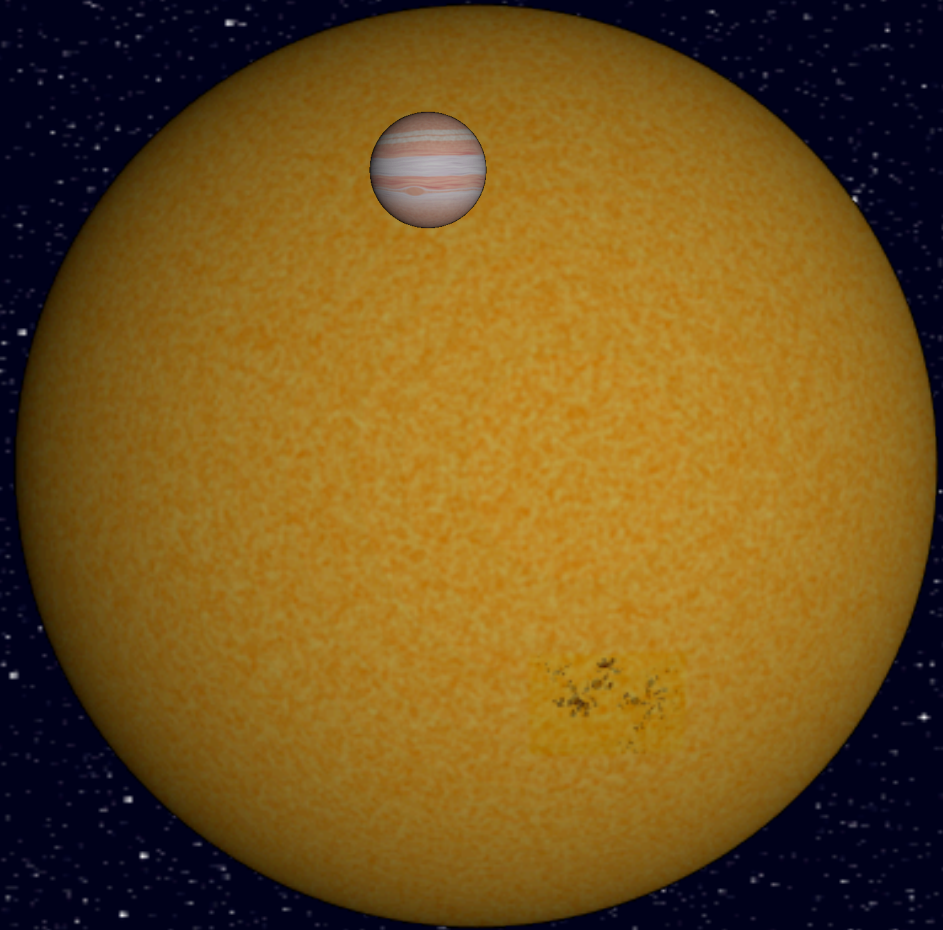
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- 2) It “transits” the face of its host star as viewed from the Earth



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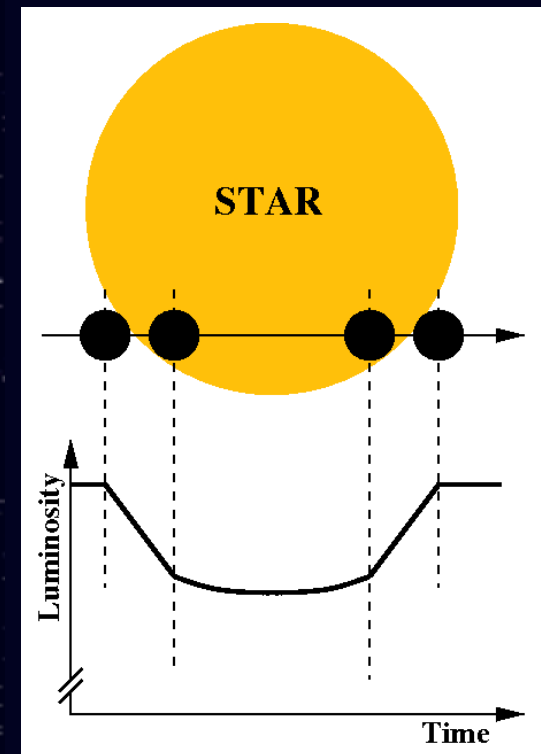
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Why we Care about Transiting Planets

- 1) Of the ~750 known planets, ~200 are transiting planets

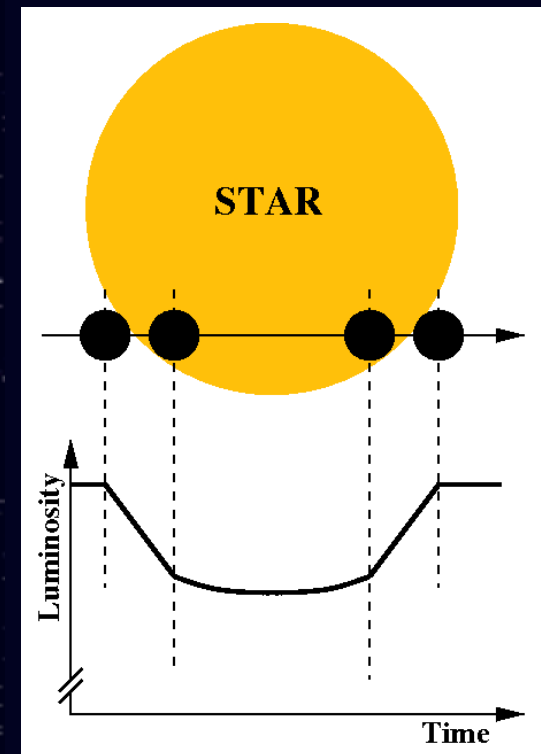
Transit lightcurve
schematic



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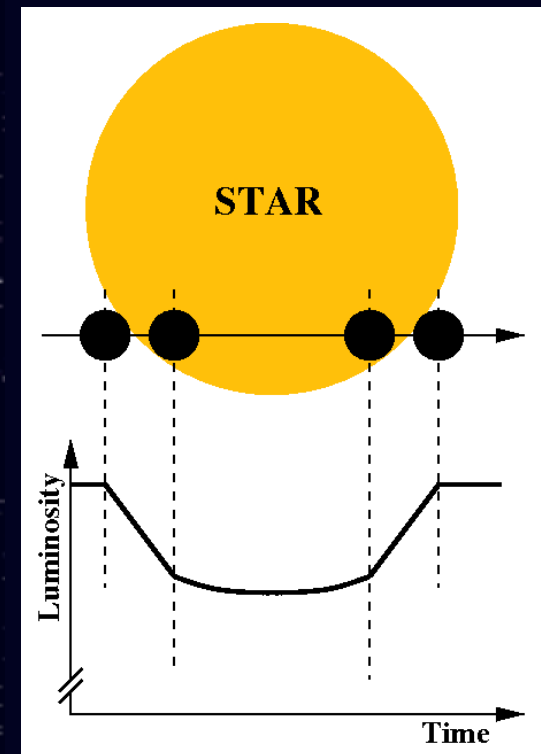
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 - Bulk composition
 - Atmospheric composition
 - Rings
 - Moons
 - Other planets ...

