Speaker Contact Information

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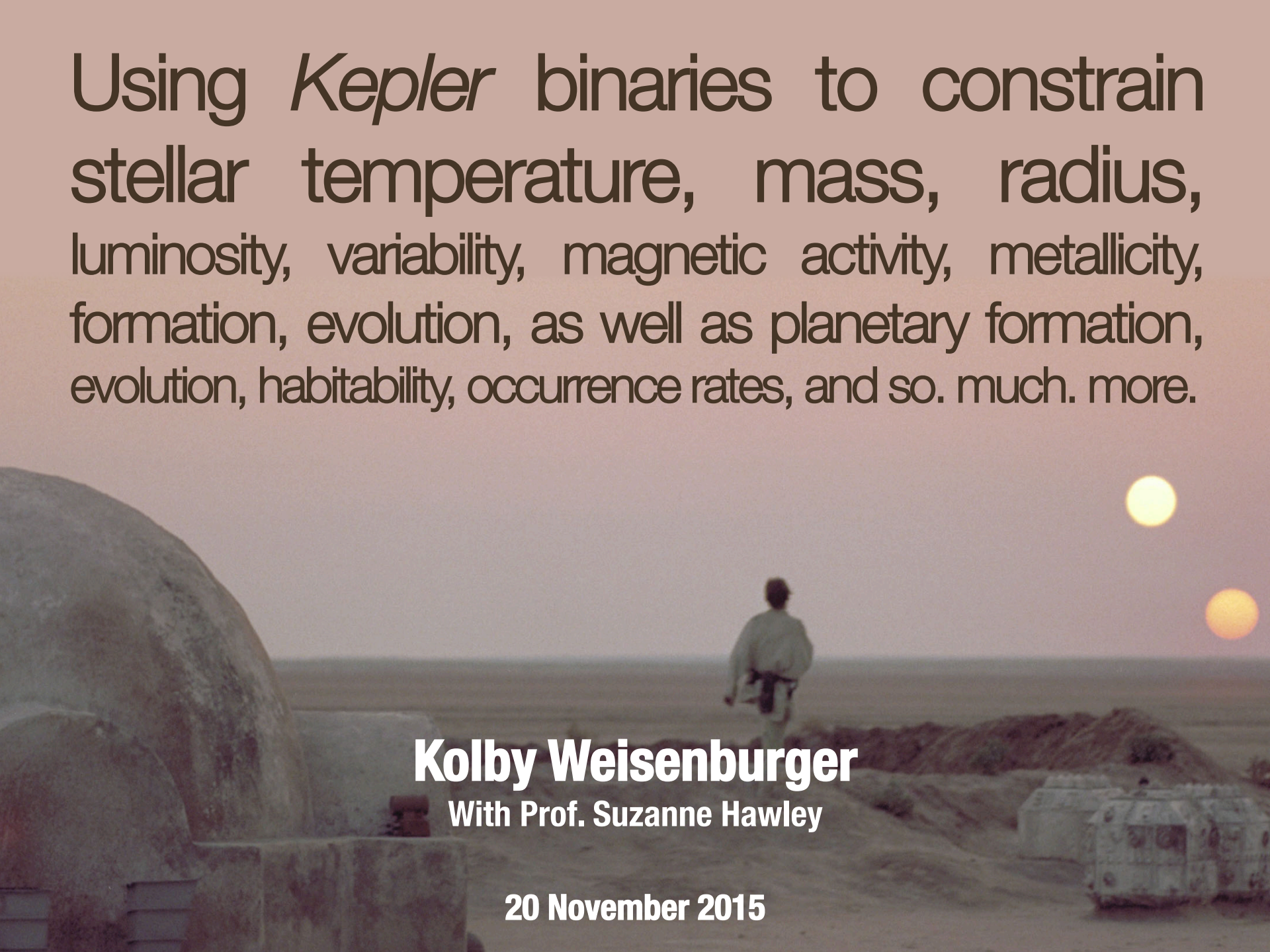
- Russell Deitrick & Rory Barnes: deitrr@u.washington.edu , rory@astro.washington.edu
- Rodrigo Luger: rodluger@uw.edu
- Jacob Lustig-Yaeger: jlustigy@uw.edu
- Eddie Schwieterman: eschwiet@astro.washington.edu

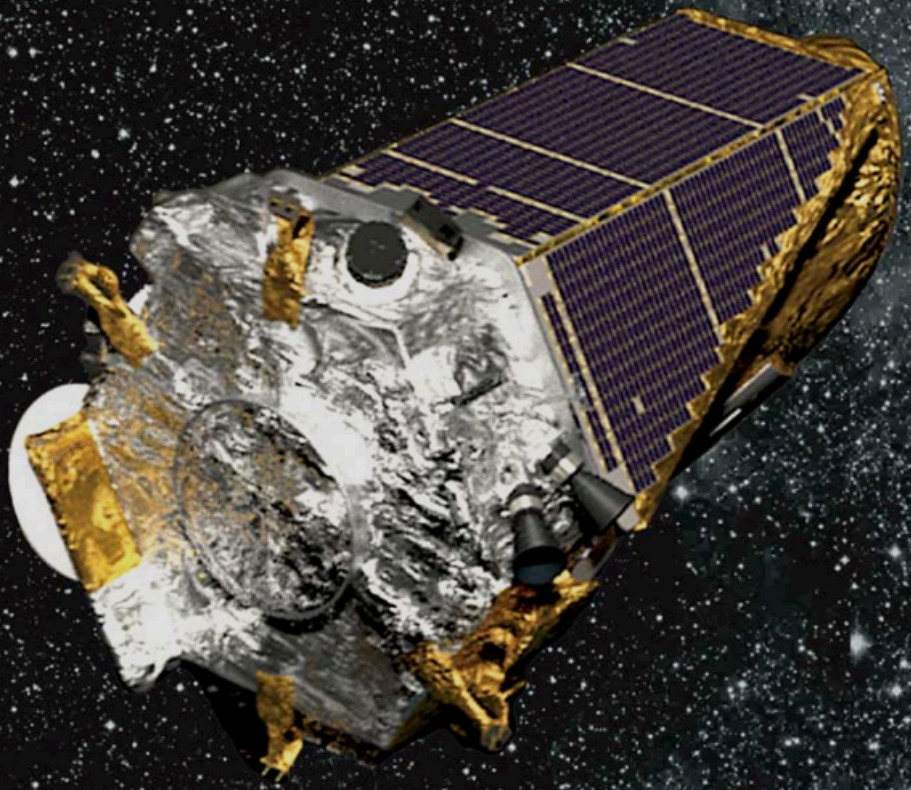
Using *Kepler* binaries to constrain stellar temperature, mass, radius, luminosity, variability, magnetic activity, metallicity, formation, evolution, as well as planetary formation, evolution, habitability, occurrence rates, and so. much. more.



