

# *DISCOVERY OF A TESS GIANT PLANET ON A 261 DAY ORBIT ENABLED BY CITIZEN SCIENCE*

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*Collaborators:*

*The Visual Survey Citizen Scientist Group*

*The TESS Keck Survey*

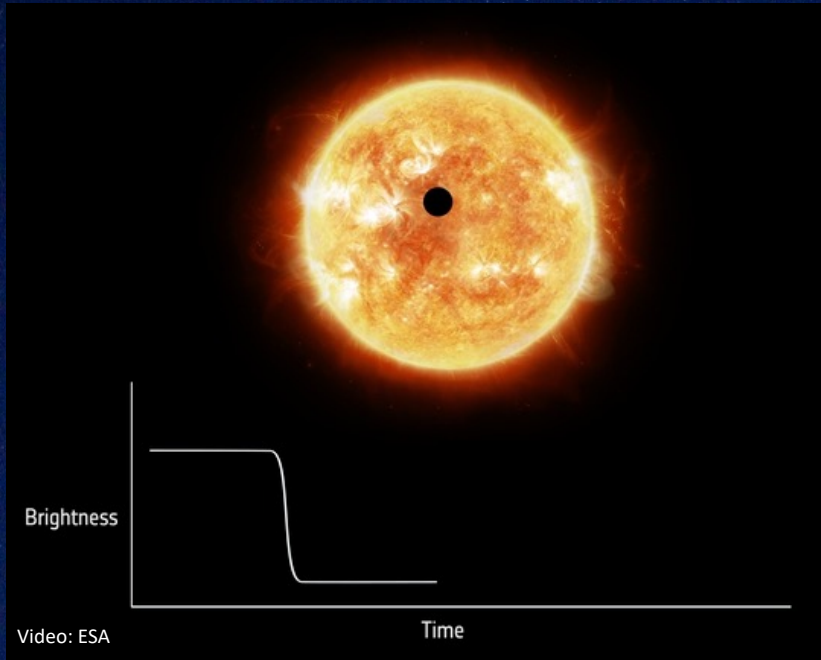
 [@Paul\\_Dalba](https://twitter.com/Paul_Dalba)

