

Long-period super Jupiter mass companion around Tabby's star and the search of similar systems

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WORKSHOP ON THE SHOULDERS OF GIANTS

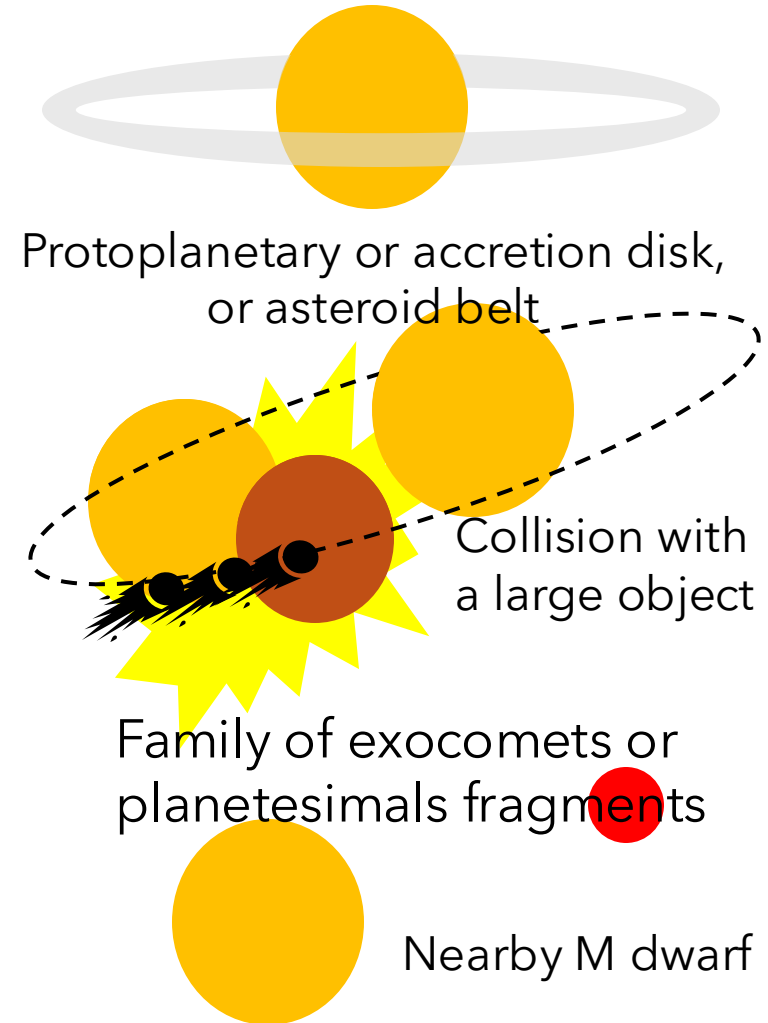
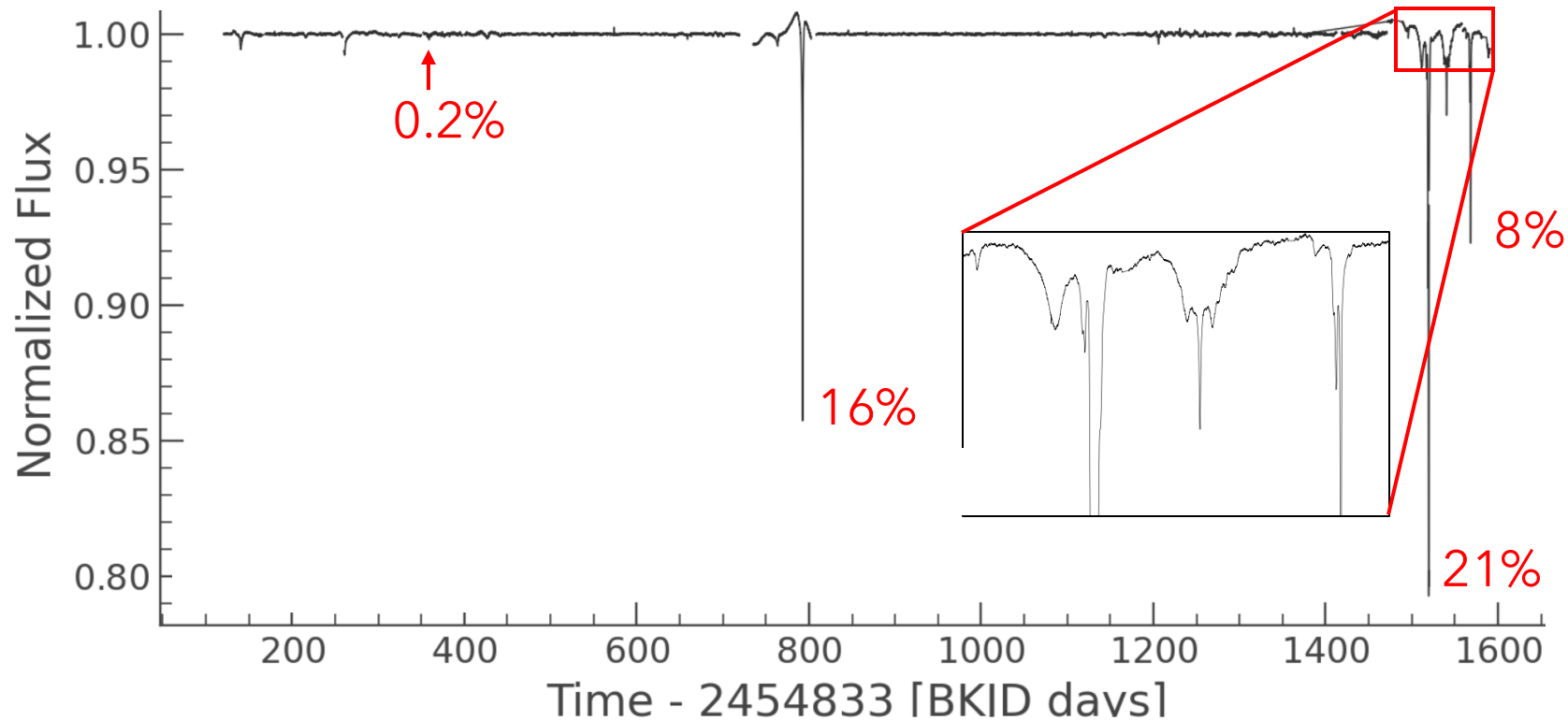


