A planet within the debris disk around the pre-main-sequence star AU Microscopii

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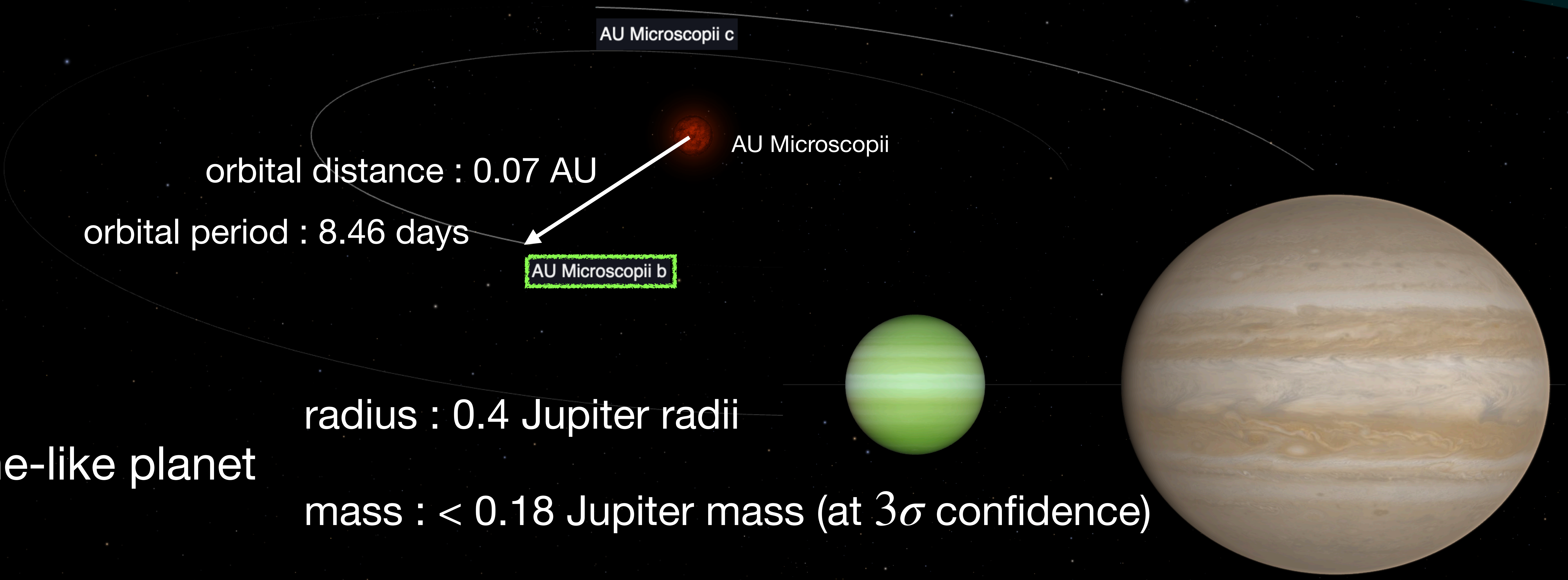
Outline

- Take home message
- Background & Method
- Possible formation history
- Summary
- Questions

Take home message

A transiting planet (AU Mic b) is found around an M-dwarf star AU Mic.