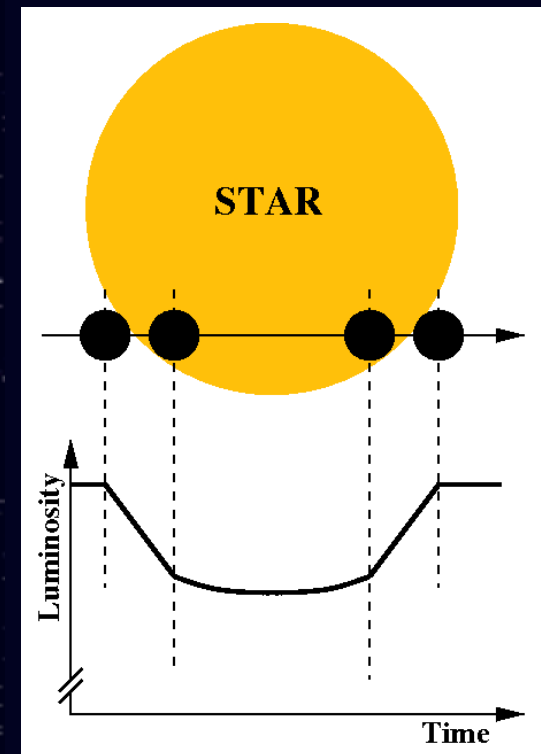
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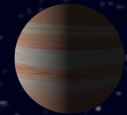
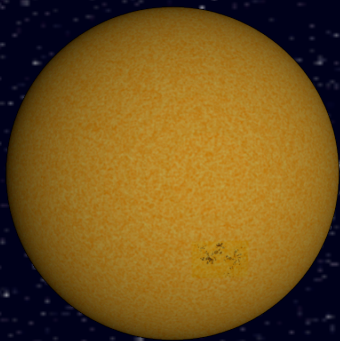
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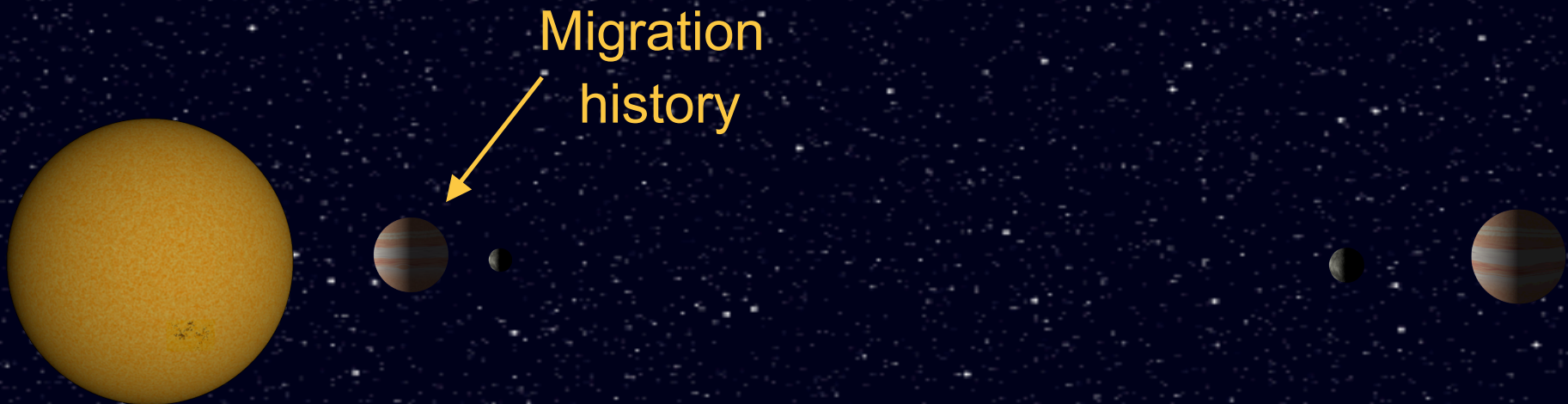
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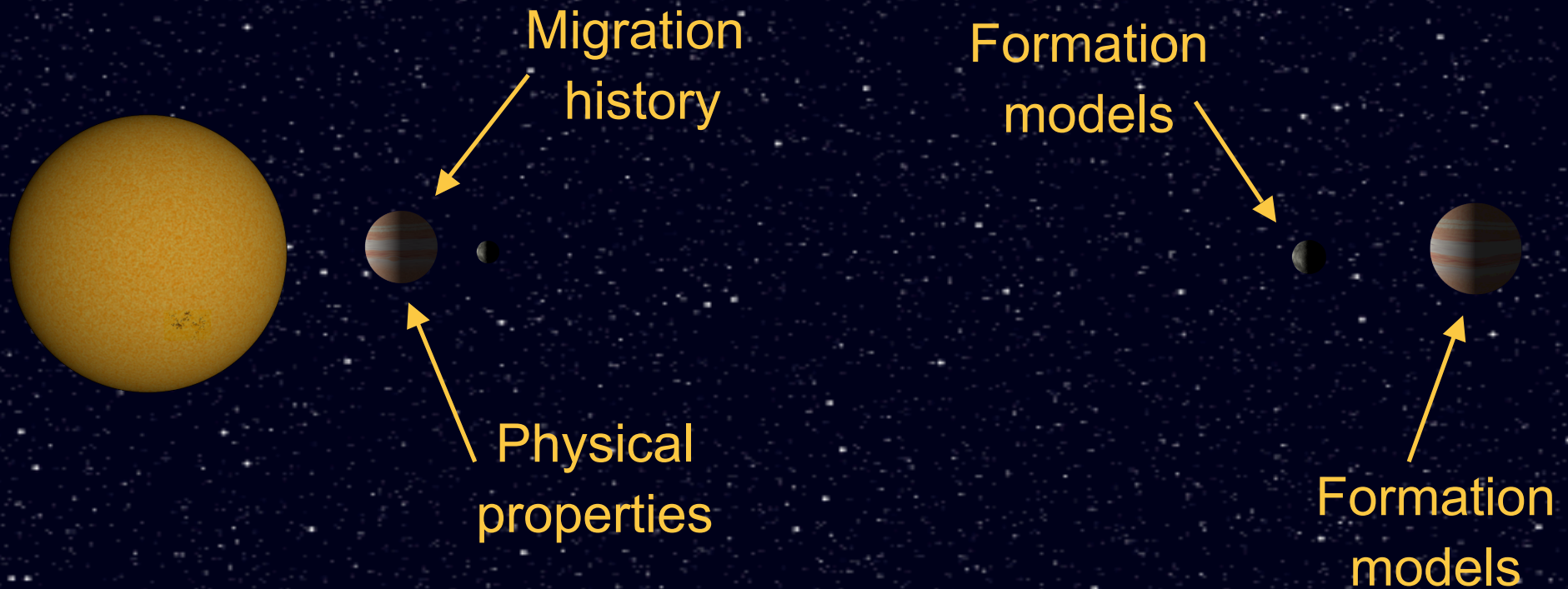
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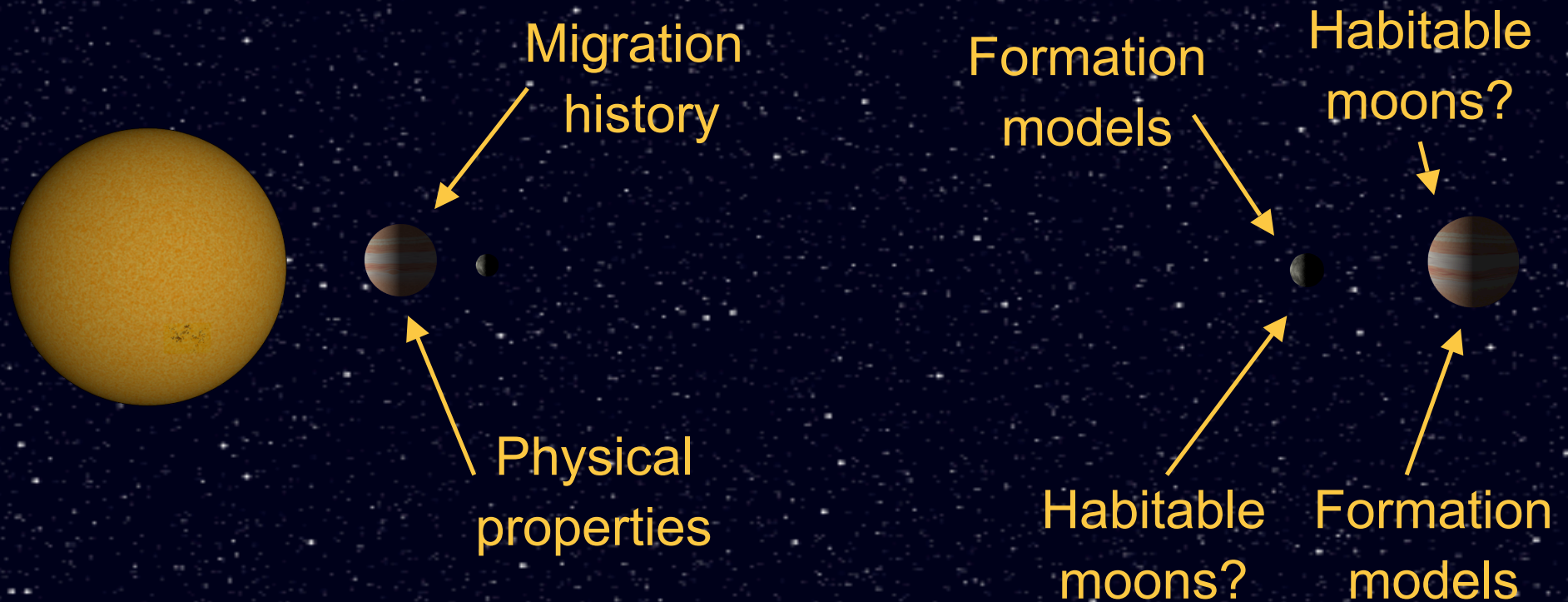
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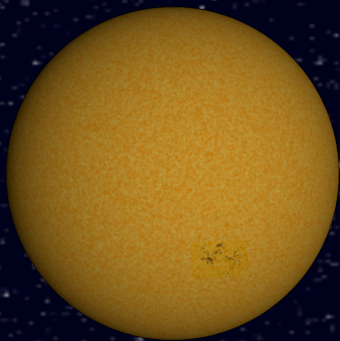
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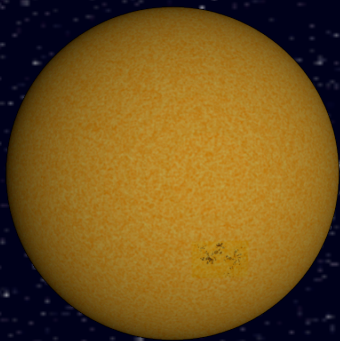
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- 2) Because transiting planets are one of the best places to look