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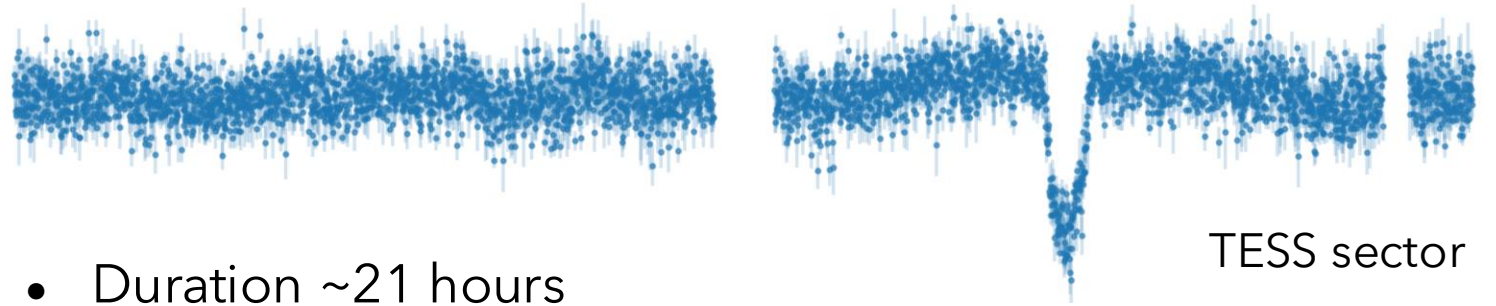
Tabby's star and its irregularities

F3V Main sequence

Kepler light curve over 4 years



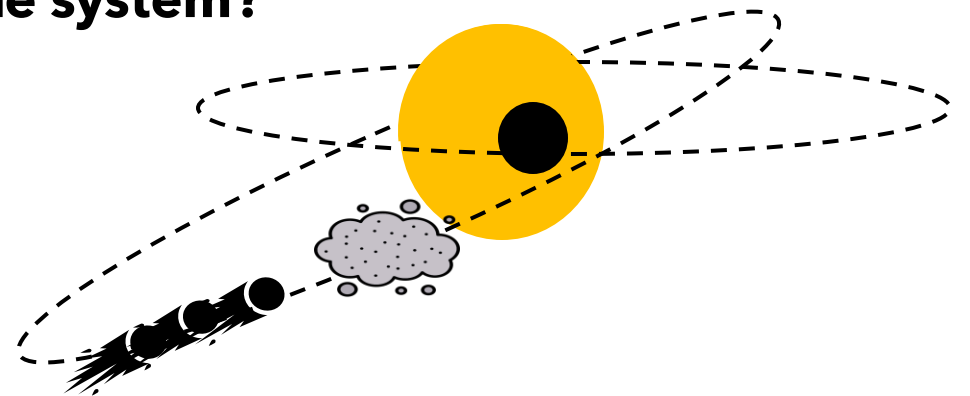
Transit found in TESS data



- Duration ~21 hours
- Depth ~1.1 %
- Symmetric round shape

→ Long-period exoplanet or brown dwarf

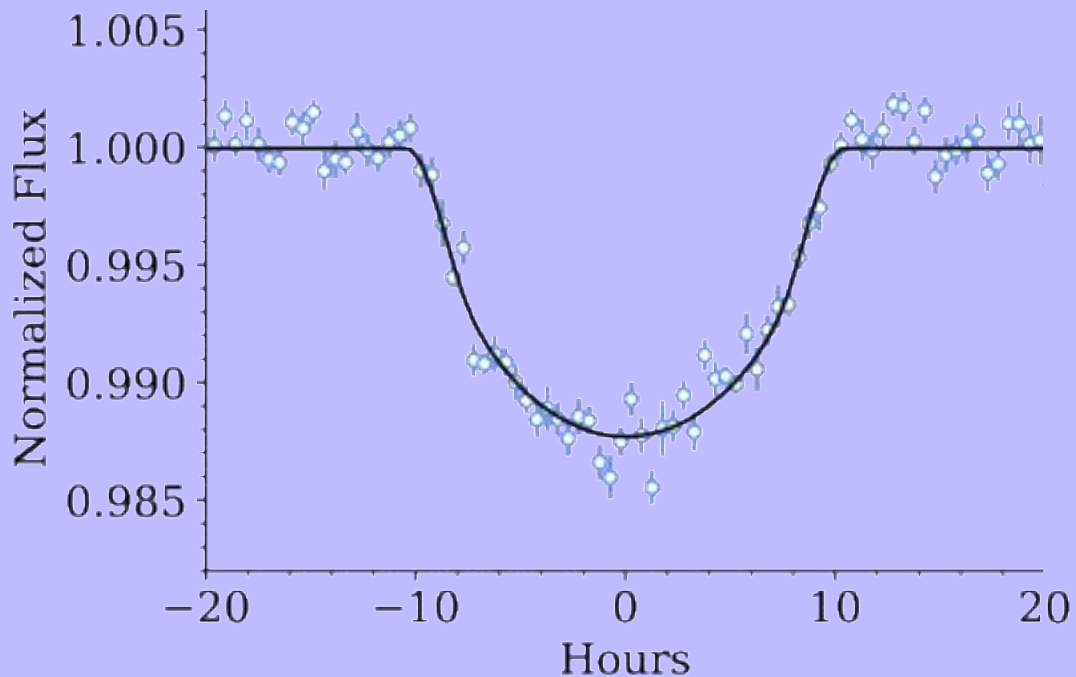
**Could it be perturbing the orbits of
the planetesimals in the system?**