*Article published in AJ today!*



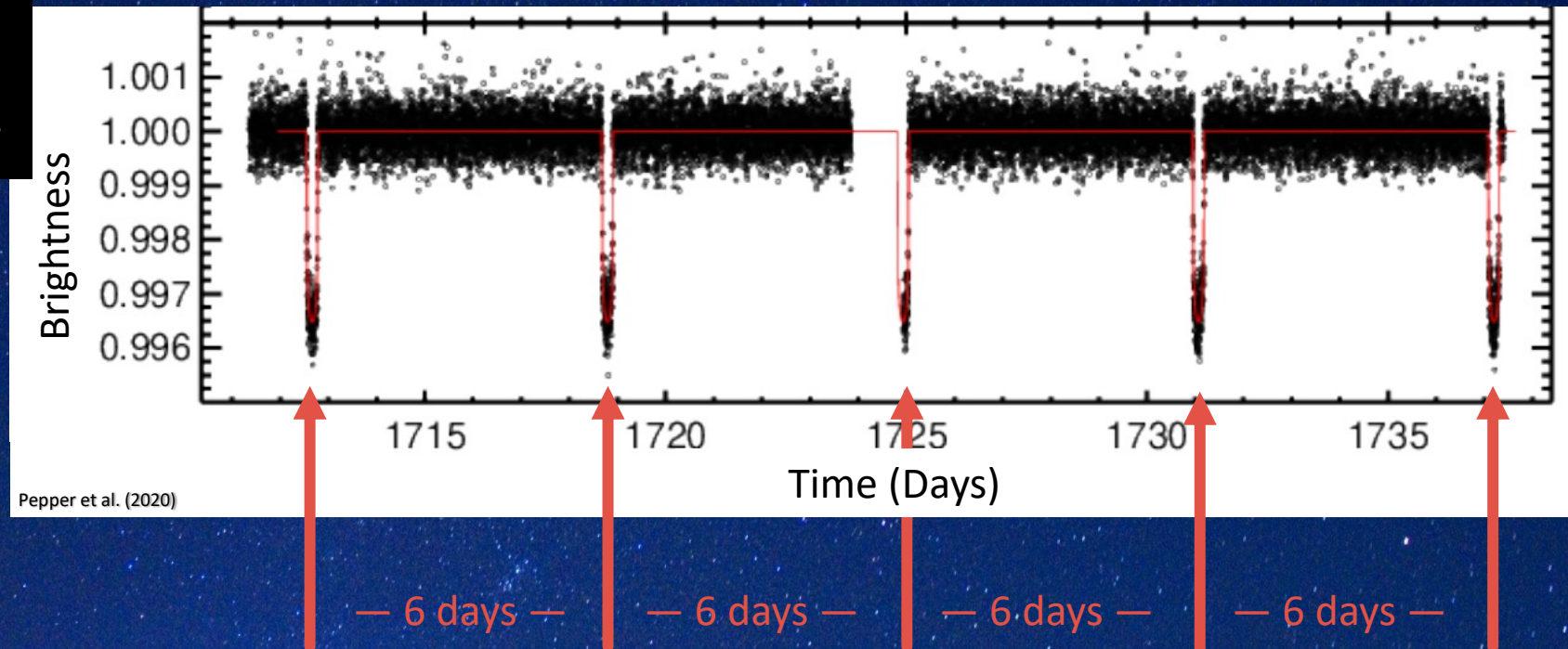
**UC SANTA CRUZ**

# THE LONGER THE ORBIT, THE HARDER TO DETECT



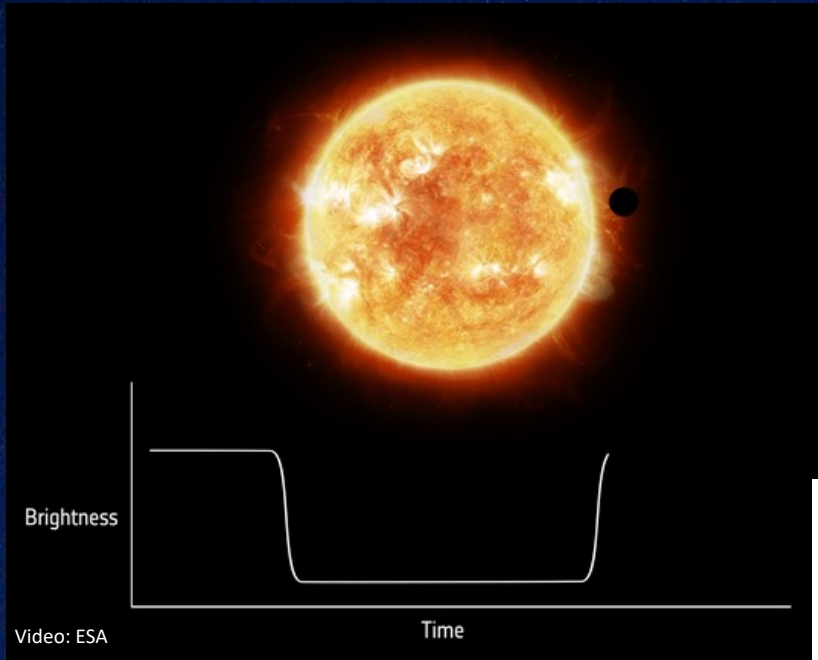
Automatic detection typically relies on periodic transits to identify exoplanets.