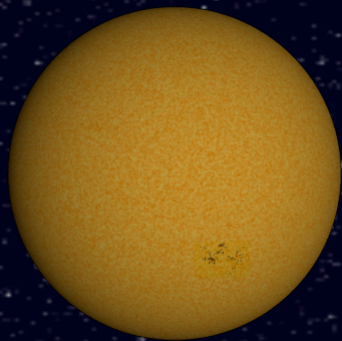
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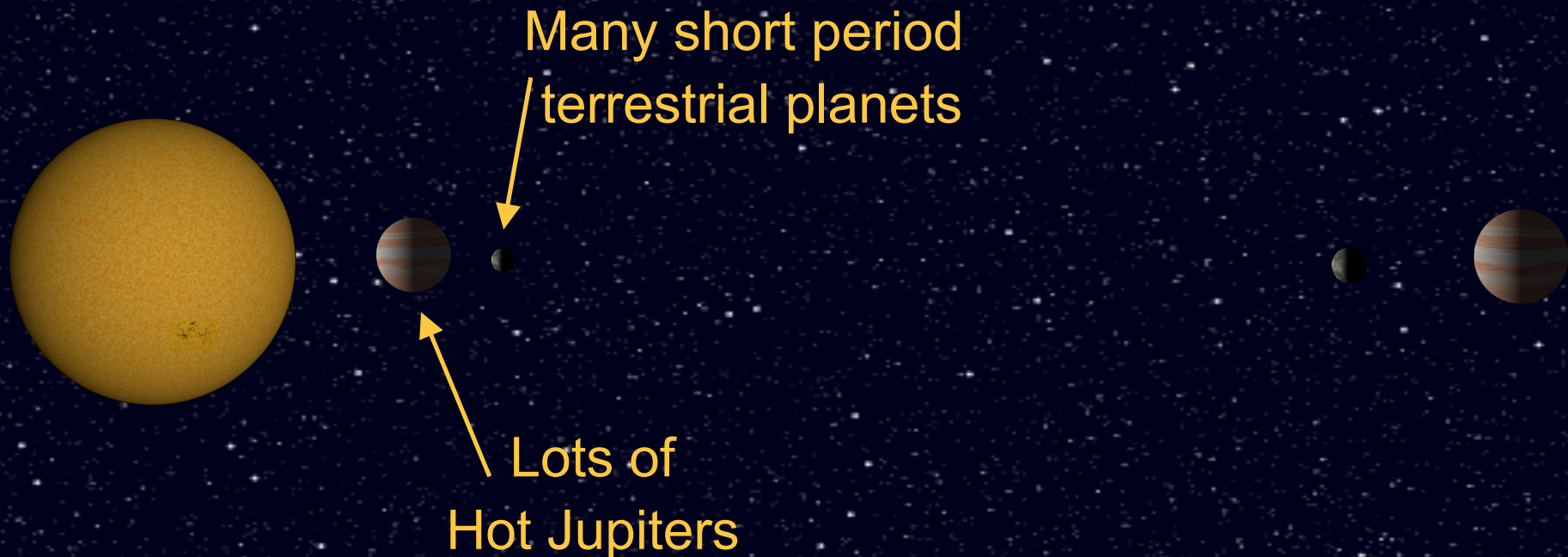
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Lots of
Hot Jupiters