orbital distance : 0.07 AU

orbital period : 8.46 days

Neptune-like planet

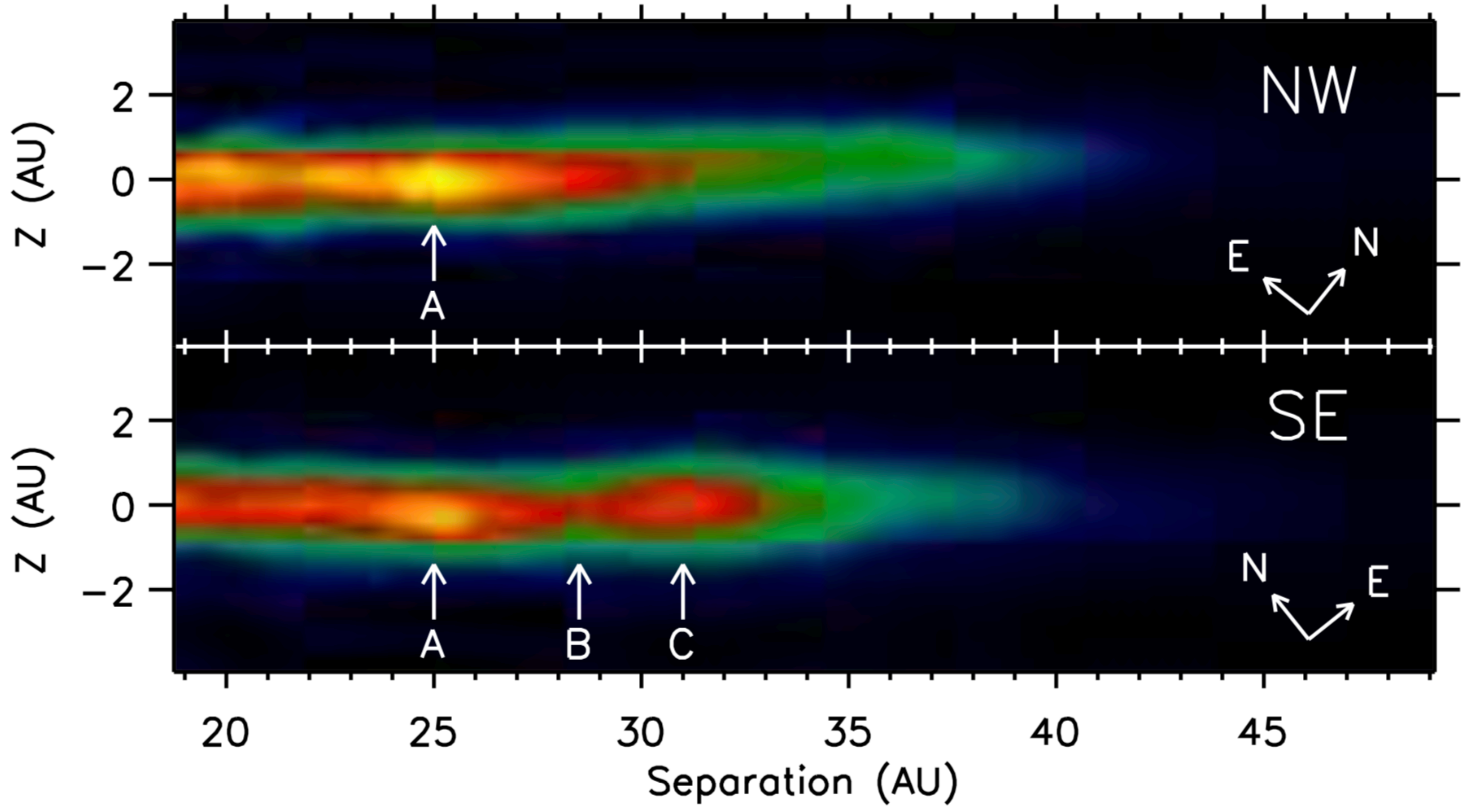
radius : 0.4 Jupiter radii

mass : $<$ 0.18 Jupiter mass (at 3σ confidence)

AU Microscopii (AU Mic)

- The second closest pre-main-sequence star
- active M-dwarf
- distance : 9.79 pc
- age : 22 million years
- nonaxisymmetric substructure in the dust debris disc

planet ? (Ozernoy+2000)



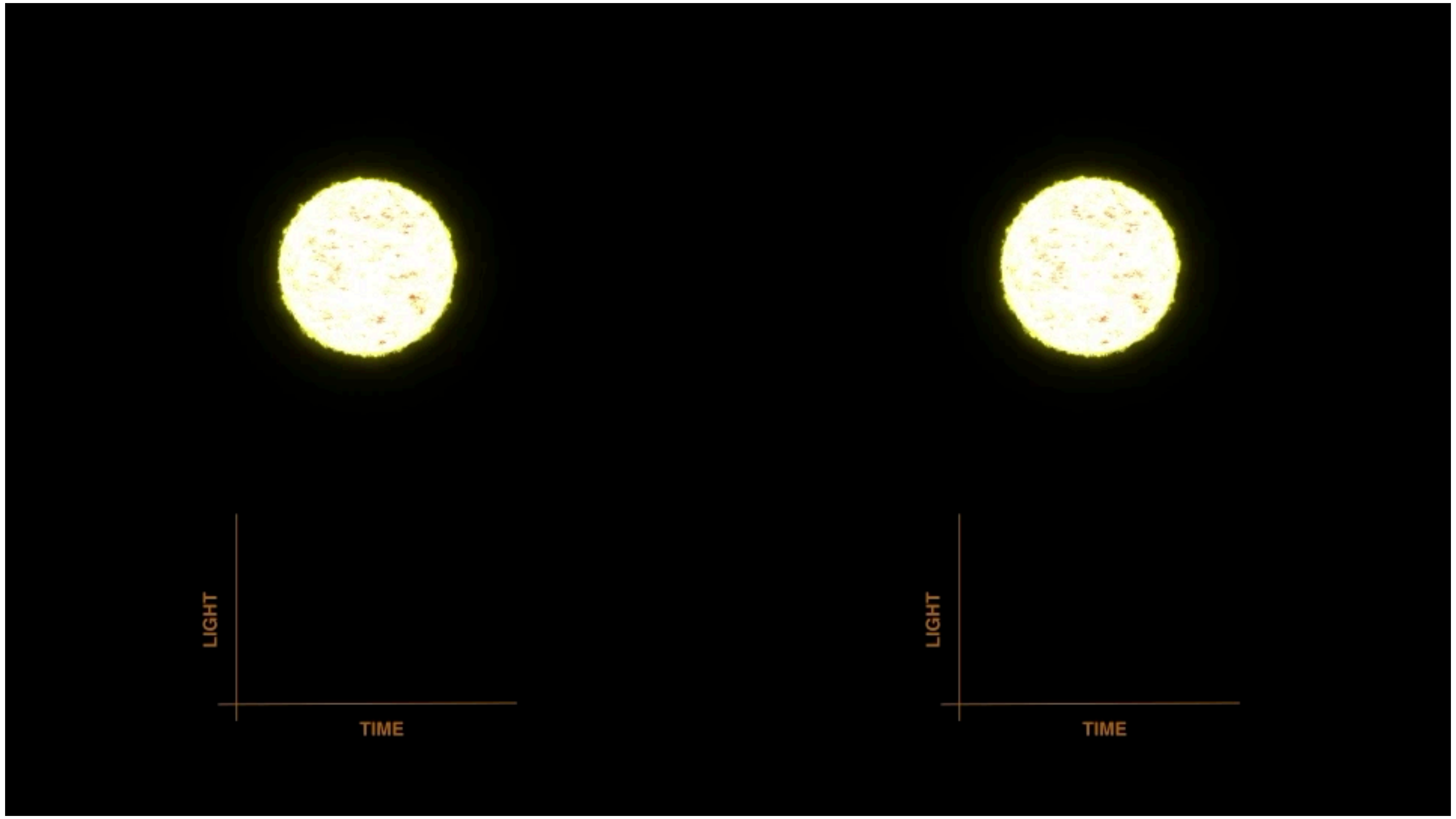
Liu 2004, Keck 1.63micron

It is suitable to use transit method to search for it

Transit

From the light curve of the star we can learn several planet characteristics :