Joint-fit with the observations

PHOTOMETRY

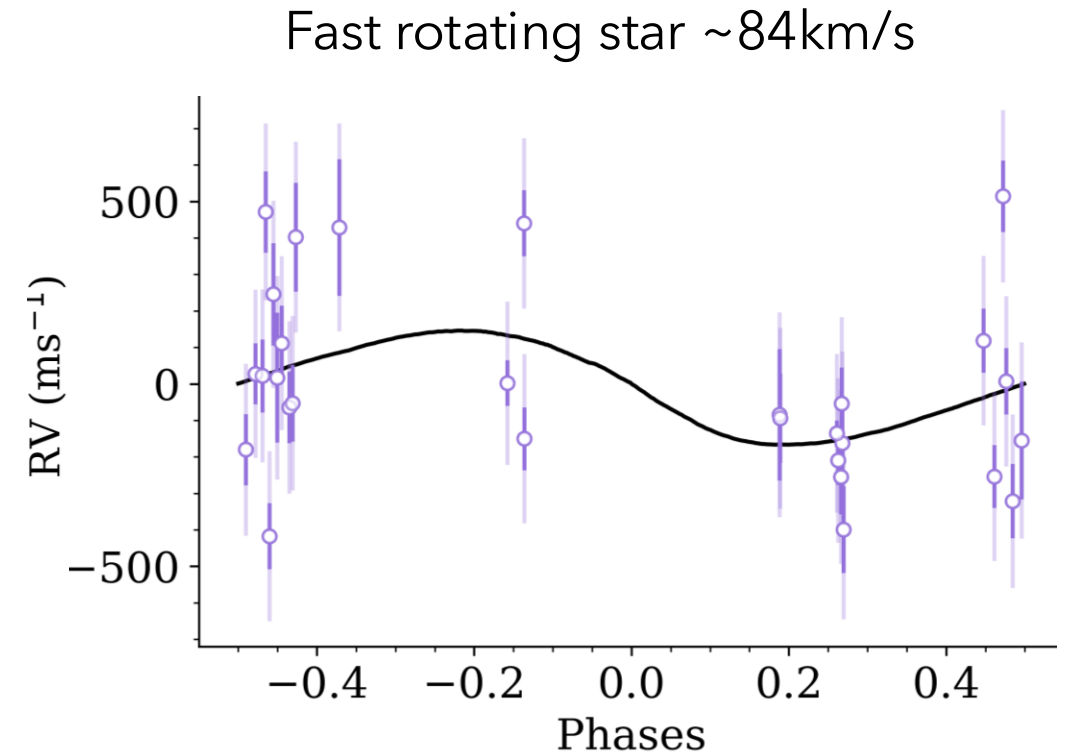
- TESS data
- Transit model + nested sampling with GP regression