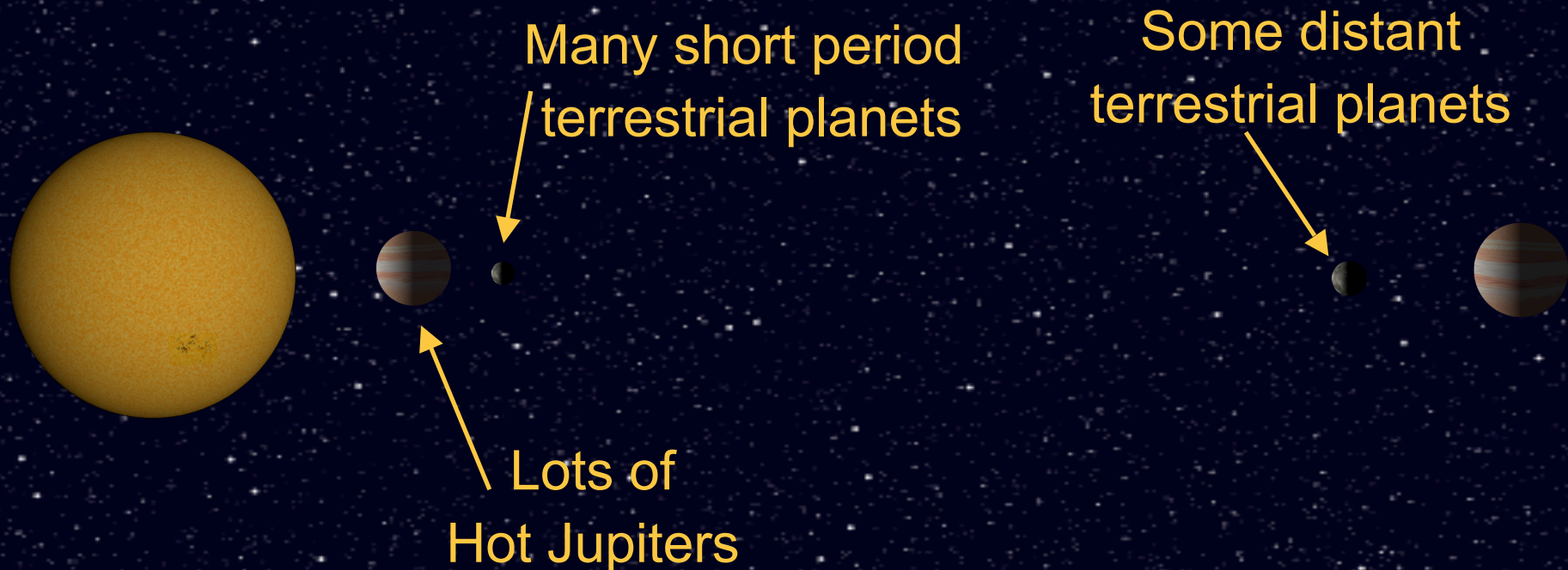
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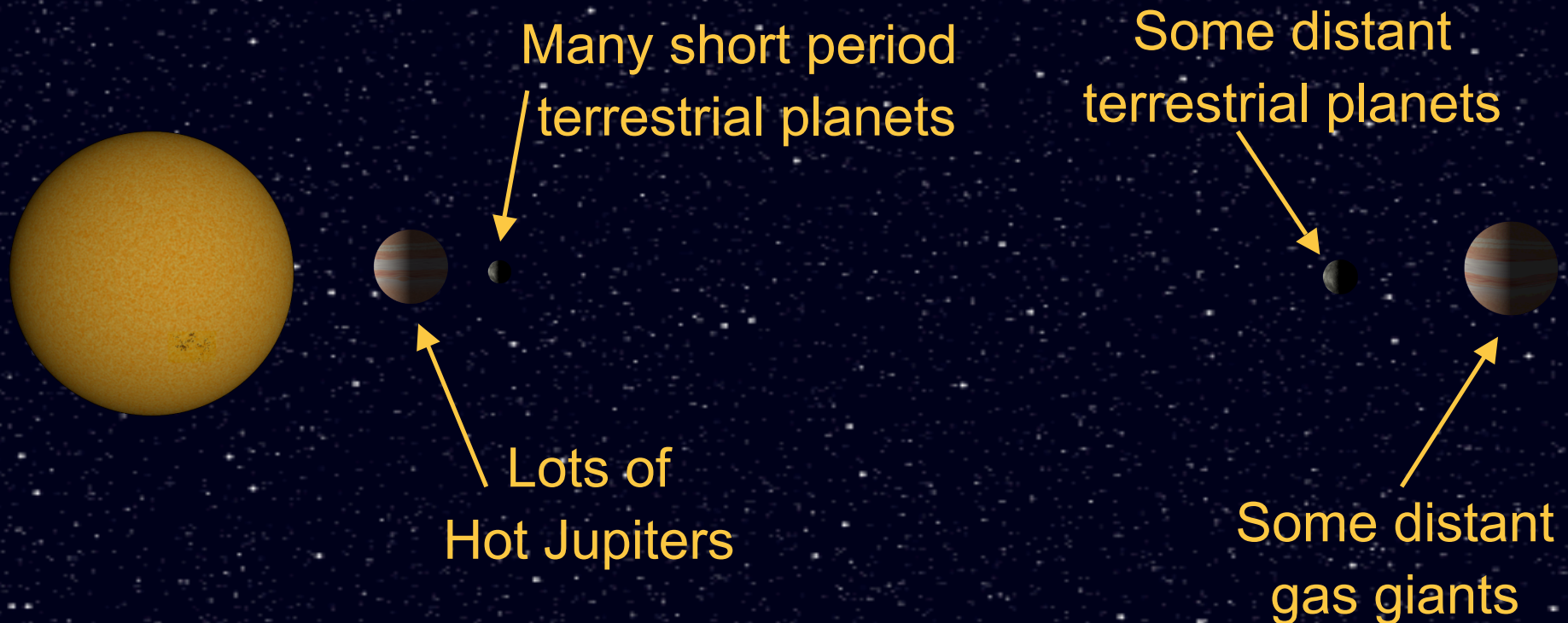
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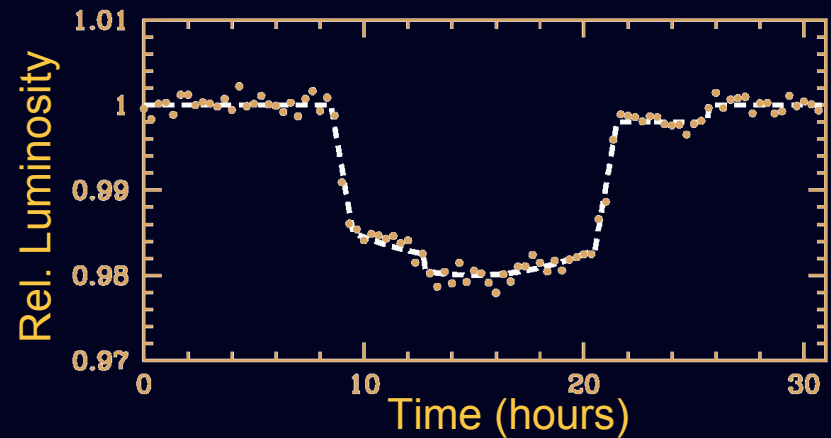
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How to Look for Moons of Transiting Planets