Rule of thumb = 3 transits

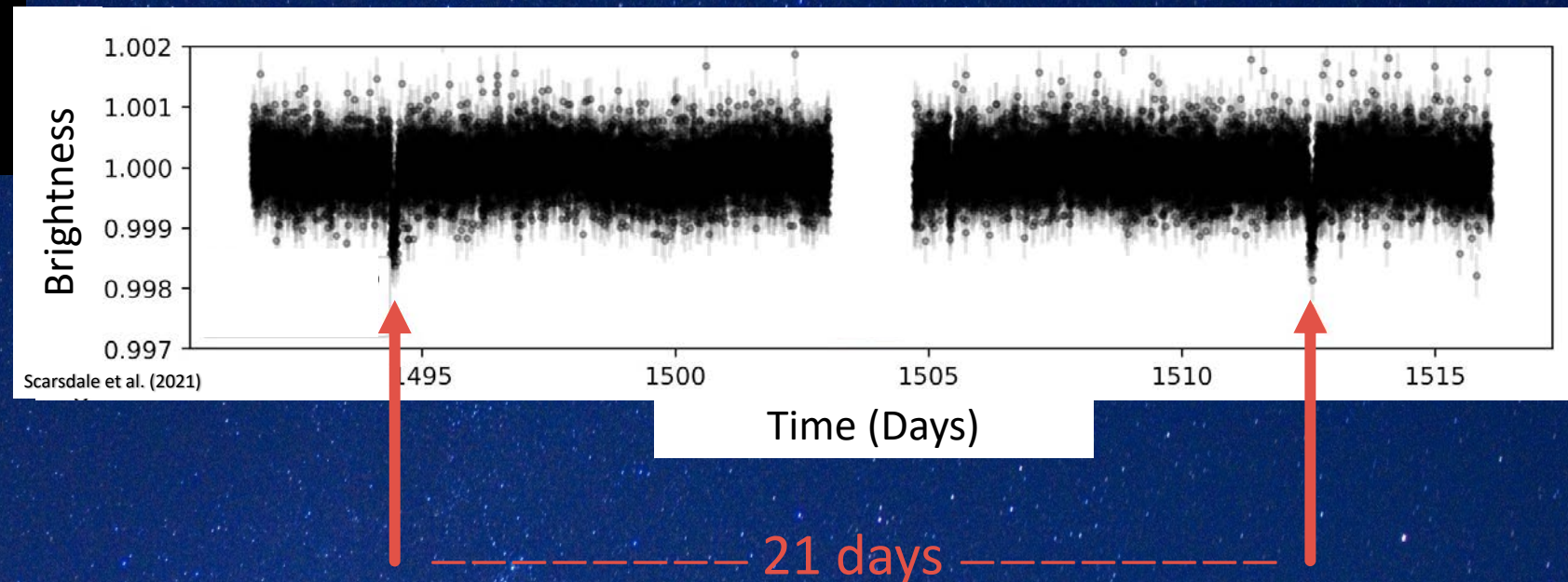


The “Transit Method”

# THE LONGER THE ORBIT, THE HARDER TO DETECT

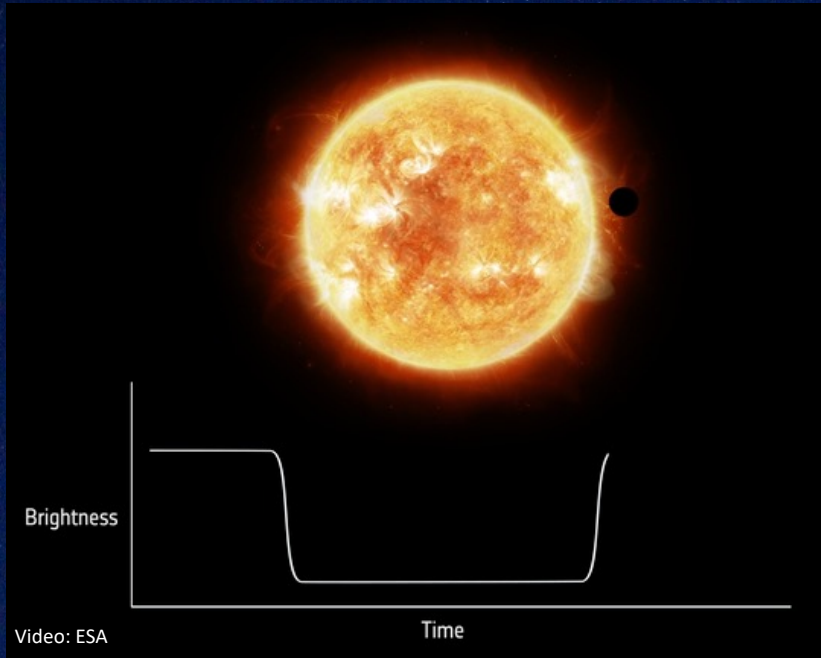


The ~28 day baseline of TESS observations sets a limit on the length of orbits we can easily detect with periodic transits.