+

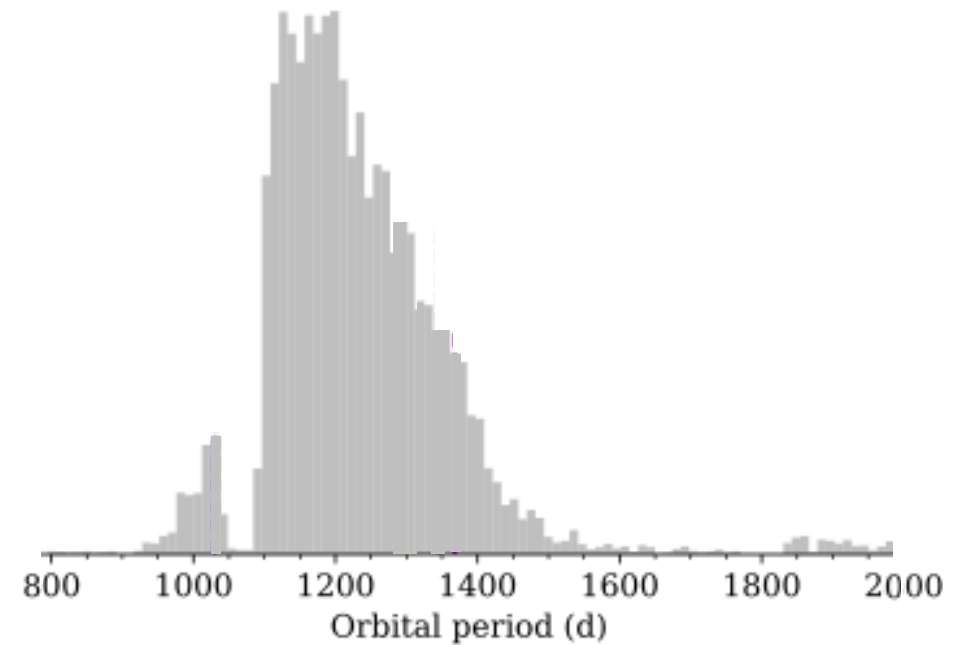
RADIAL VELOCITY

- OHP/SOPHIE
- Keplerian model

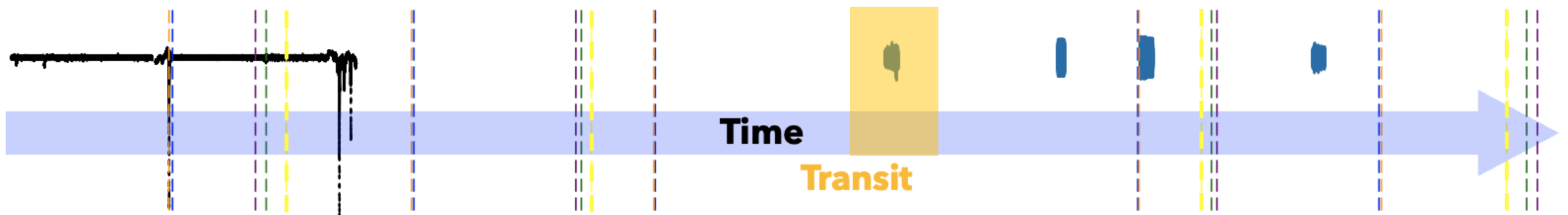


Constraints on the period

Not all periods are possible because Kepler data showed no other transit like this one

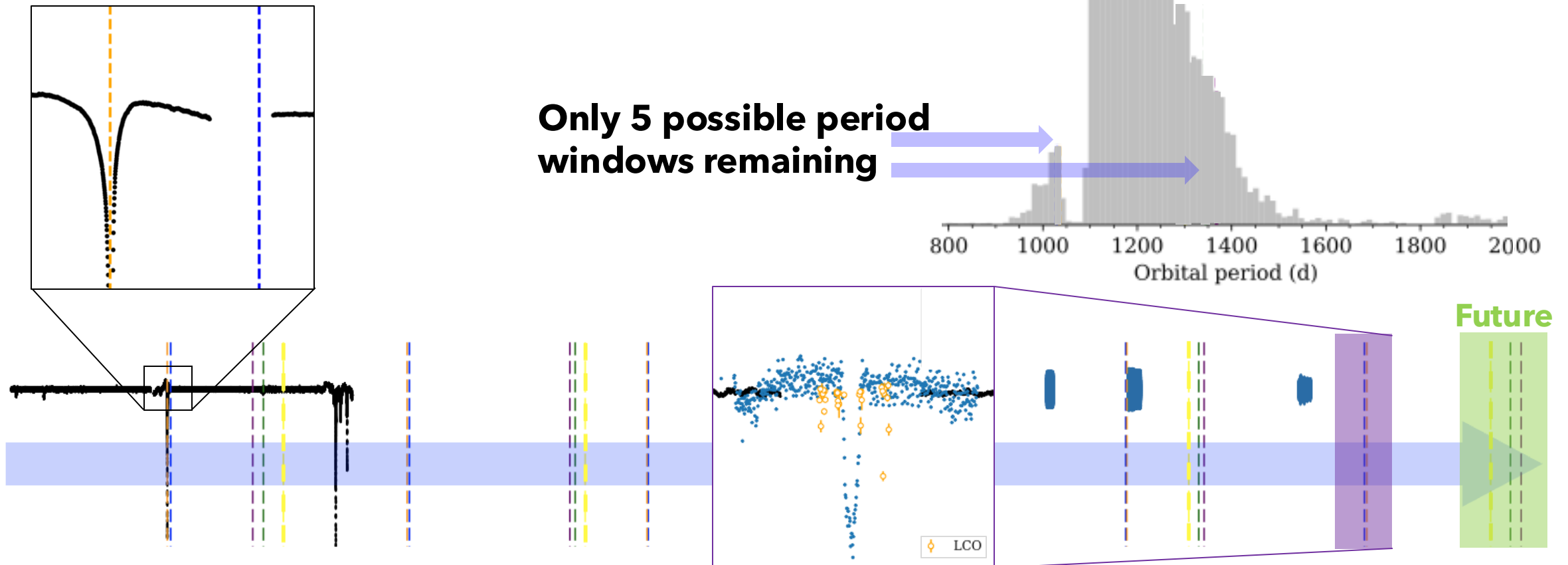


Photometric check: **Kepler** and **TESS** data over time



Constraints on the period

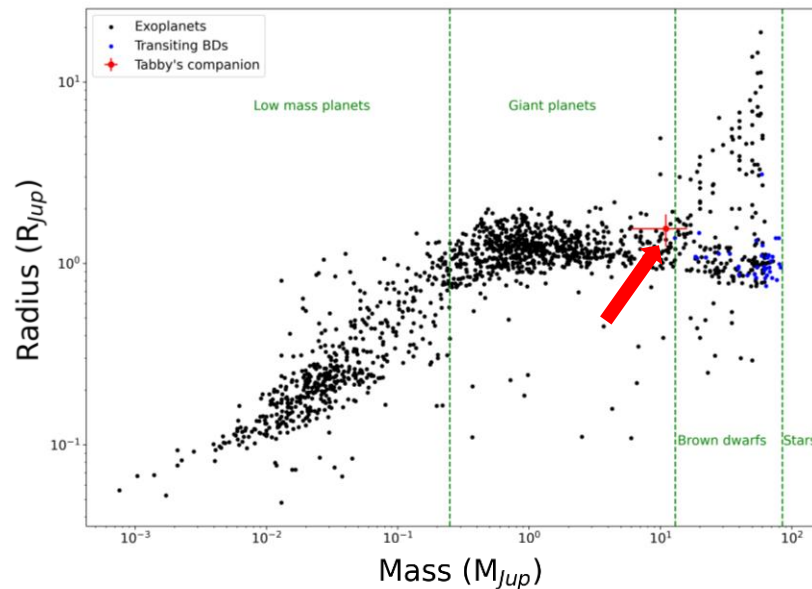
During a **gap** or during **one of the deeper dips**