Five proposed methods:

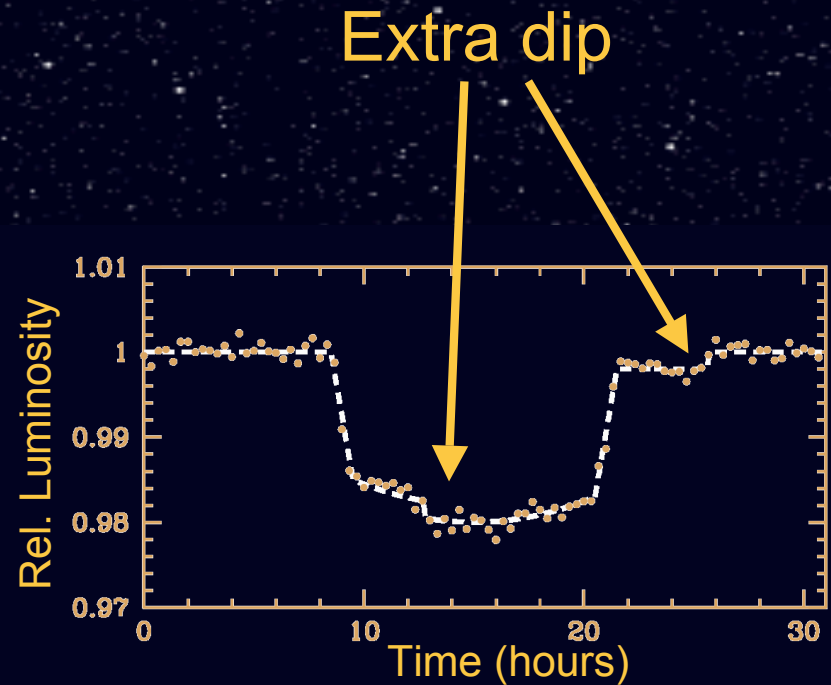
1. Direct detection
2. Scatter in folded lightcurves
3. Barycentric transit timing
4. Transit duration variation
5. Photometric transit timing