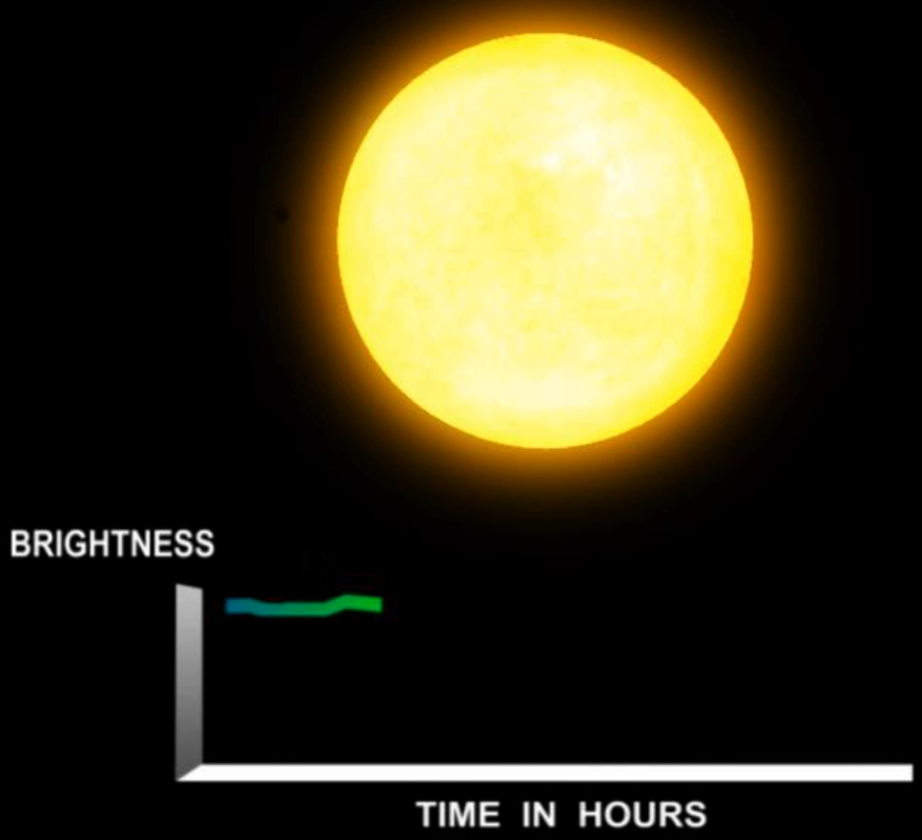
Kolby Weisenburger
With Prof. Suzanne Hawley