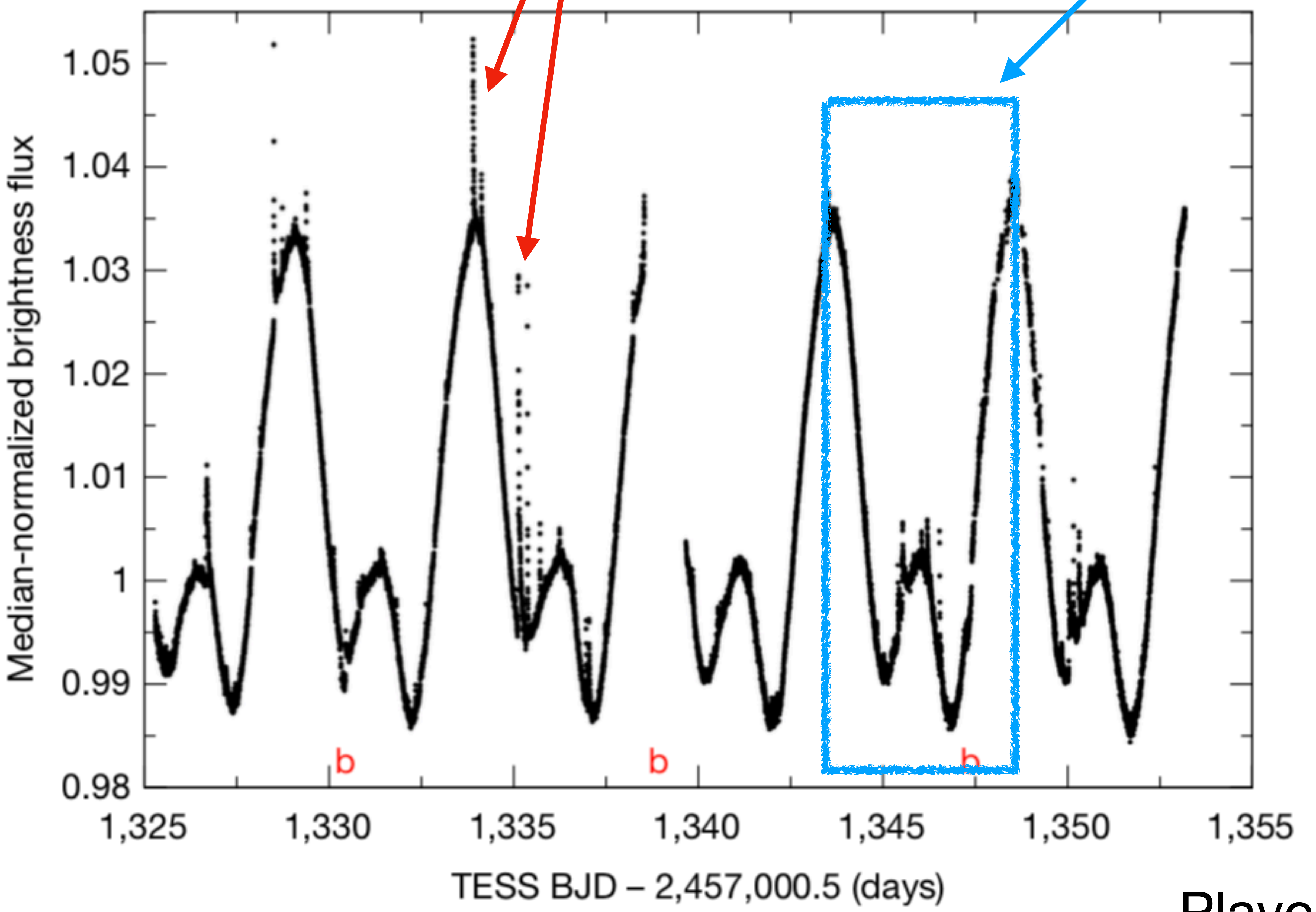
- orbital distance
- Orbital period
- planet radius



https://exoplanets.nasa.gov/faq/31/whats-a-transit/

However ...