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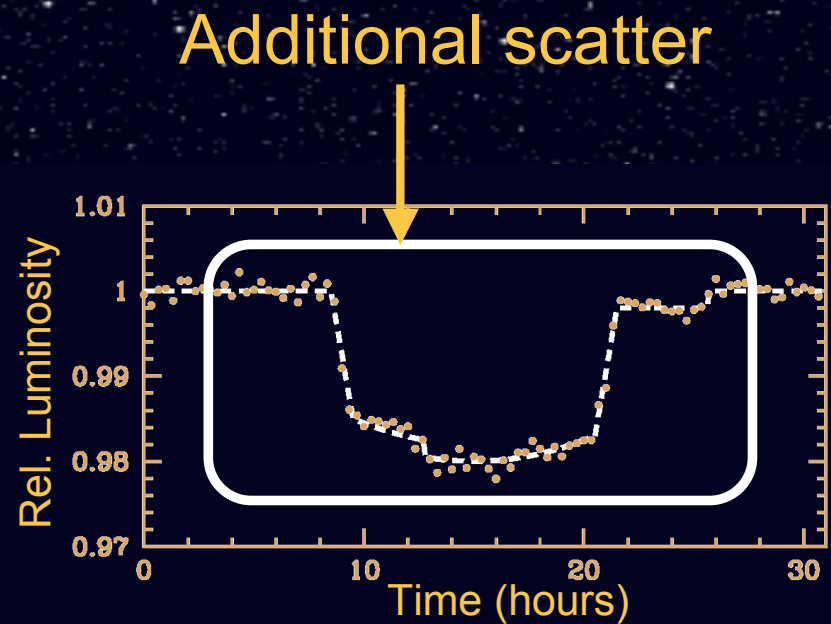
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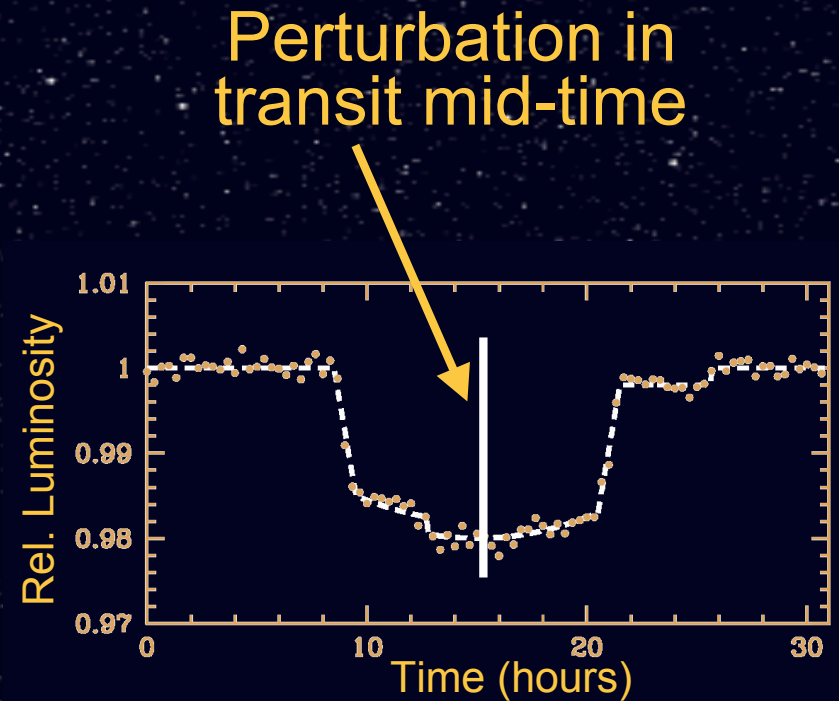
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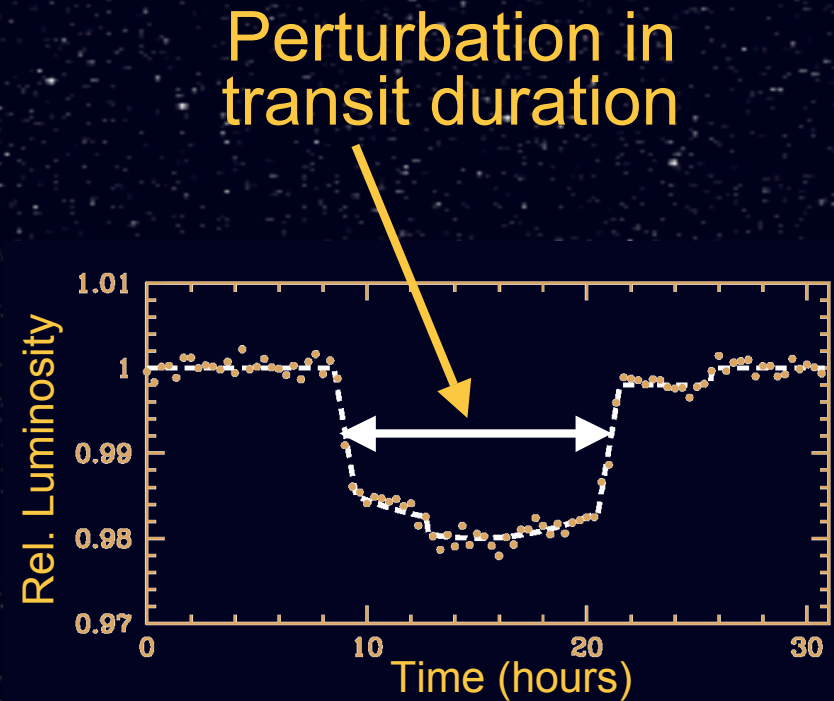
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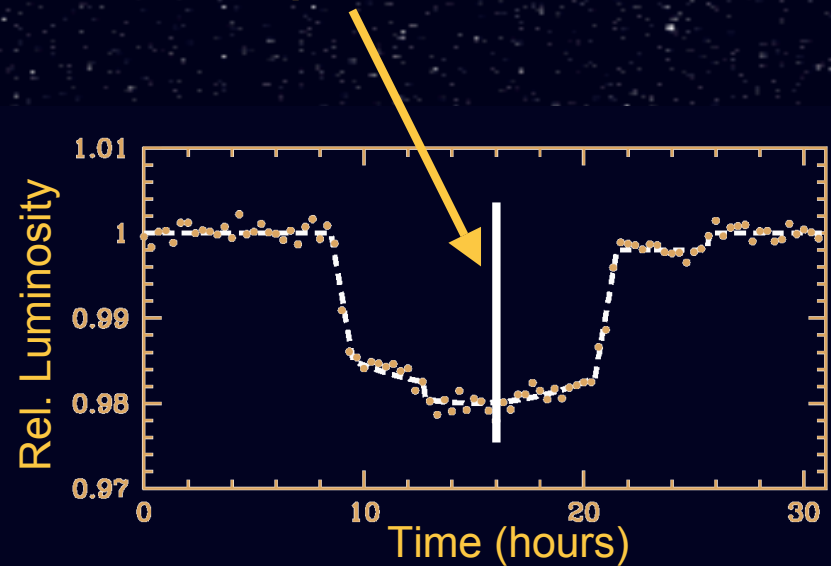


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Perturbation in transit “photocentre” τ



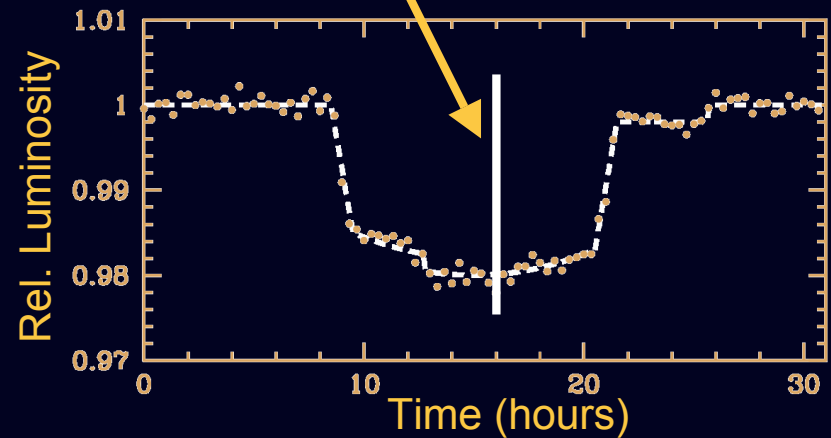
$$\tau = \frac{\sum_i t_i \alpha(t_i)}{\sum_i \alpha(t_i)},$$