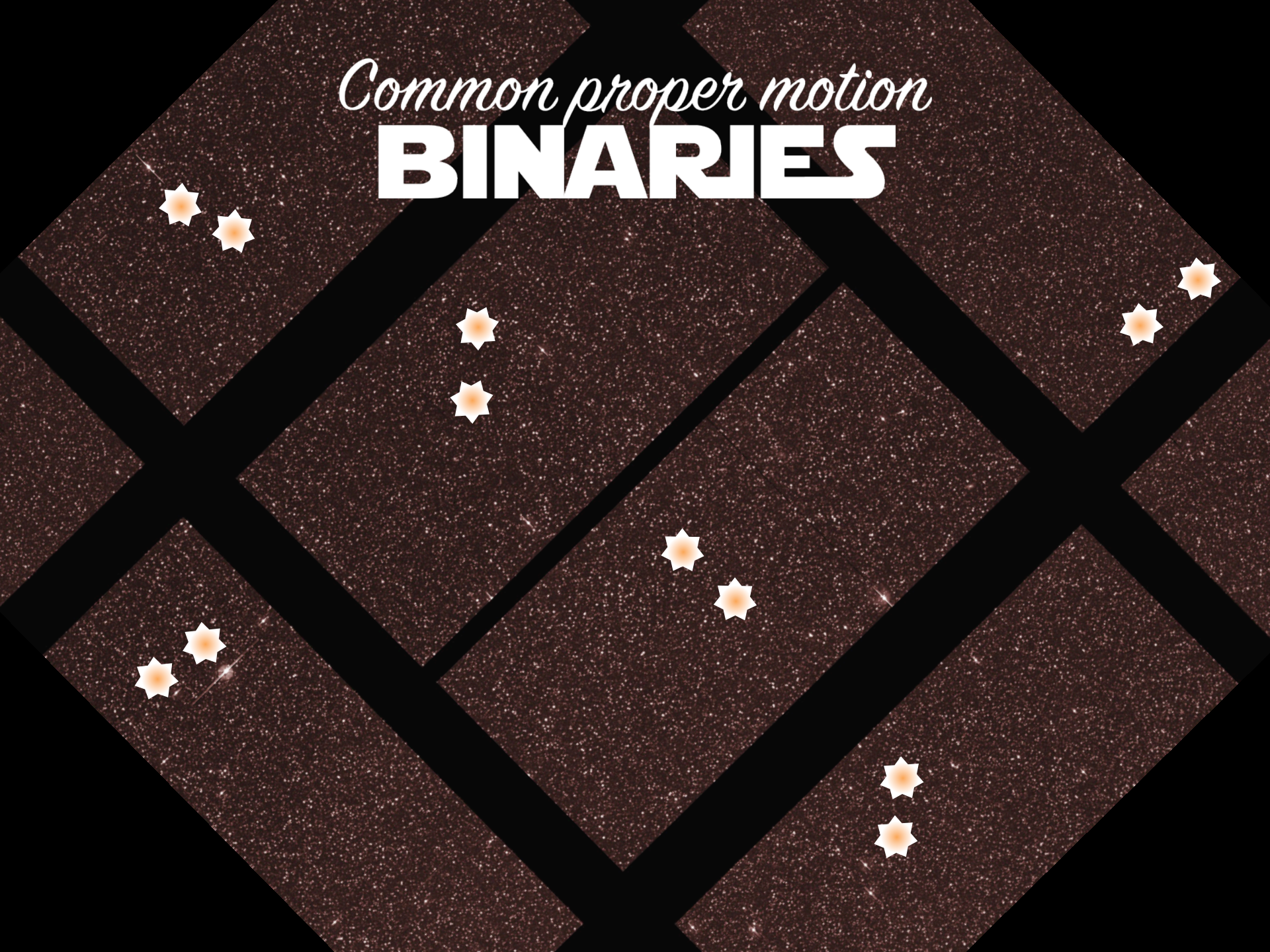
20 November 2015

KEPLER

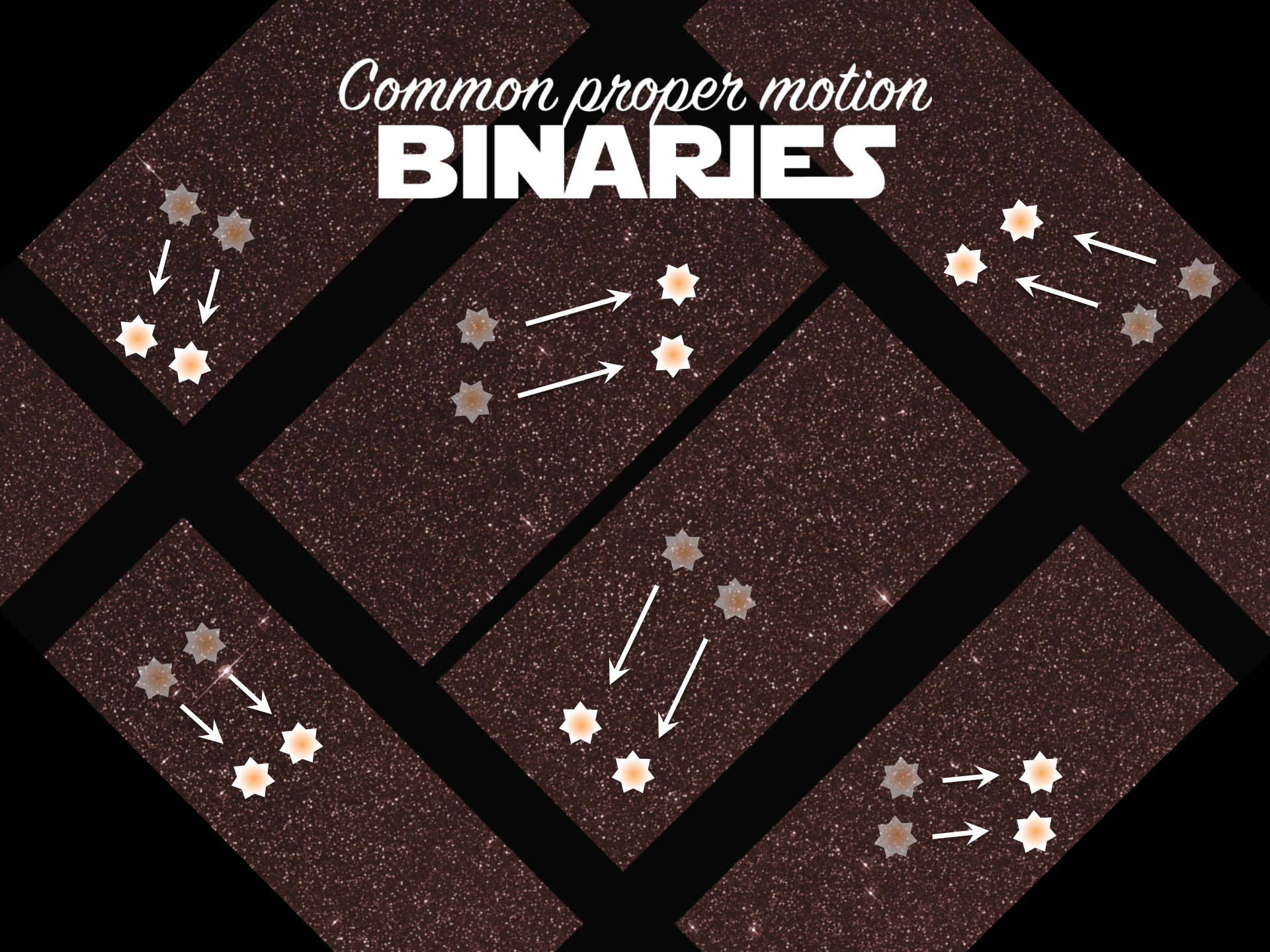


KEPLER




Common proper motion
BINARIES