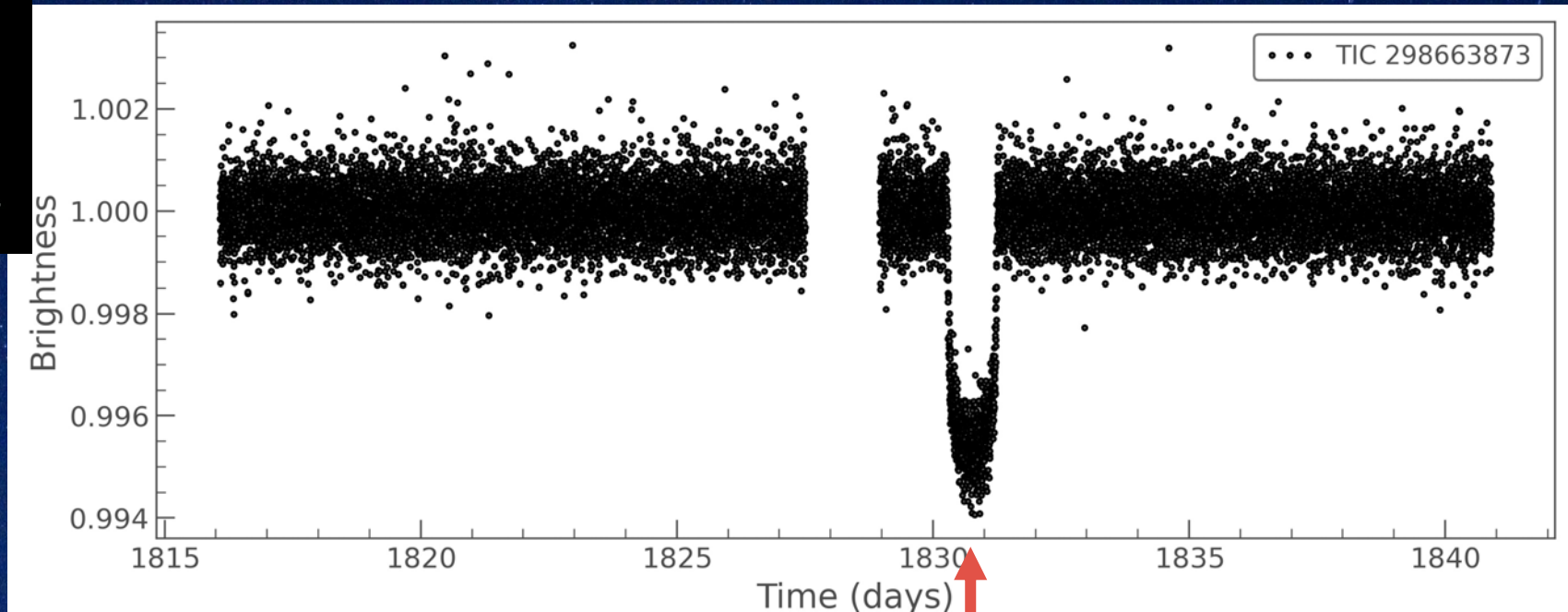


The "Transit Method"

# THE LONGER THE ORBIT, THE HARDER TO DETECT



*Single transit events*—while clear by eye—are like needles in a haystack of spurious noise and other signals to an automated code.



The “Transit Method”