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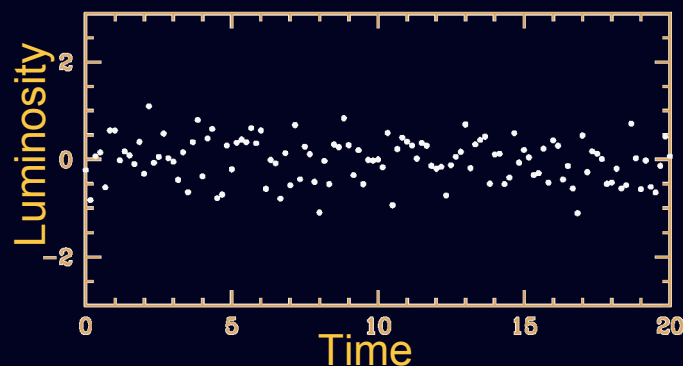
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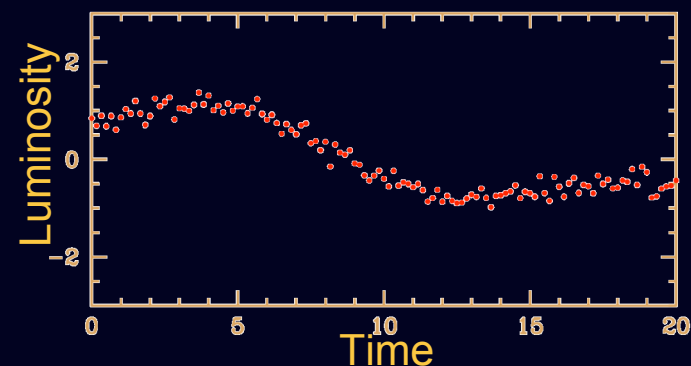
White vs. Red Photometric Noise

White Noise



- Uncorrelated
- Example source: Shot noise
- Easy to detect planets

Red Noise

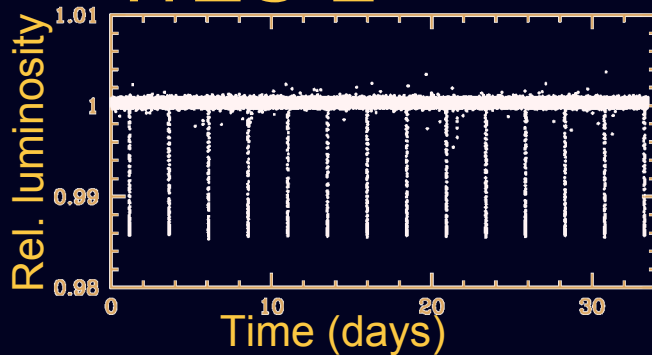


- Correlated over long timescales
- Example source: Intrinsic stellar noise
- Hard to detect planets e.g. Pont et.al (2006)

Realistic Stellar Photometric Noise



TrES-2

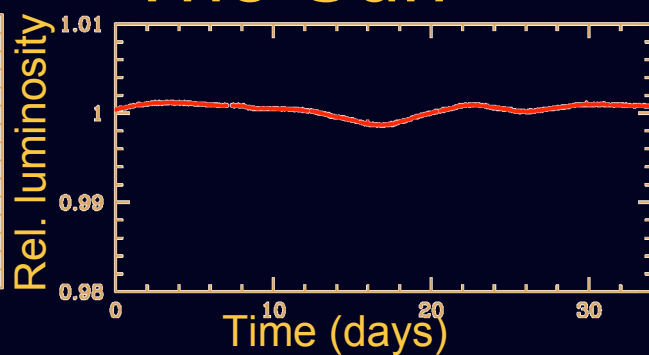


Mass: $0.98M_{\text{Sun}}$

Magnitude: 11.4

Exp. time: 1min

The Sun

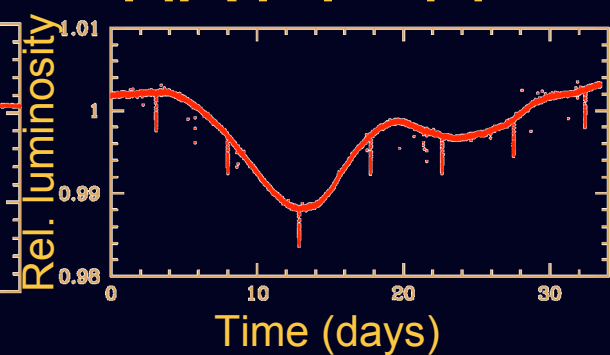


Mass: $1.00M_{\text{Sun}}$

Magnitude: -26.7

Exp. time: 3min

HAT-P-11



Mass: $0.81M_{\text{Sun}}$

Magnitude: 9.6

Exp. time: 1min

Does Realistic Photometric Noise Affect Moon Detectability?