Common proper motion
BINARIES



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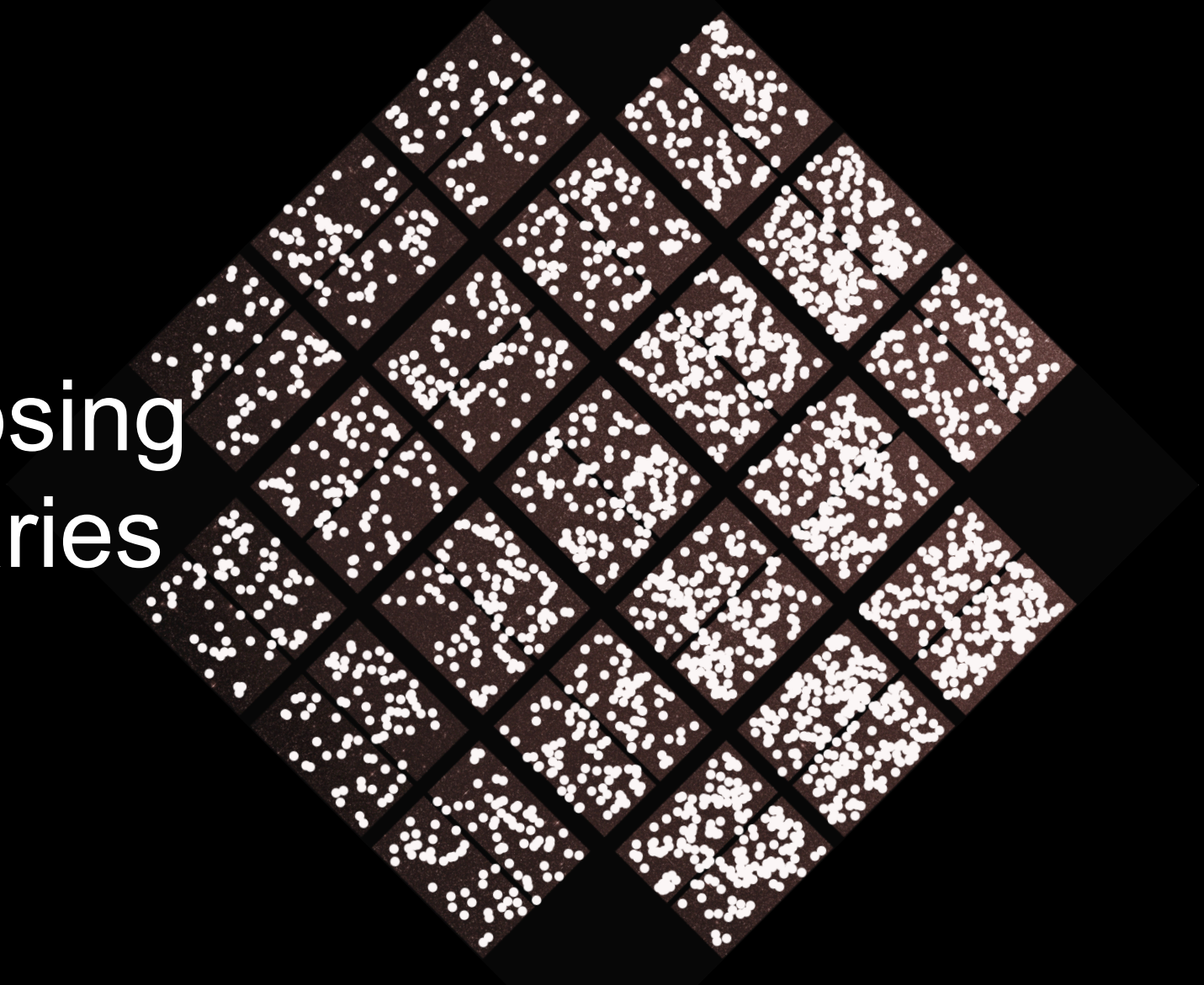
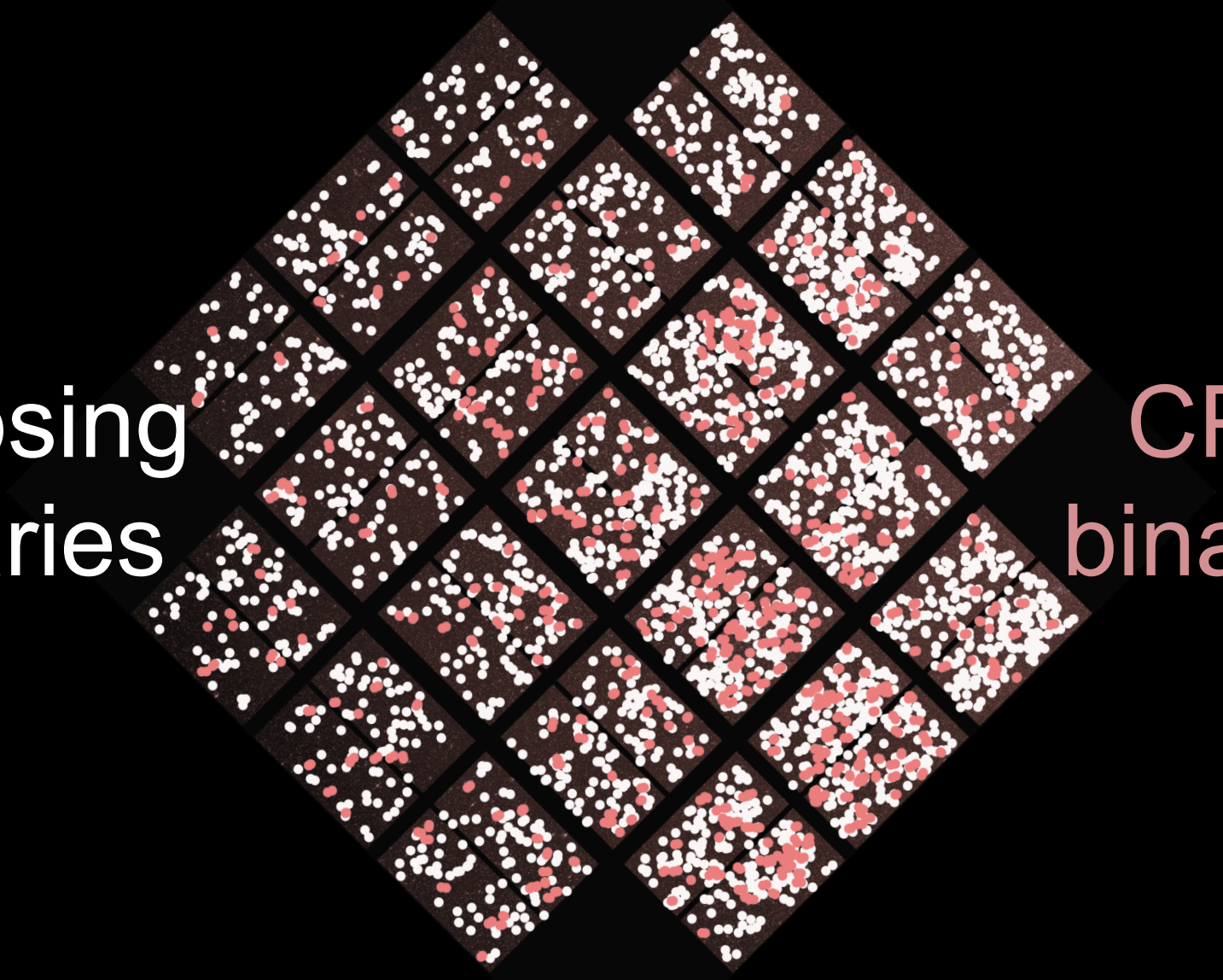