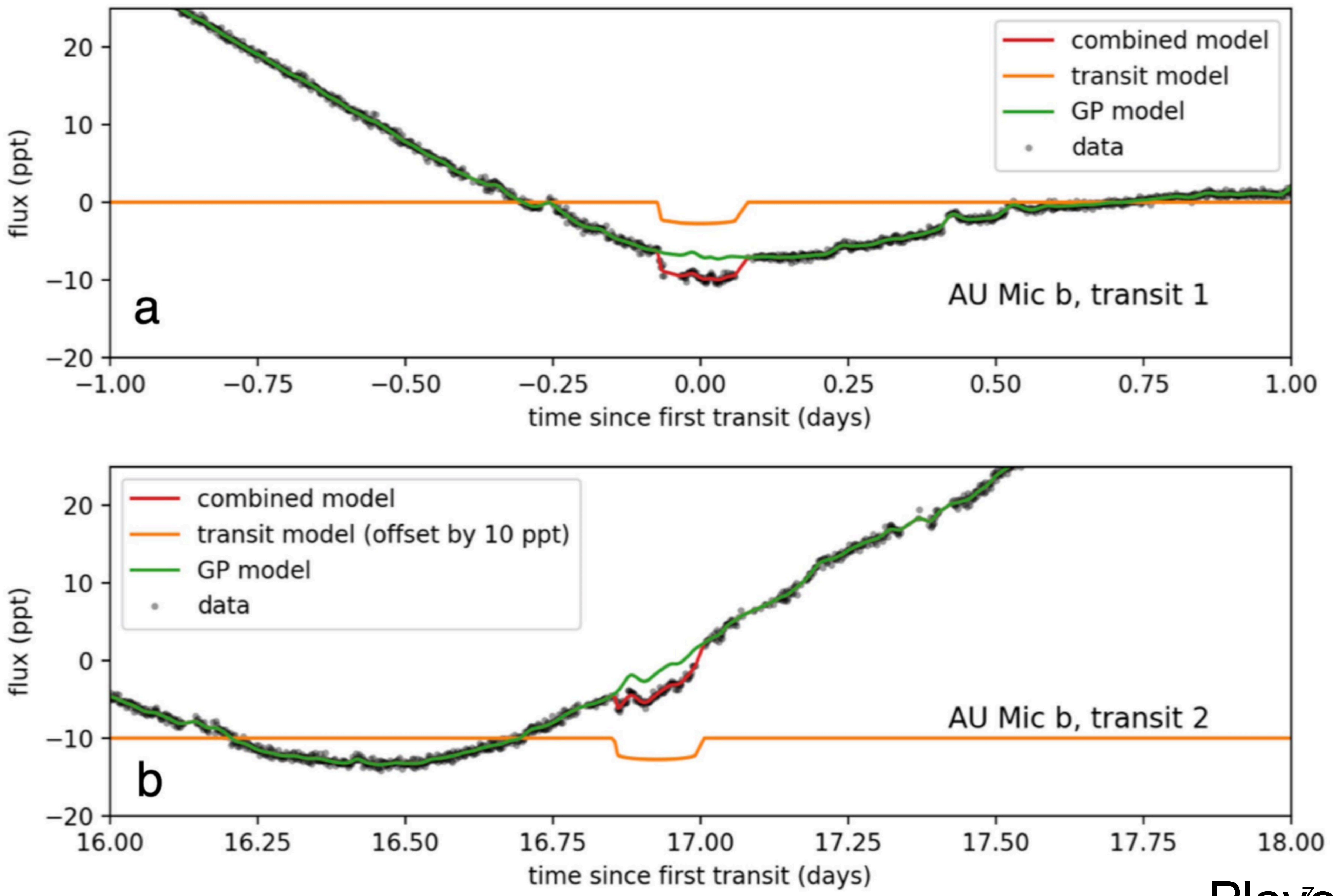
Since AU Mic is very active, its flares, plages and starspots can challenge the detection of transit signal