Method: Photometric Transit Timing

Proxy for moon

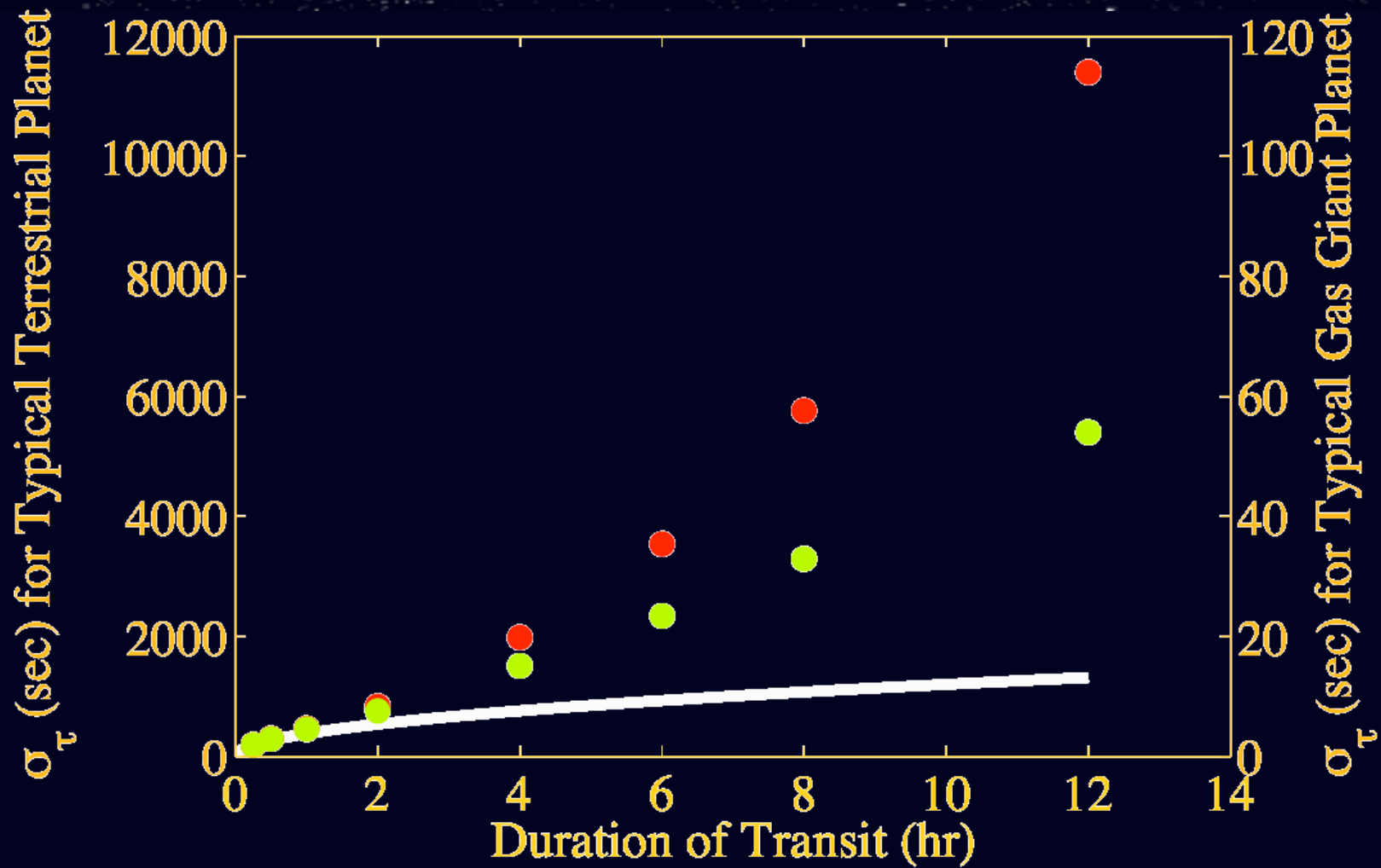
detectability: Timing error

Photometric noise: White

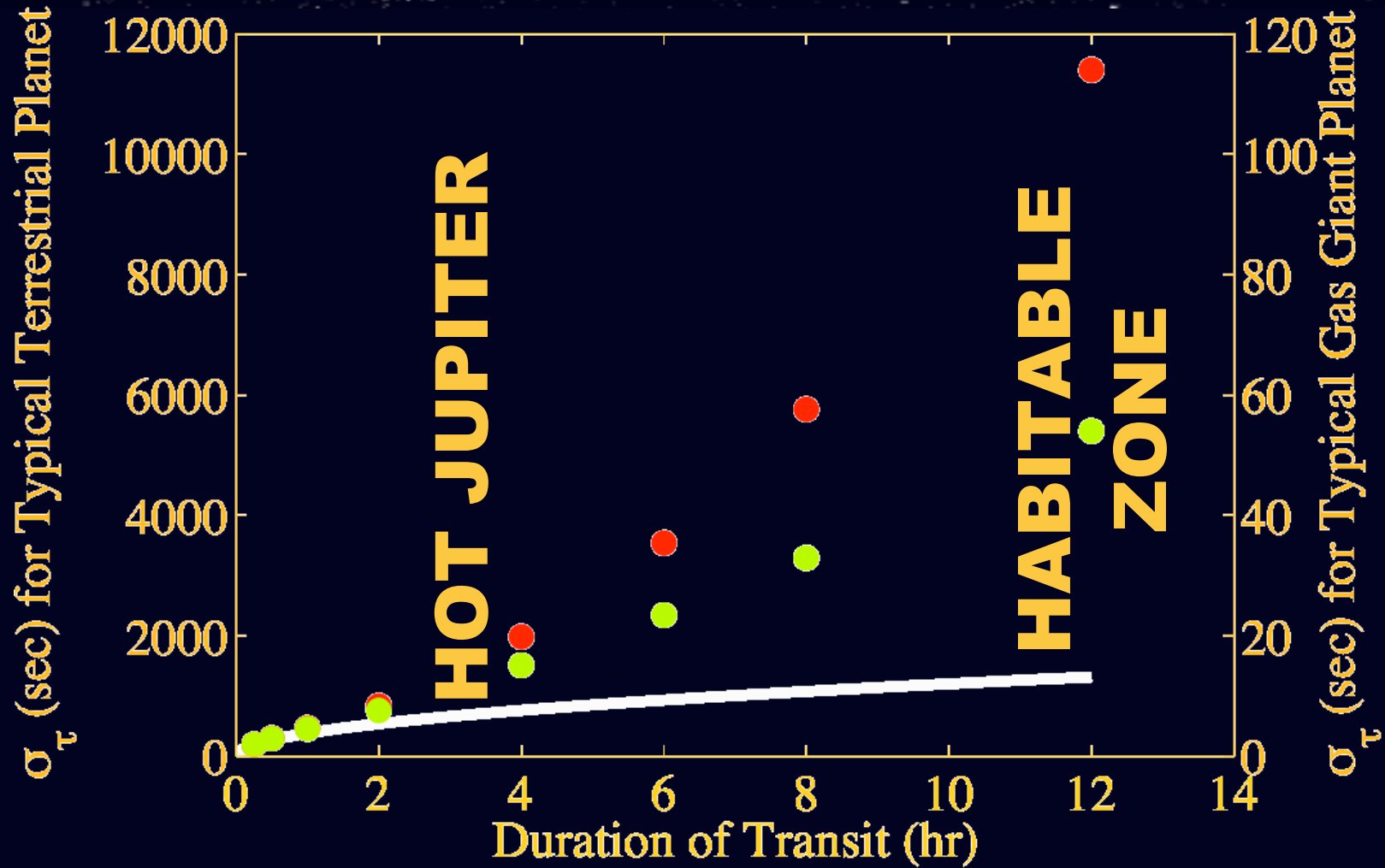
Solar

Filtered Solar

The Result



The Result



Summary

- Realistic photometric noise decreases moon detectability using photometric transit timing, especially for distant planets
- This effect is NOT fully reversed by filtering.
- To make good use of CoRoT/Kepler data, an investigation of the effect of red noise on other methods is required.



Questions?