Eclipsing binaries

KEPLER

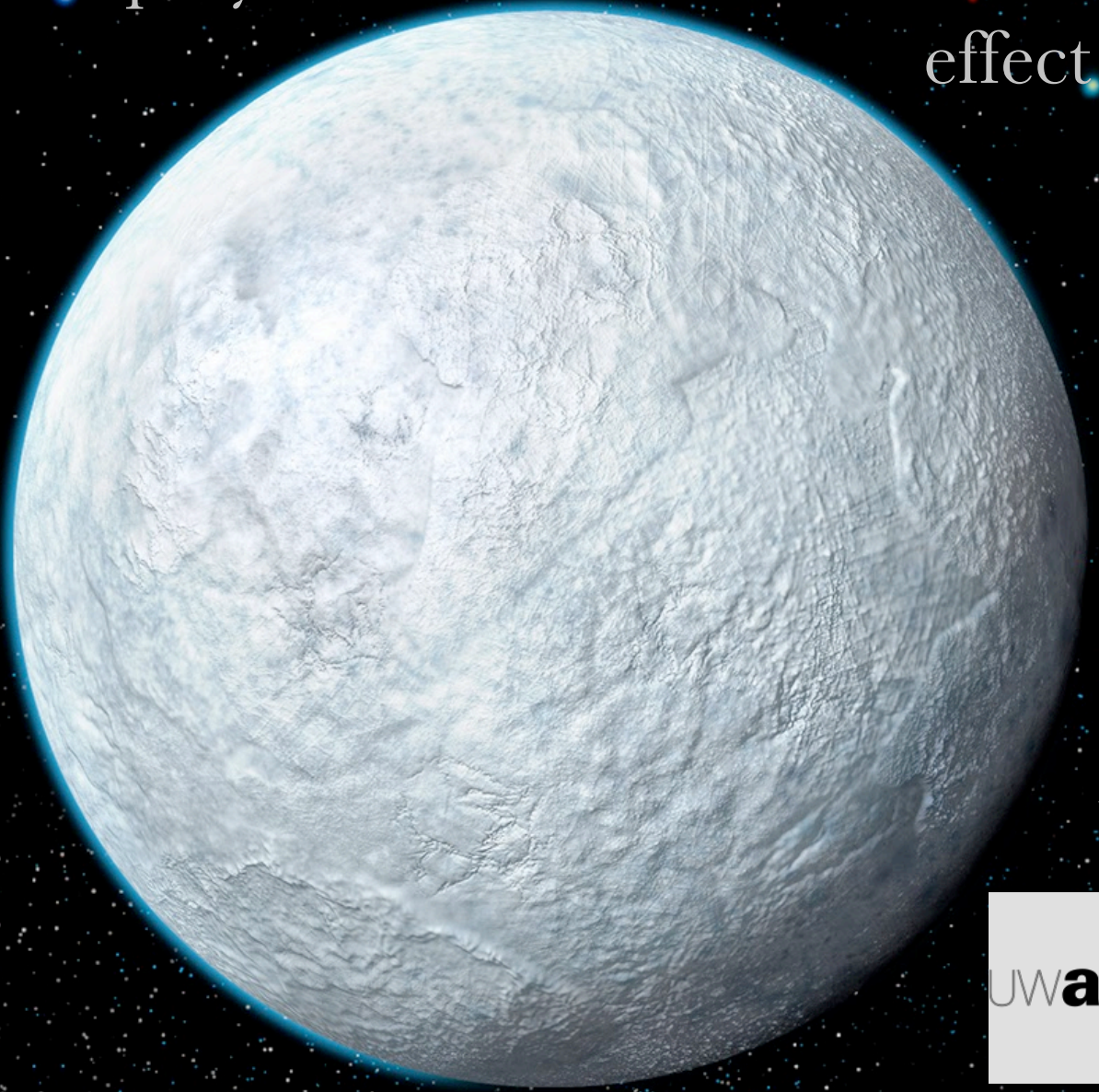


Eclipsing binaries

CPM binaries


Thanks!
Image credit Joe Shymansky

Obliquity evolution of Earth-like exoplanets and its effect on habitability



Russell Deitrick
Collaborators:
Rory Barnes
Cecilia Bitz
Tom Quinn
John Armstrong
Victoria Meadows
Benjamin Charnay