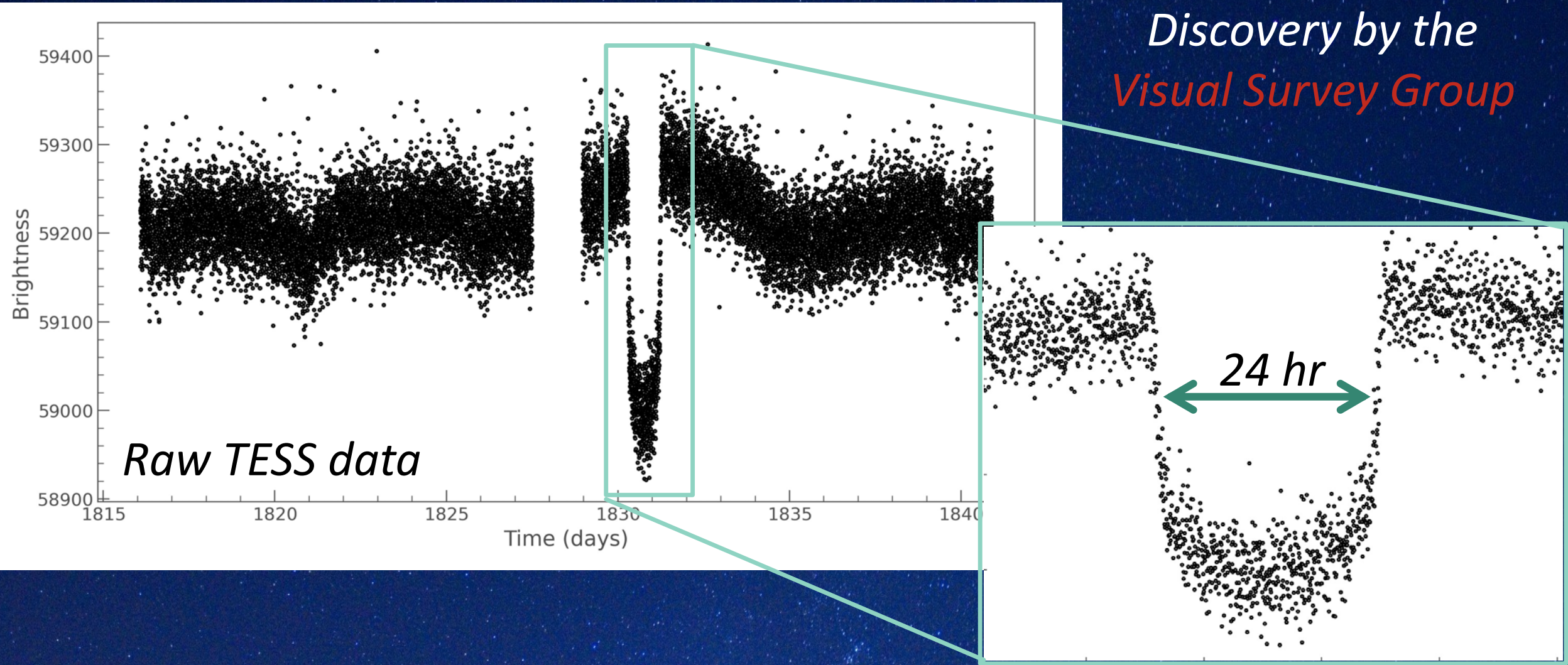
Single Transit  
Events



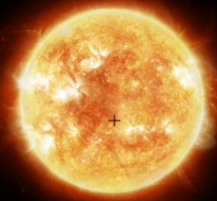
*Cooler  
Exoplanets, on  
Longer Orbits*

- Do short and long-orbit planets *form or evolve* in different ways?
- Different *atmospheric chemistry* at cooler temperatures?
- “*Stepping stones*” between the very hot giant exoplanets and the very cold Solar System gas giants, Jupiter and Saturn.

# THE DETECTION: "SEEMS TOO GOOD TO BE TRUE"



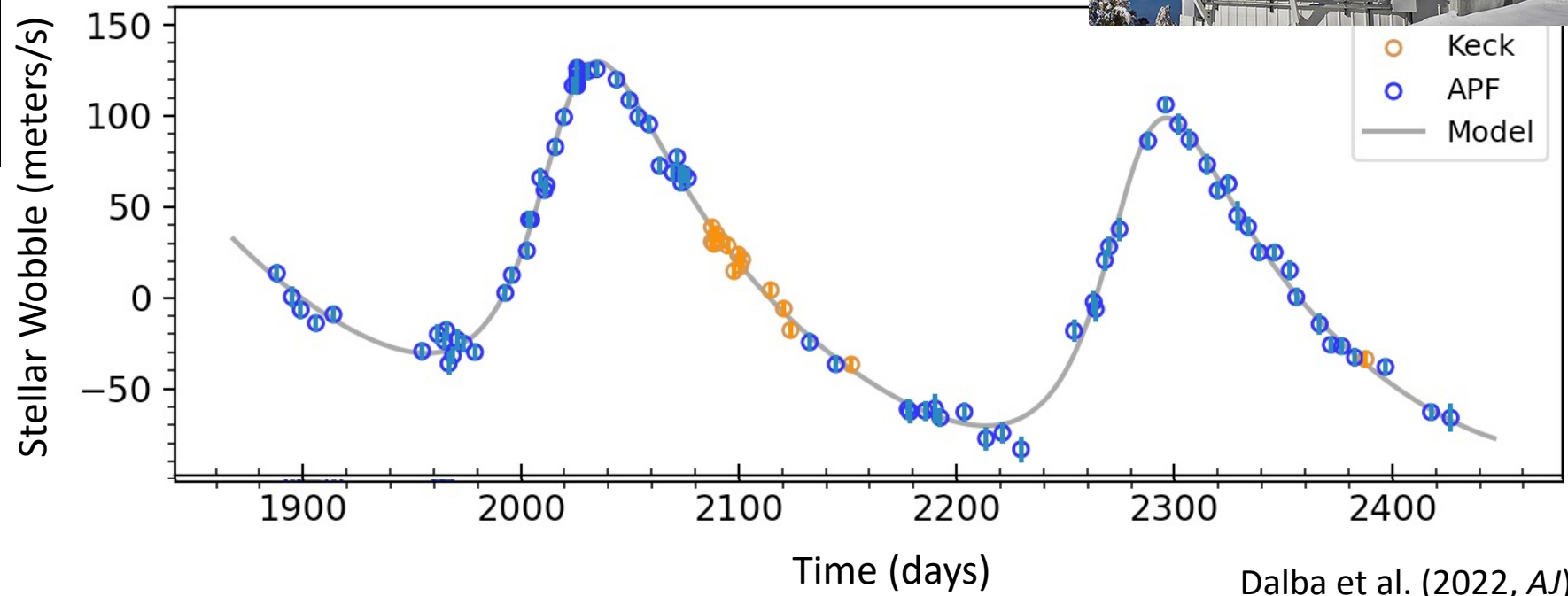
# THE FOLLOW-UP: THE ROBOTIC APF TELESCOPE