Results: Nature of the companion

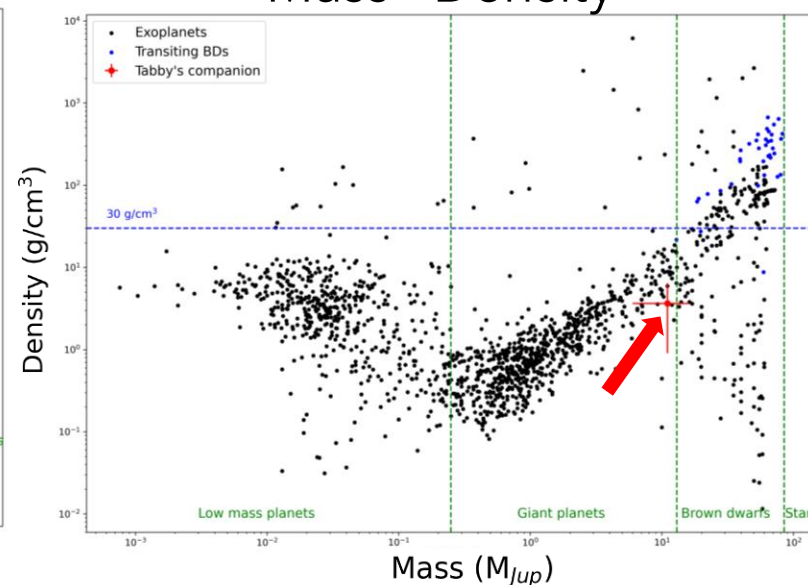
Period	$1230_{-88}^{+10^9}$ days
Mass	$11.3_{-5.0}^{+6.0} M_{Jup}$
Radius	$1.6 \pm 0.3 R_{Jup}$
Density	$3.7 \pm 2.8 \text{ g cm}^{-3}$
T_{eq}	$258 \pm 28 \text{ K}$

Mass - Radius



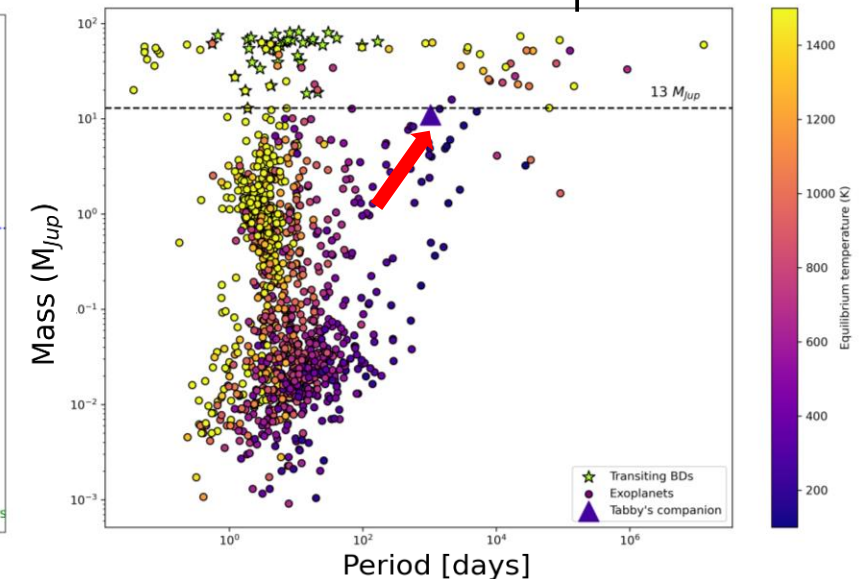
Madurga-Favieres et al. submitted

Mass - Density



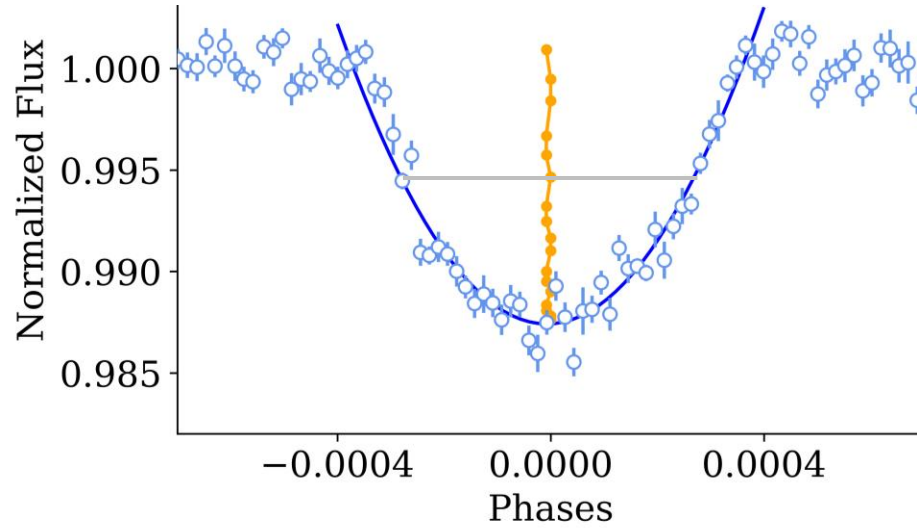
Transiting brown dwarfs from Carmichael (2023)