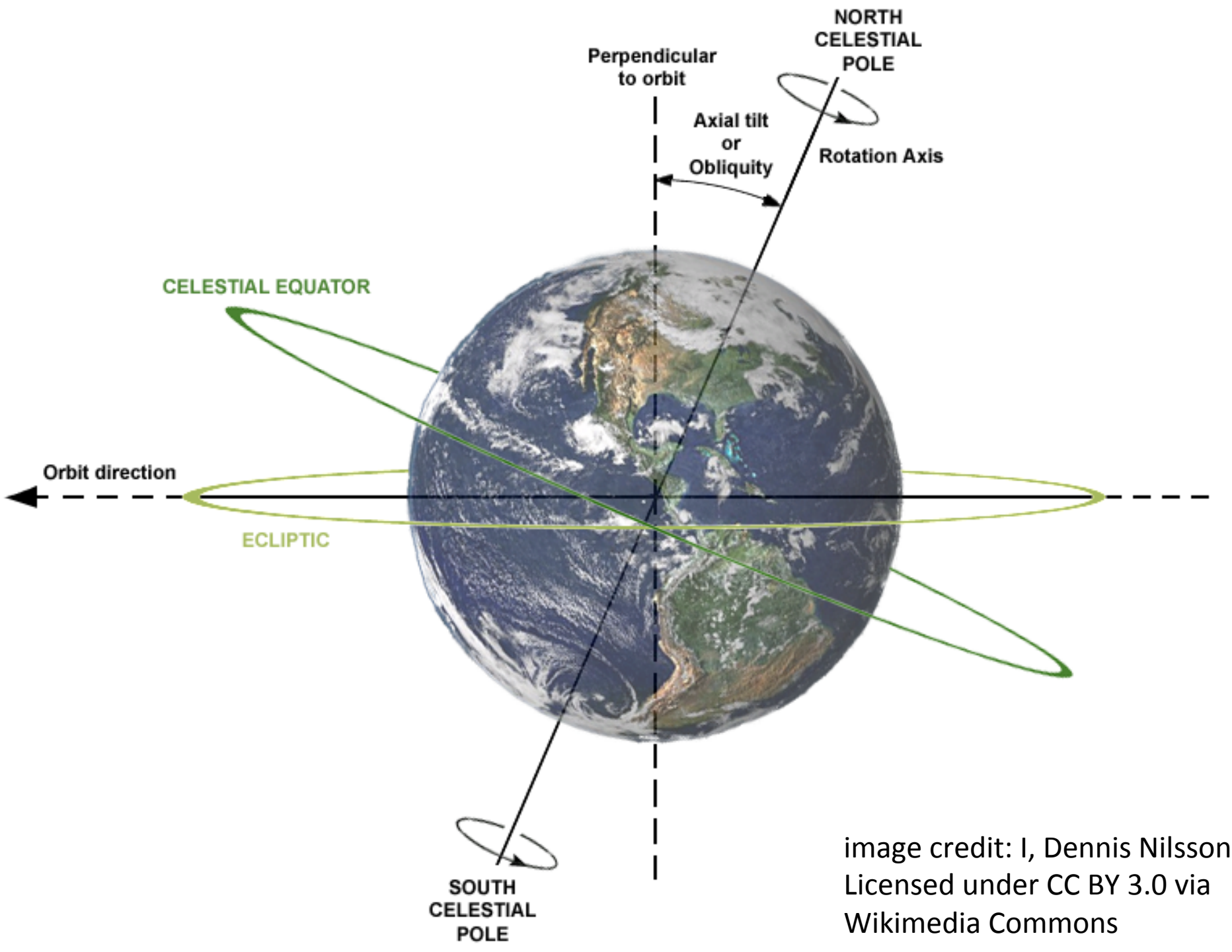
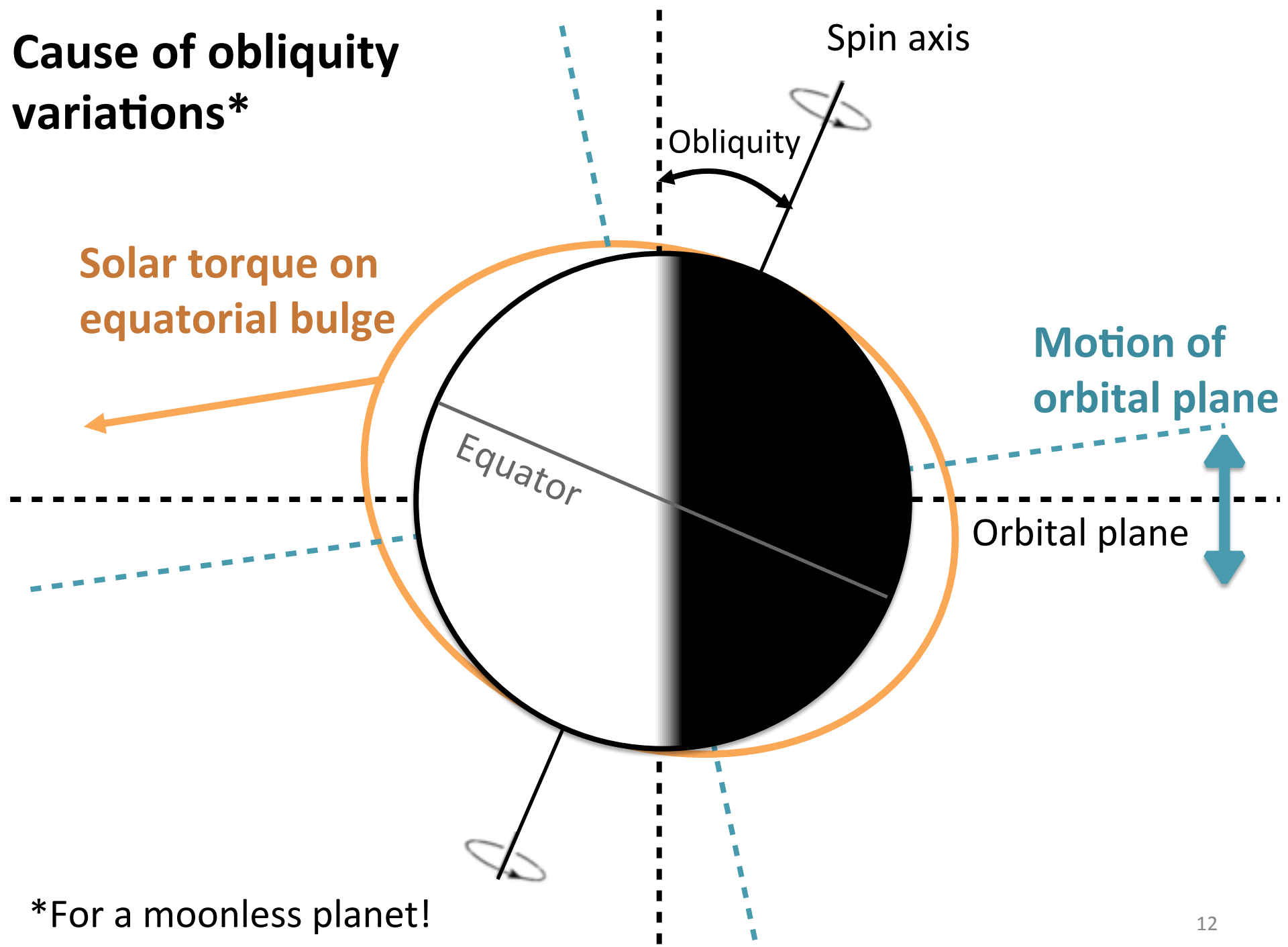