Video: ESA

The “Wobble Method”

- Automated Planet Finder Telescope observations taken over 500 days reveal length of orbit and mass of planet
- Supplement with Keck Observatory Observations due to wildfires at Lick Observatory



# THE PLANET: **TOI-2180 b**, A TEMPERATE JOVIAN PLANET

- Same size as Jupiter
- 2.8x as massive as Jupiter
- 170 °F (*temperate*)
- Longest orbit for a TESS planet (so far)
- Models suggest TOI-2180 b is composed of over 100 Earth masses of material heavier than H and He

## *A Rare Trifecta of Properties*

Bright Host Star:  
only 379  
lightyears away

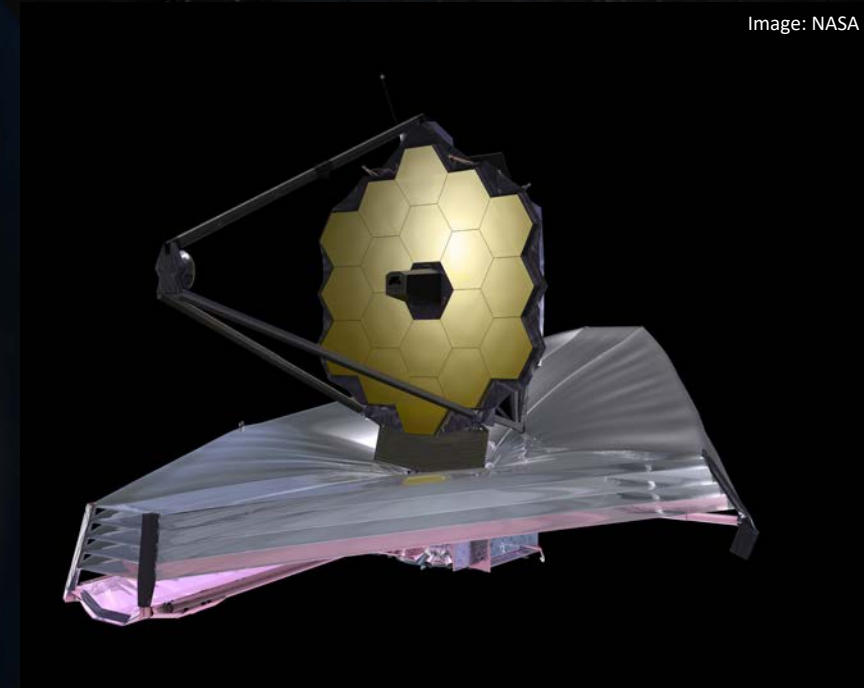
TOI-2180 b  
“transits” its  
star from our  
point of view

Long Orbit:  
(261 days is 1  
“year” for  
TOI-2180 b)