Period - Mass - Temperature

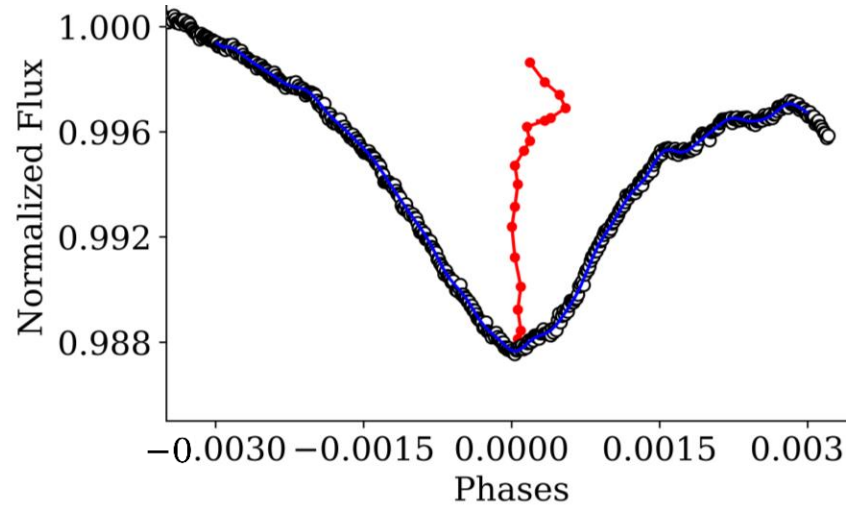


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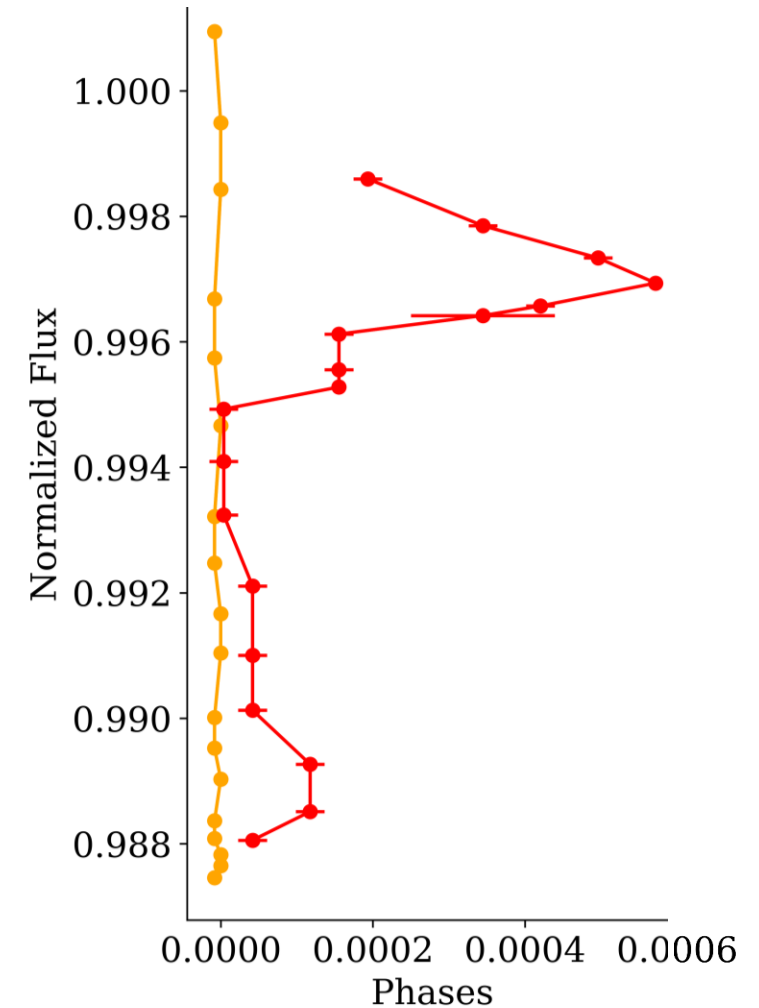
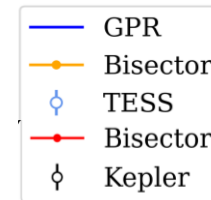
Understanding the transit origin: Bisector analysis