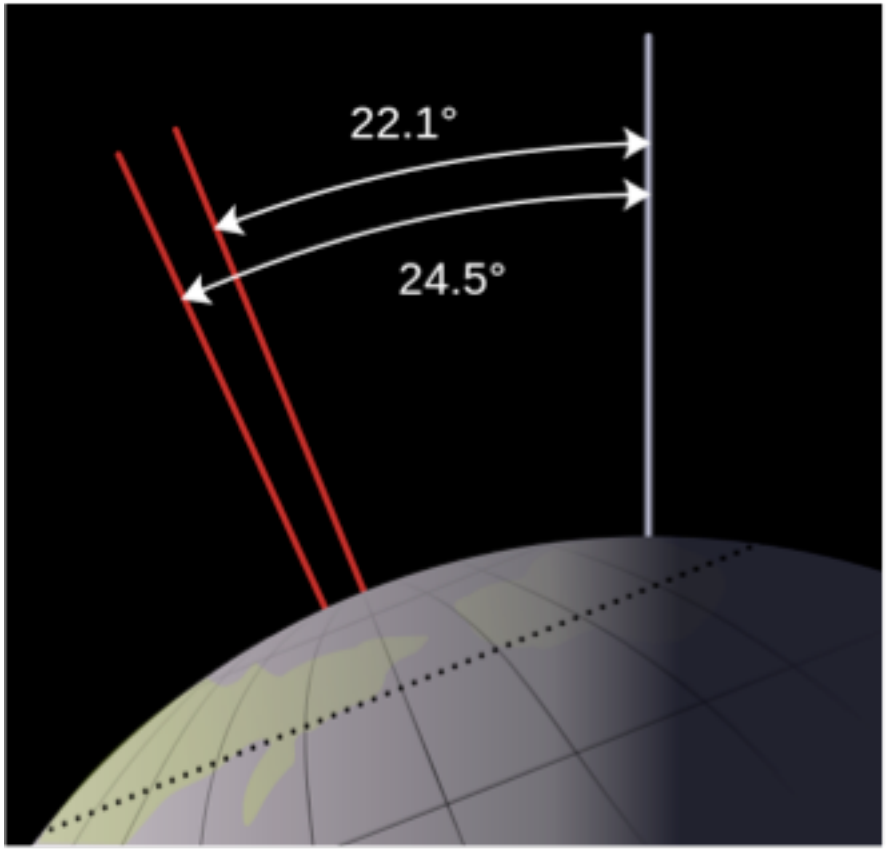
image credit: I, Dennis Nilsson. Licensed under CC BY 3.0 via Wikimedia Commons

Cause of obliquity variations*

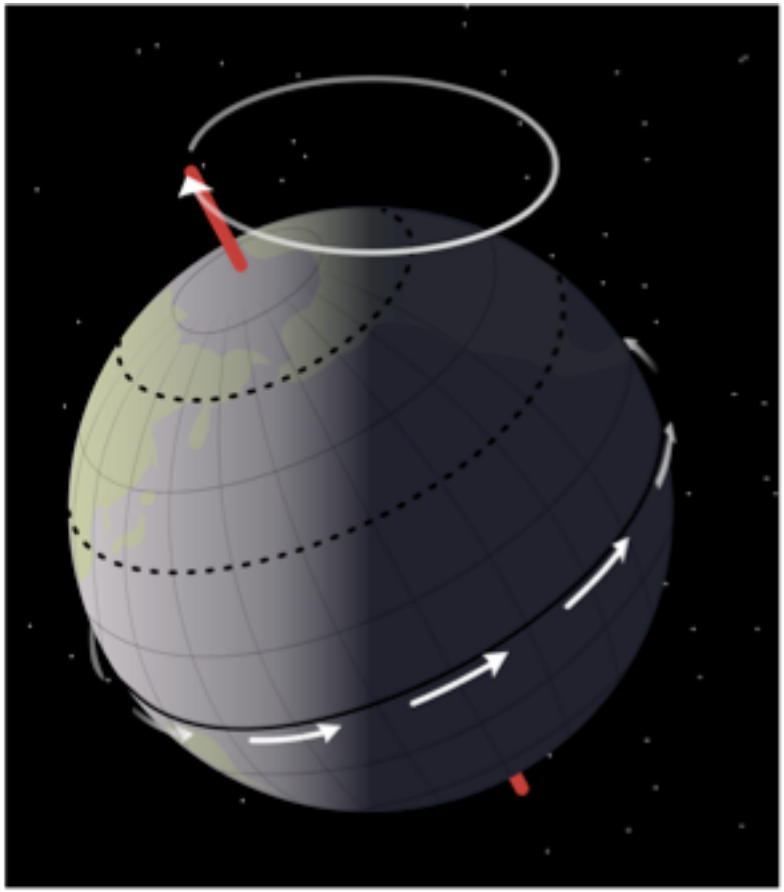


*For a moonless planet!

Obliquity variations



Nutation aka “Wobble”