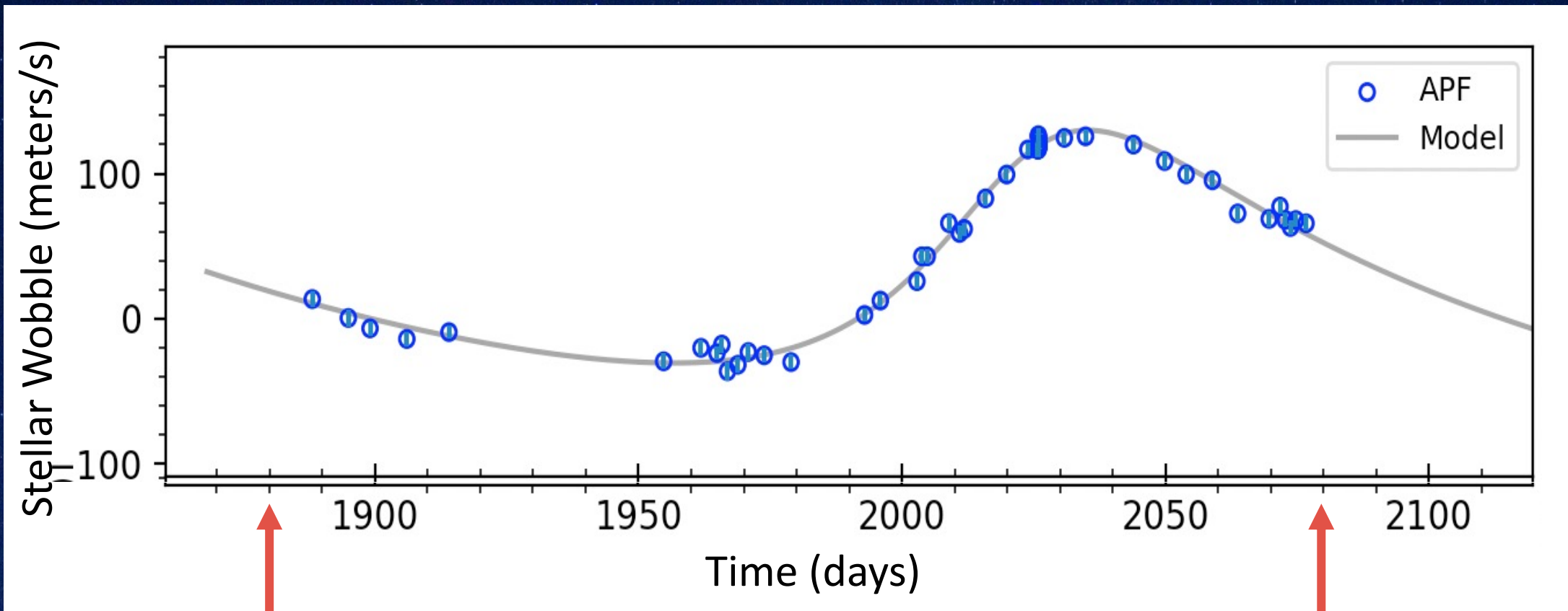


# THE FUTURE: EXCITING PROSPECTS FOR JWST

- Atmospheric characterization via emission spectroscopy
  - Exciting comparison for chemistry in Jupiter/Saturn
- Rings?
- Exomoons?



# OBSERVING A SECOND TRANSIT



Date of Discovery

**NEXT TRANSIT IMMINENT!**  
But TESS was no longer looking...

# THE WORLD-WIDE CAMPAIGN: TRACKING A TRANSIT



The “Transit Window” was 11 days long

- 3 continents
- 14 sites (including several Citizen Scientists)
- 55 data sets
- >20,000 individual images of TOI-2180

# THE WORLD-WIDE CAMPAIGN: TRACKING A TRANSIT



Unistellar eVscopes in Joshua Tree National Park (astronomers)

- 55 data sets
- >20,000 individual images of TOI-2180

# THE WORLD-WIDE CAMPAIGN: TRACKING A TRANSIT



No confident detection, but many confident non-detections



Prediction: *TESS* will see another transit in 3 weeks!

*The VSG Citizen Scientists are poised to make the discovery!*

# SUMMARY

- *The Discovery*: Single transit spotting by Citizen Scientists
- *The Follow-Up*: Mass measurement by APF Telescope
- *The Planet*: A temperate Jovian with a rare trifecta of favorable properties
- *The Worldwide Campaign*: Global effort to catch another transit

# ACKNOWLEDGEMENTS

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- Mark Omohundro
- Hans Schwengeler
- Ivan Terentev
- Alan Schmitt
- Andrew Vanderburg
- Saul Rappaport

## Other Citizen Scientist Observers:

- Paul Benni
- Pat Boyce
- Grady Boyce
- Eric Girardin
- Didier Laloum
- Pablo Lewin
- Gregor Srdoc

## The TESS-Keck Survey (TKS)

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California Institute of Technology – NASA – NASA Exoplanet Science Institute – University of California, Berkeley – University of California, Irvine – University of California, Riverside – University of California, Santa Cruz – University of Hawaii – University of Kansas – W. M. Keck Observatory