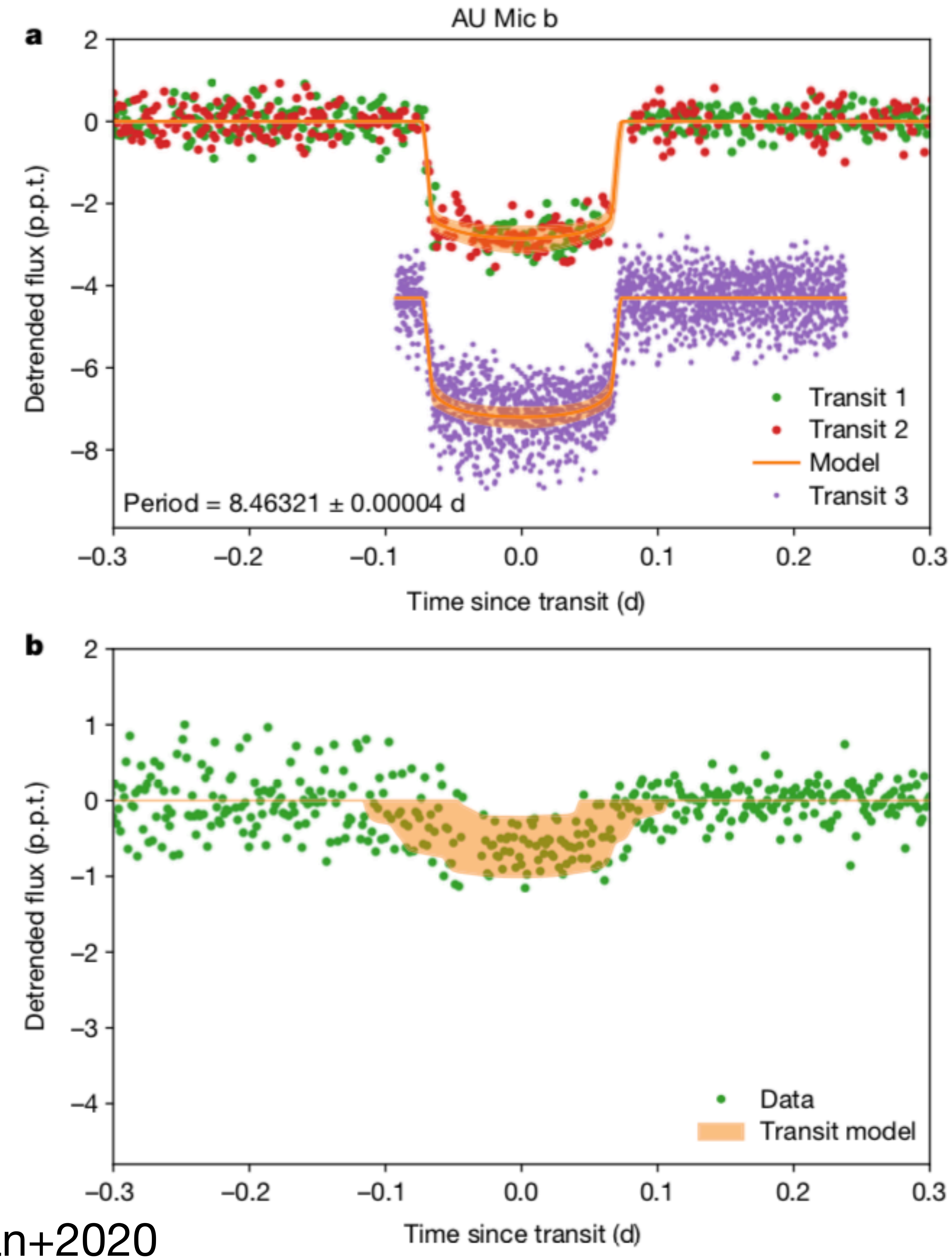


Plavchan+2020

TESS observation

Two transits of AU Mic b are found, there is also a candidate transit which is shallower than those two transits





Plavchan+2020

What is the formation and evolution history of AU Mic b?

Disk-driven migration

spin-orbit obliquity λ : the angle between planet orbital axis and stellar spin axis

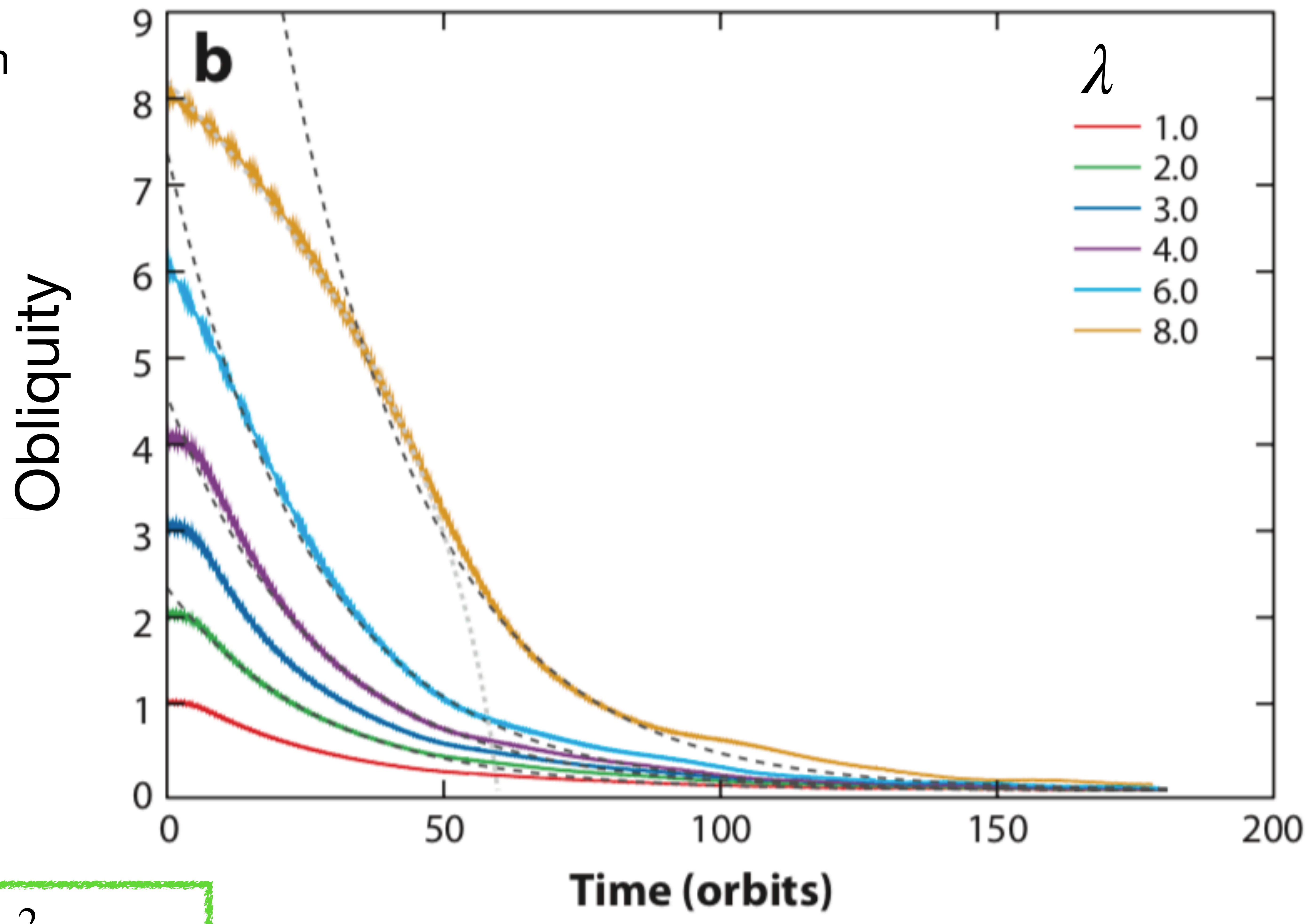
Disk-driven migration predicts aligned planet orbital axis and stellar spin axis (small λ)

For small obliquity $\lambda \lesssim H/r$:

Exponential damping : $d\lambda/dt \propto -\lambda$

Timescale : $t_d \sim (H/r)^2 t_m$

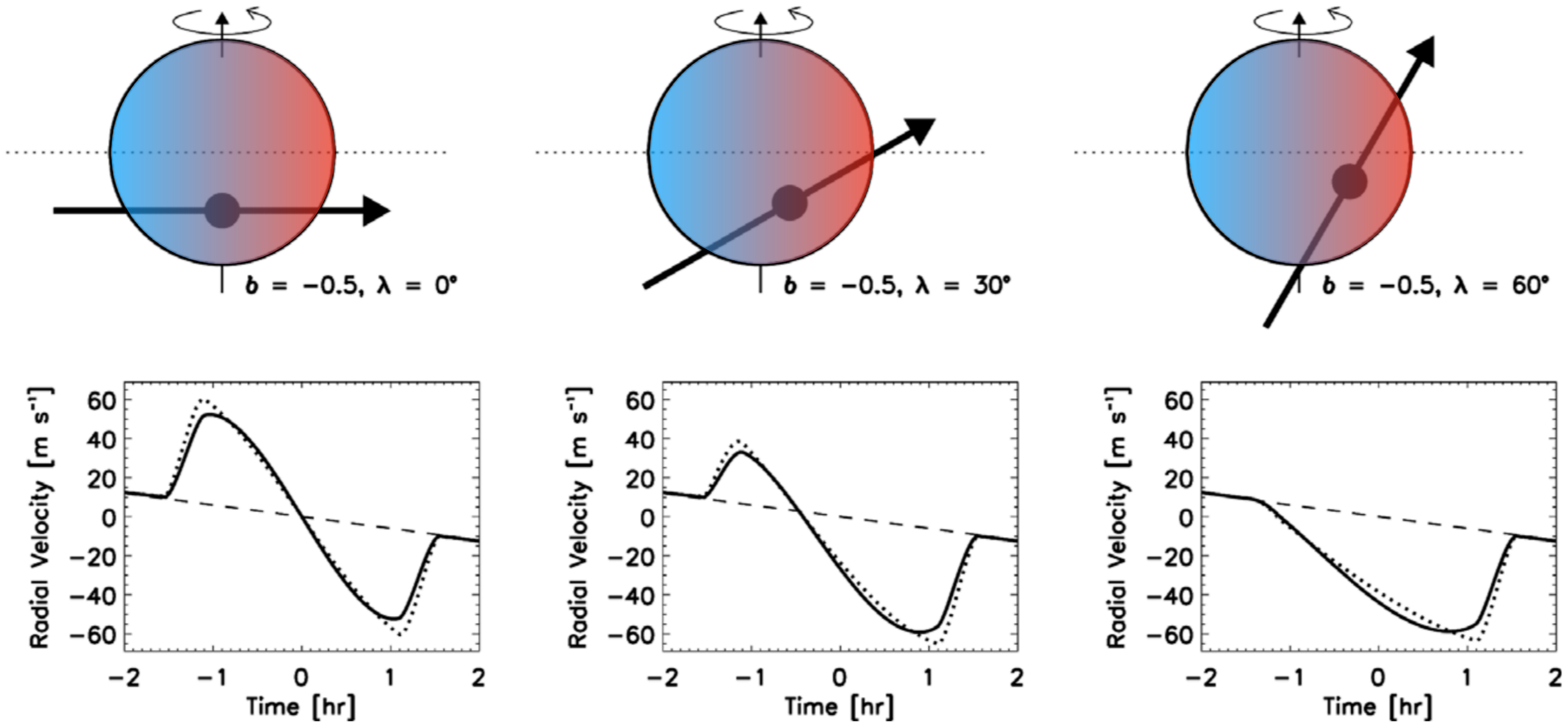
For larger obliquity $\lambda \gtrsim H/r : d\lambda/dt \propto -\lambda^{-2}$



Kley & Nelson 2012

Rossiter-McLaughlin effect

The shape of radial velocity signal can be used to assess the obliquity



Joshua 2010

Obliquity measurements via R-M effect

Palle et al. 2020 : $\lambda = -2.96^{+10.44^\circ}_{-10.30}$

Hirano et al. 2020 : $\lambda = -4.7^{+6.8^\circ}_{-6.4}$

Addison et al. 2020 : $\lambda = 47^{+26^\circ}_{-54}$

Consistent with disk-migration model

Possible formation history of AU Mic b

timescale $\lesssim 20$ Myr

The formation of AU Mic b by core-accretion and subsequent migration via type 1 and 2 disk migration are completely compatible with the observations

Summary

- A transiting planet (AU Mic b) is found around an M-dwarf star AU Mic.

- The possible formation history of AU Mic b is by core-accretion and migration via type 1 and 2 disk migration