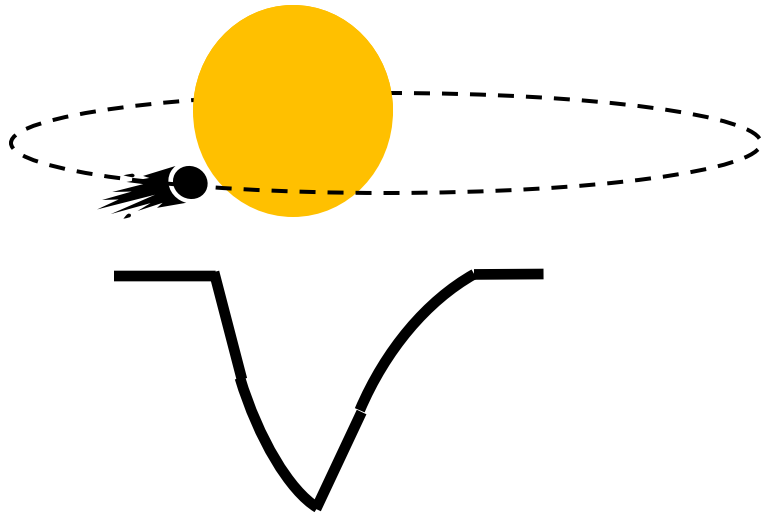


TESS transit

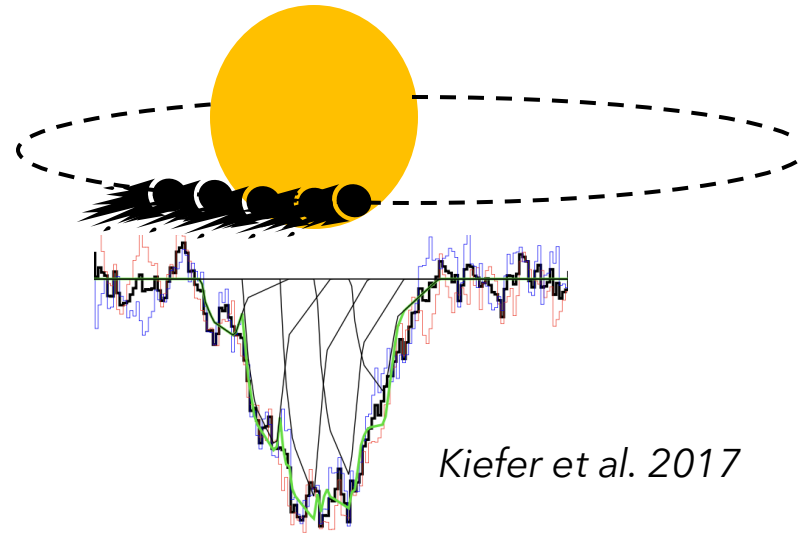


Kepler transit





One comet has an asymmetric transit



Kiefer et al. 2017

A chain of comets can combine to a more symmetric one

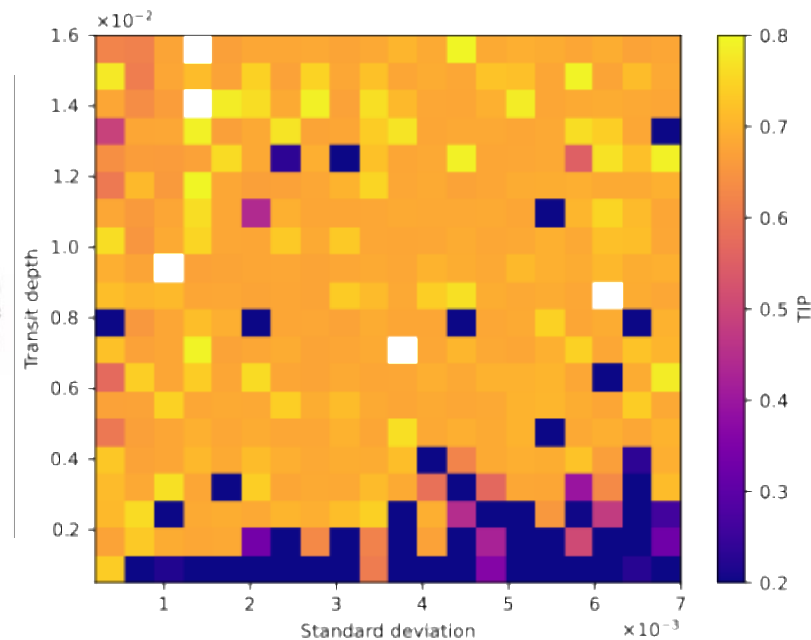
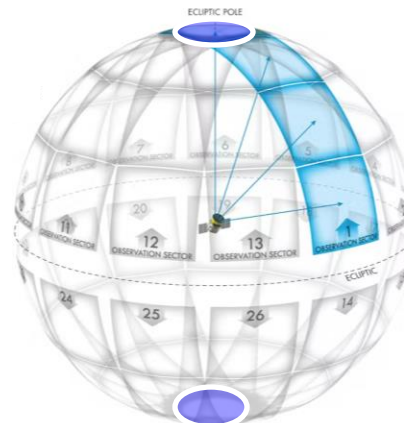
We used two models (Kennedy et al. 2019 and Lecavelier des Etangs et al. 2022) with different number of exocomets to fit the transit.

They either resulted in a poor fit or they needed physically unrealistic parameters.

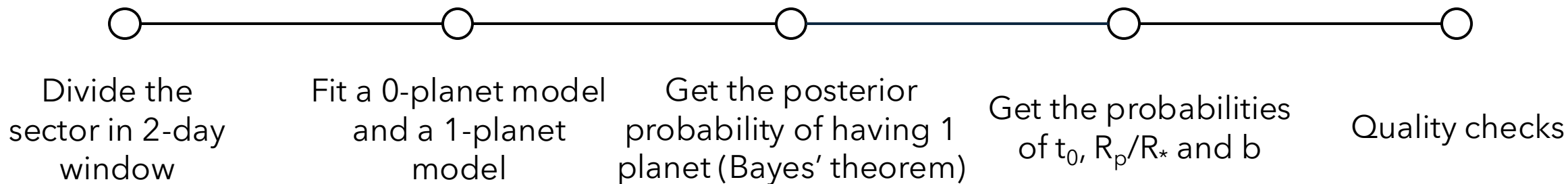
Alternative origin, exocomets?