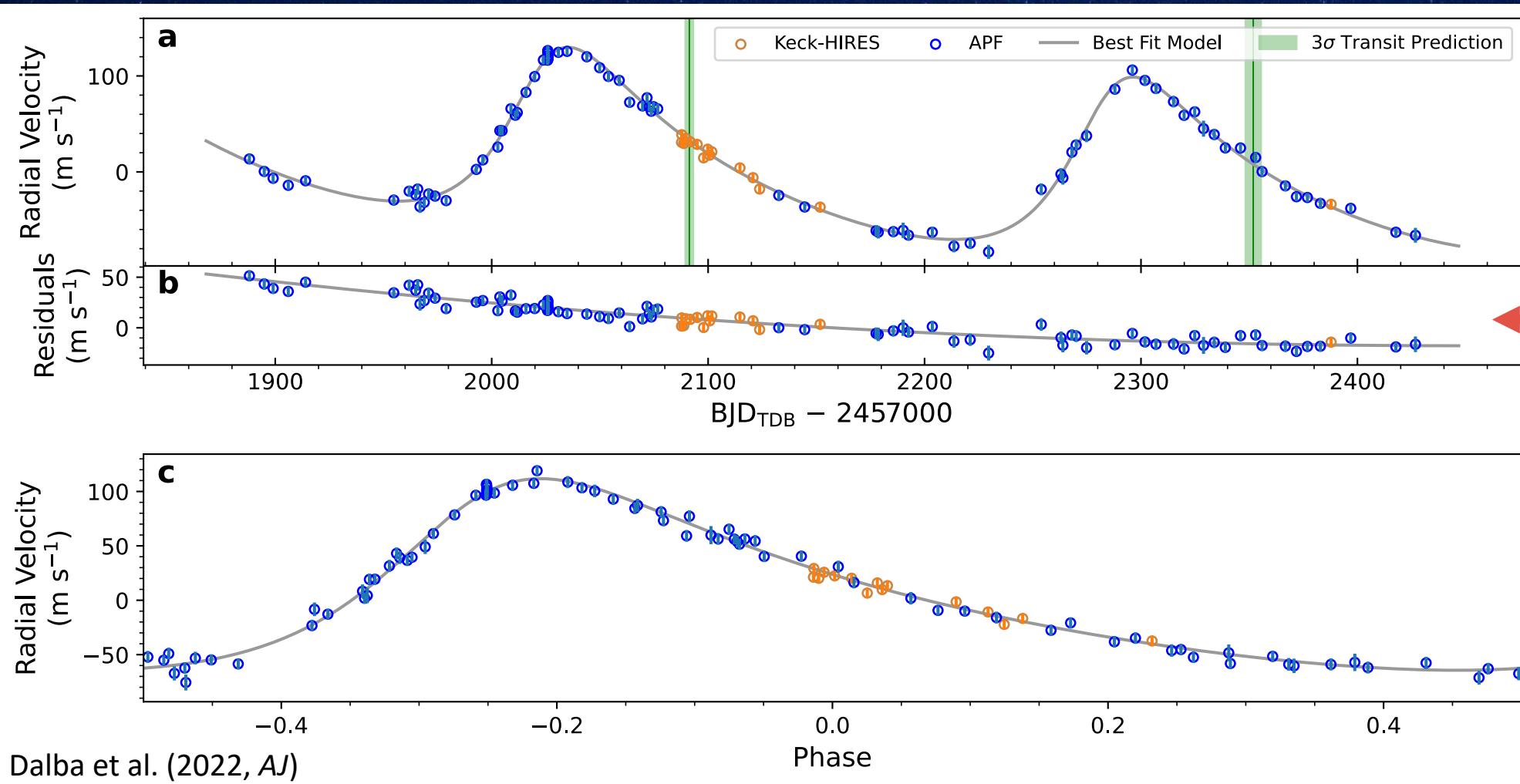


We recognize and acknowledge the cultural role and reverence that the summit of Maunakea has within the indigenous Hawaiian community. We are deeply grateful to have the opportunity to conduct observations from this mountain.

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# ANOTHER MASSIVE OBJECT IN THE TOI-2180 SYSTEM



Portion of a very long, unresolved wobble from a distant massive object (planet? star?)

Dalba et al. (2022, *AJ*)



# ANOTHER MASSIVE OBJECT IN THE TOI-2180 SYSTEM