Possible questions

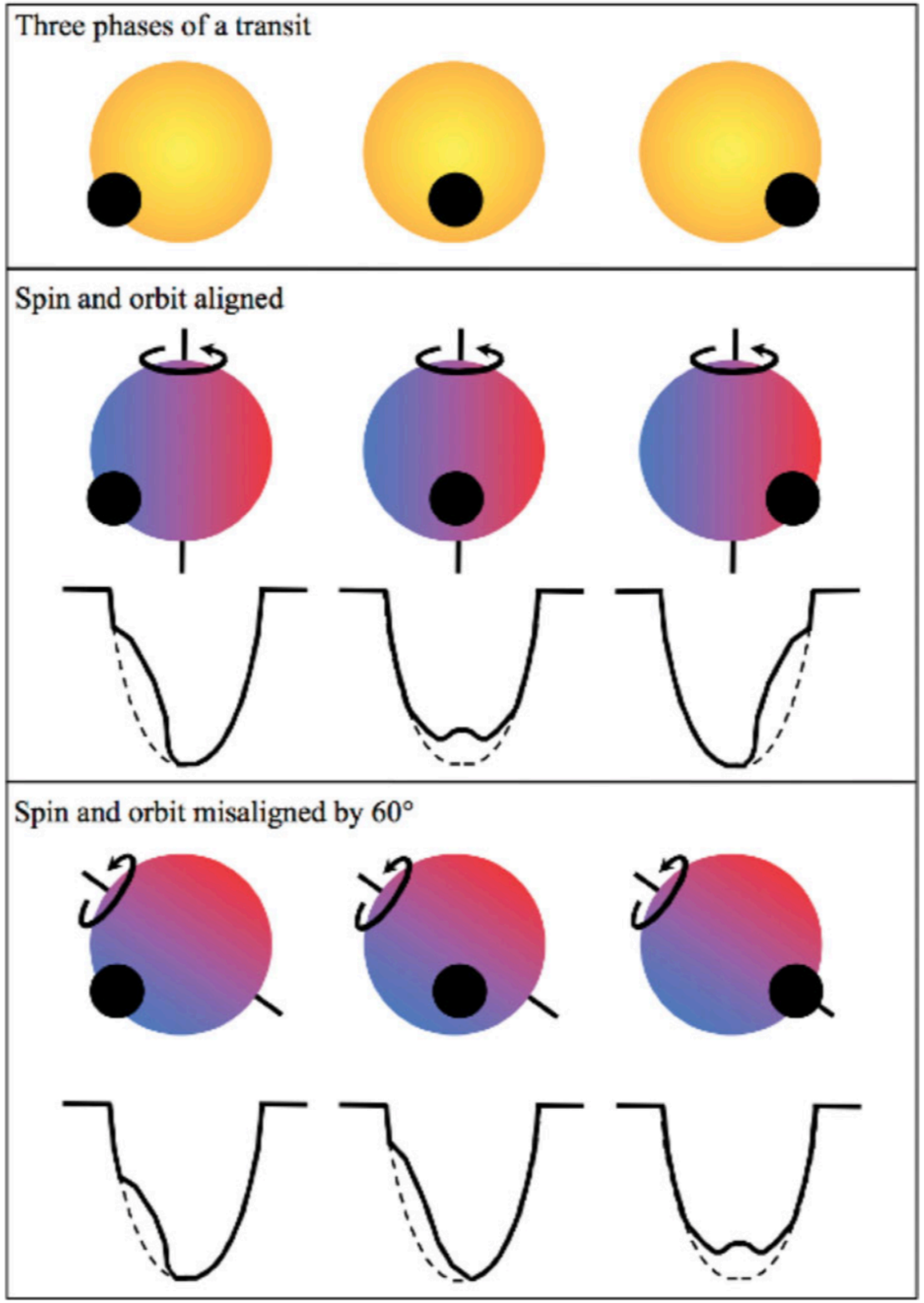
- Why this is a Nature paper ?

- Why AU Mic is a very important system ?

- Why earlier works attempting to search for planets around AU Mic did not find AU Mic b ?

- Other observational theories that can explain the observed properties of AU Mic b ?

Rossiter-McLaughlin effect



Planet atmosphere

- The density of AU Mic b is low, suitable to search for planet atmosphere

- high-dispersion transmission spectroscopy with visible and near-infrared spectrographs, around the 1083 nm HeI and the Hα line, will measure or constrain atmospheric mass loss rate from this young warm planet

TESS observation

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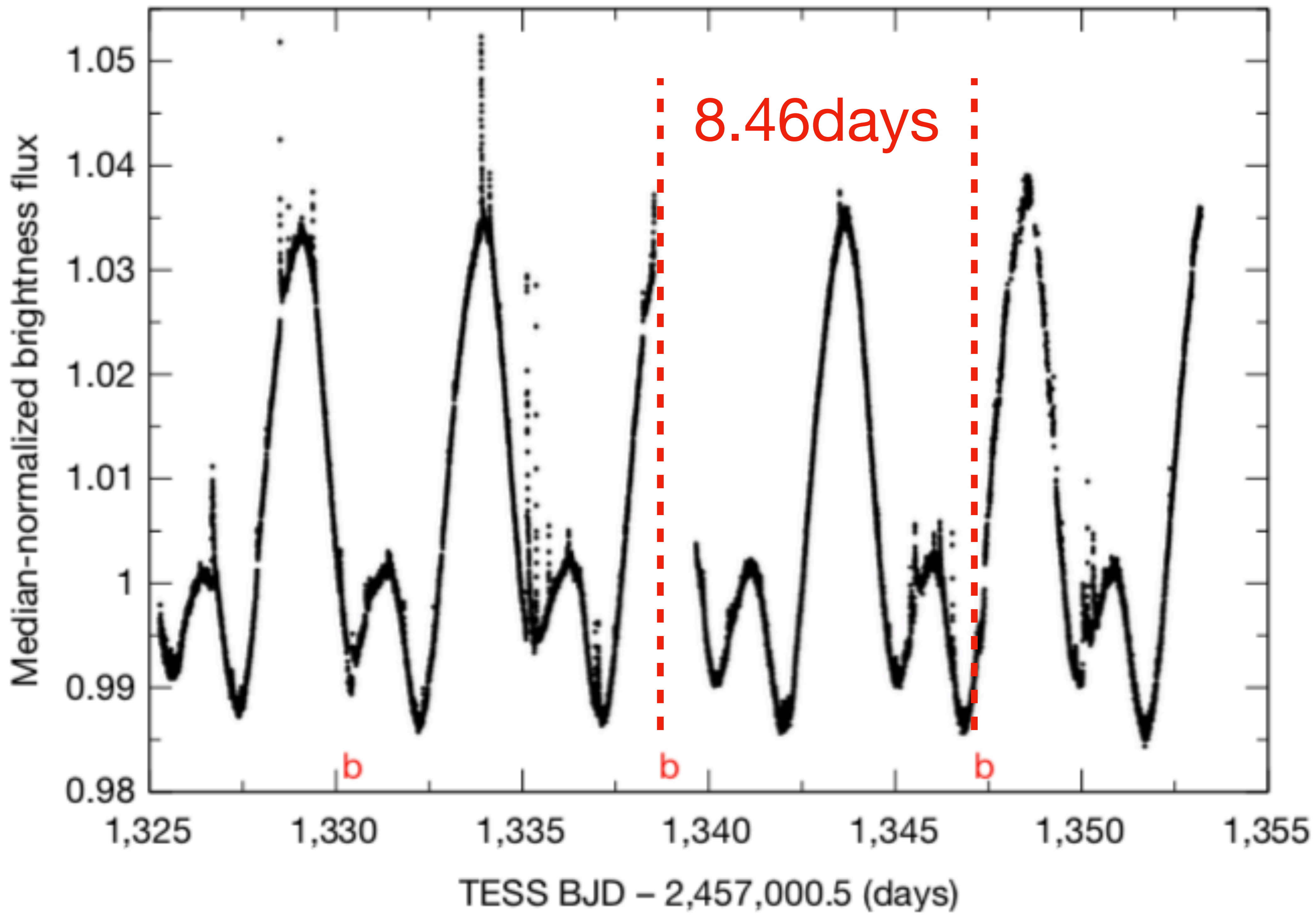