Searching for similar systems

Long-period planets in the CVZ of TESS



Pipeline to detect transits



30 confirmed TESS transits from targets with $P > 100$ d



Retrieved
Non retrieved

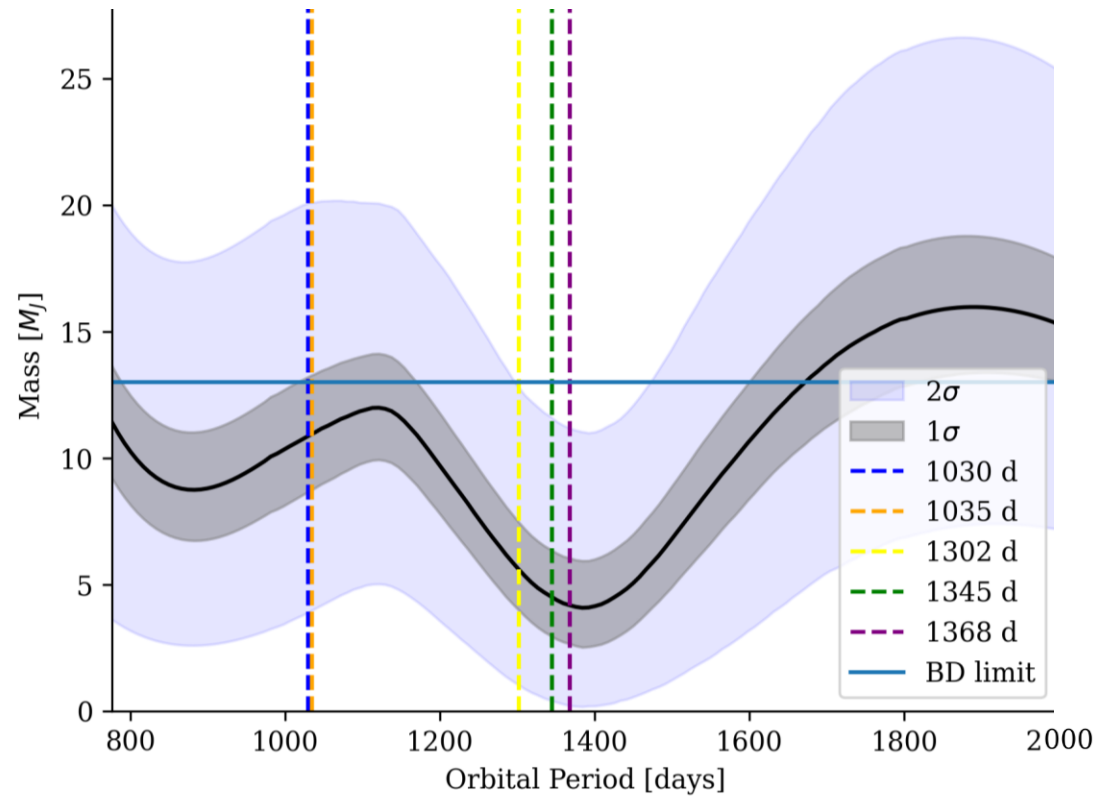
Conclusions

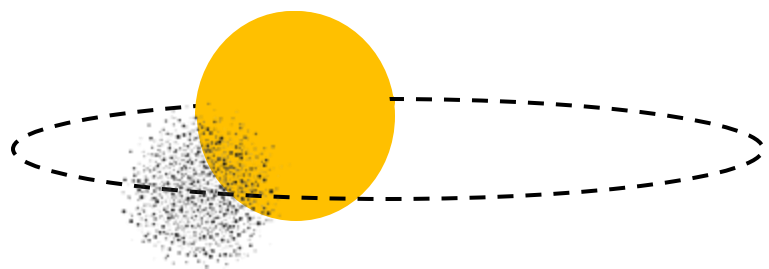
- ✓ We have found a **unique symmetric transit event**, consistent with a long-period planet around Tabby's star.
- ✓ We have gotten **new RV and photometric observations**, which have helped us to place the companion in the **super Jupiter mass exoplanet** range and **highly constrained the possible periods**, leaving only 5 windows with $P > 1030$ days.
- ✓ We have studied alternative origins, and it **is not likely due to exocomets**.

Future outlooks

- Learn about the origin of Tabby's star system.
- Search for long-period planets systems using our new pipeline.

Constraints on the mass

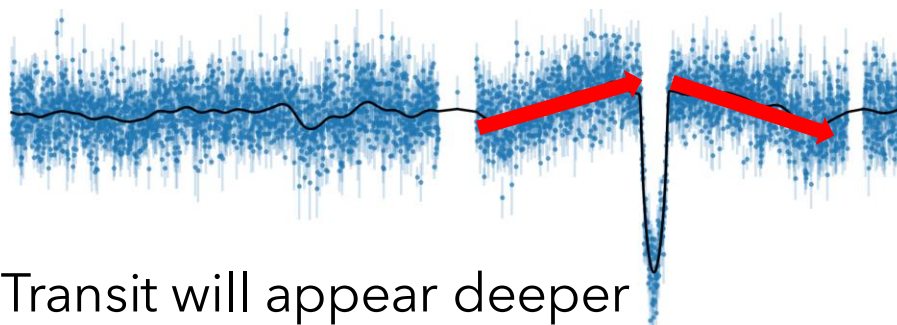




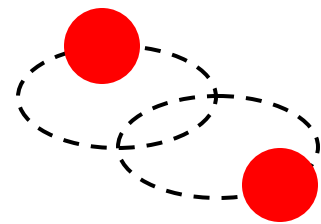
Irregular transit shape that would **not produce the large RV signal** that we have.



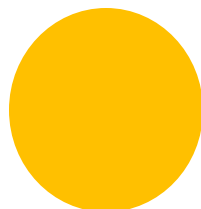
We could have dust **around the companion**



Forward scattering → Transit will appear deeper



Everything points to it being a **single star**



Alternative origin, dust cloud? M-dwarf binary?