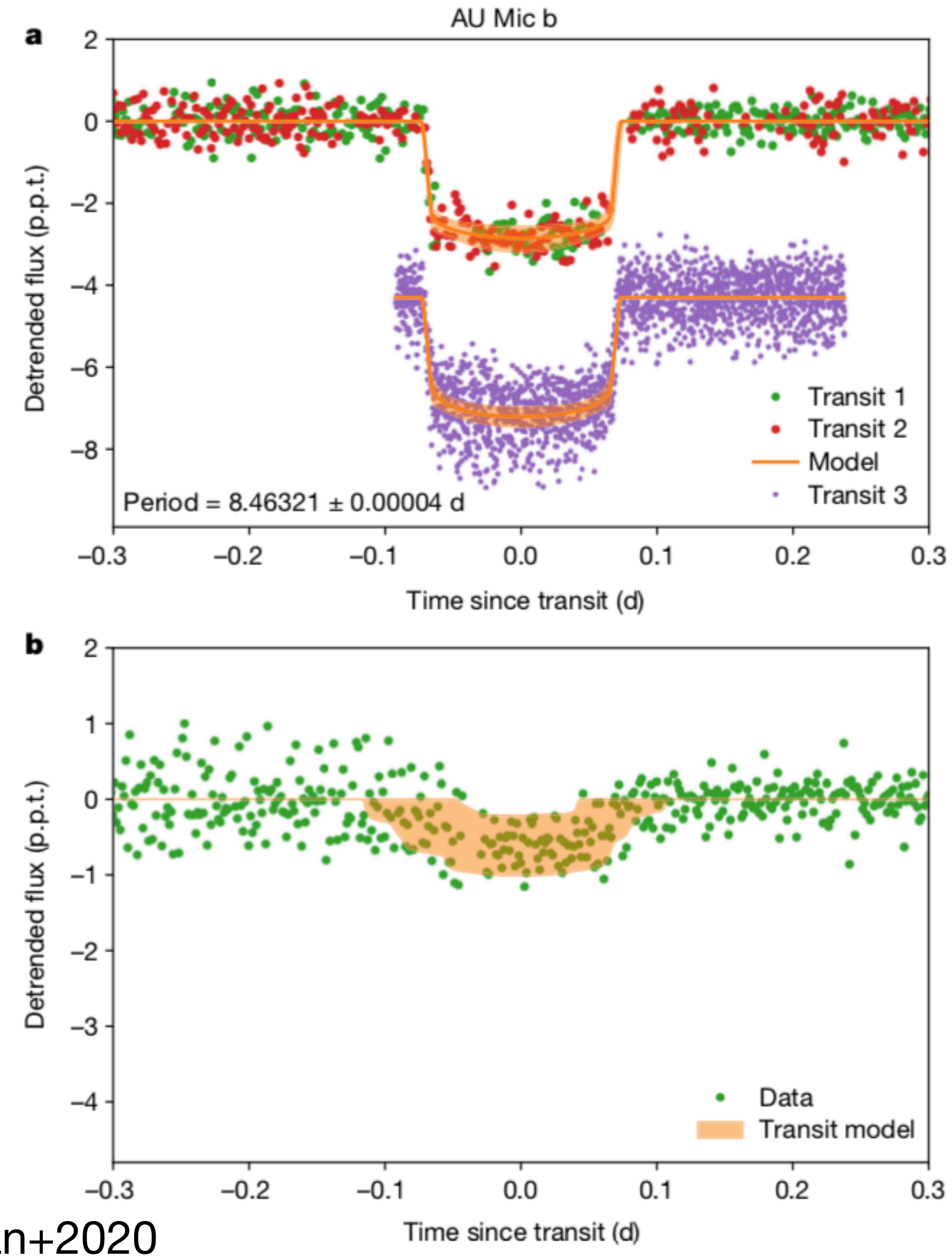

Plavchan+2020