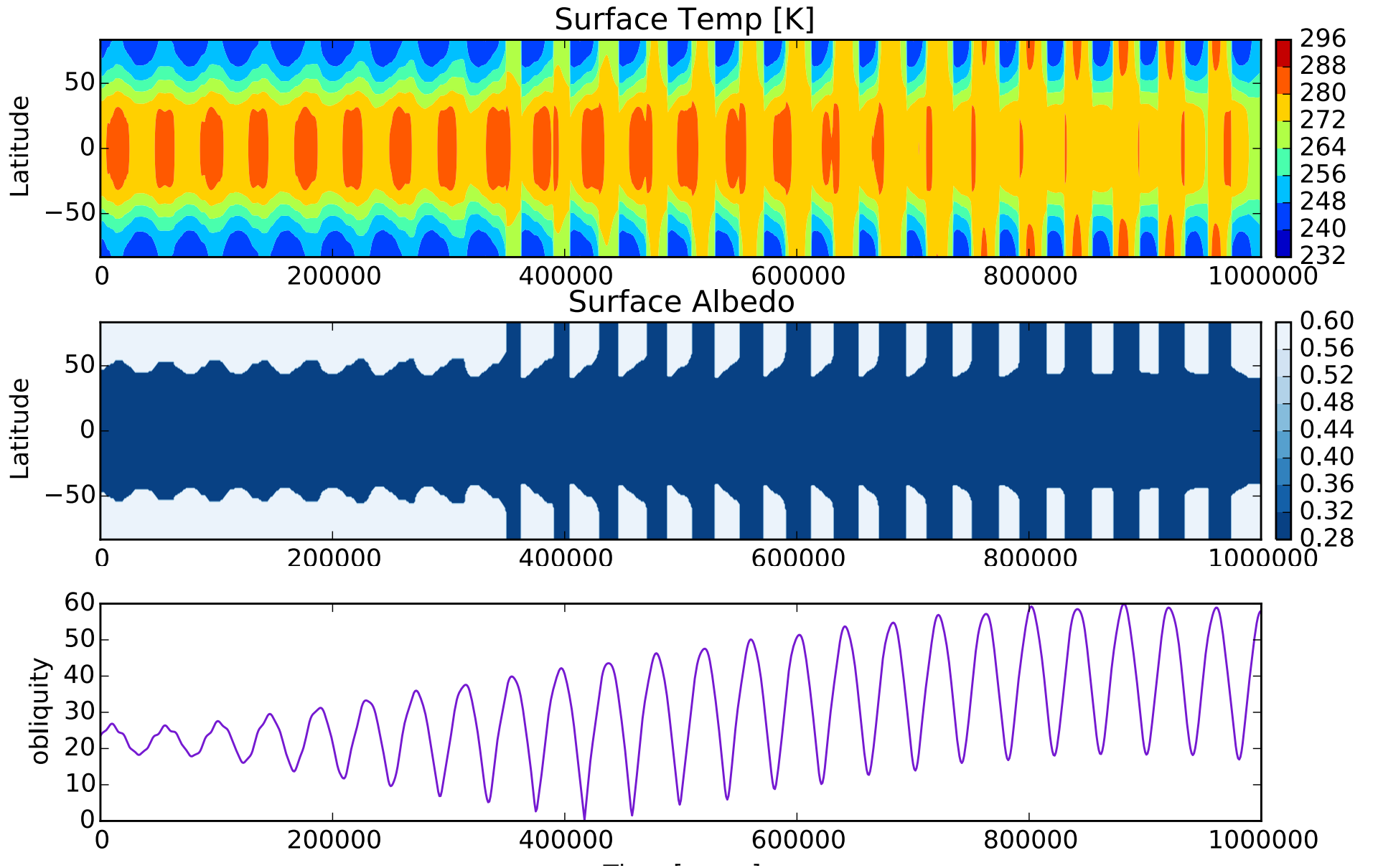


Precession

Image credit: NASA

Small for Earth, because of the Moon

Climate impact



FINDING AND CHARACTERIZING EXOPLANETS WITH KEPLER

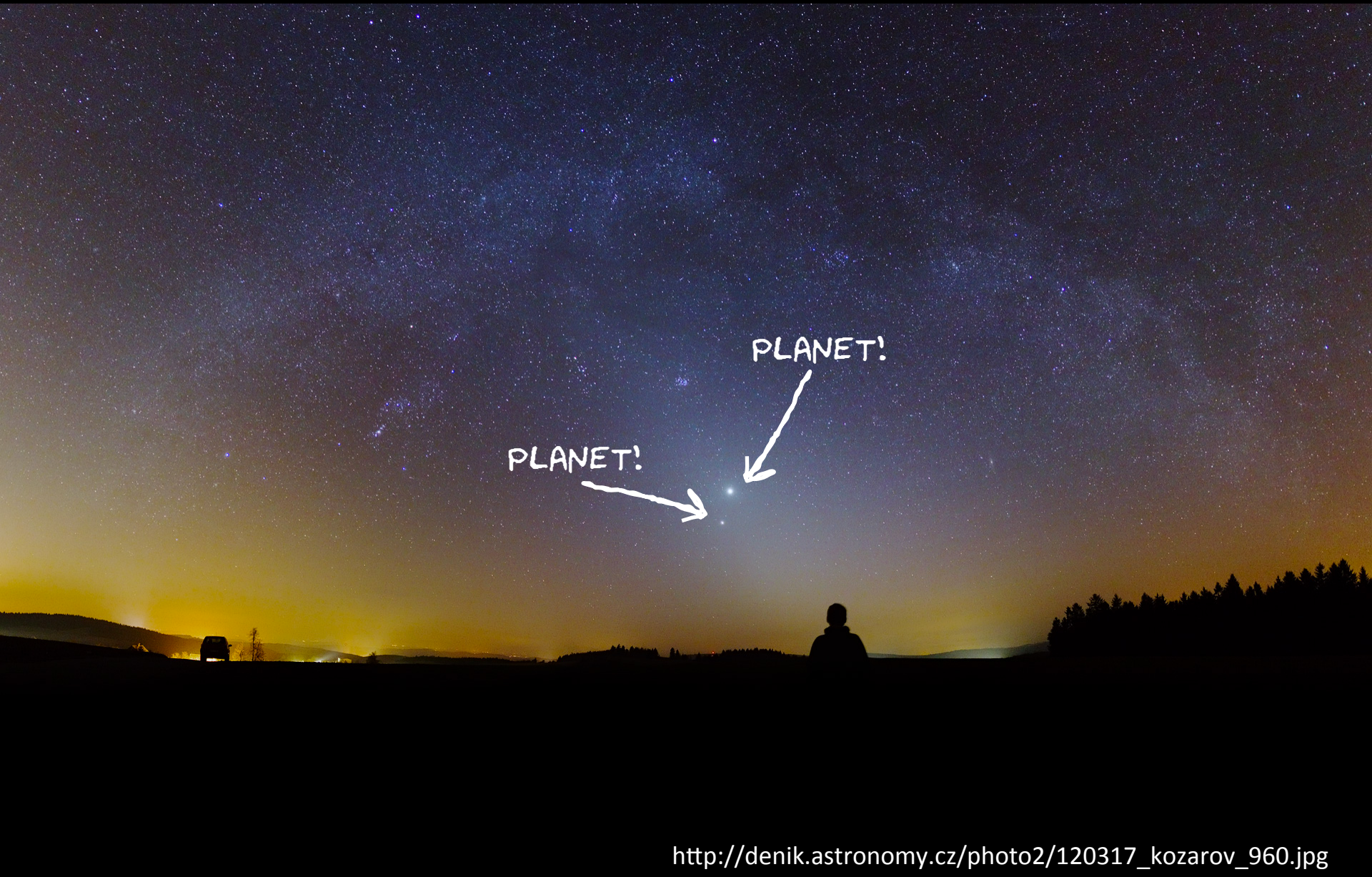
RODRIGO LUGER

GRADUATE STUDENT

UNIVERSITY *of* WASHINGTON

DEPARTMENT OF ASTRONOMY

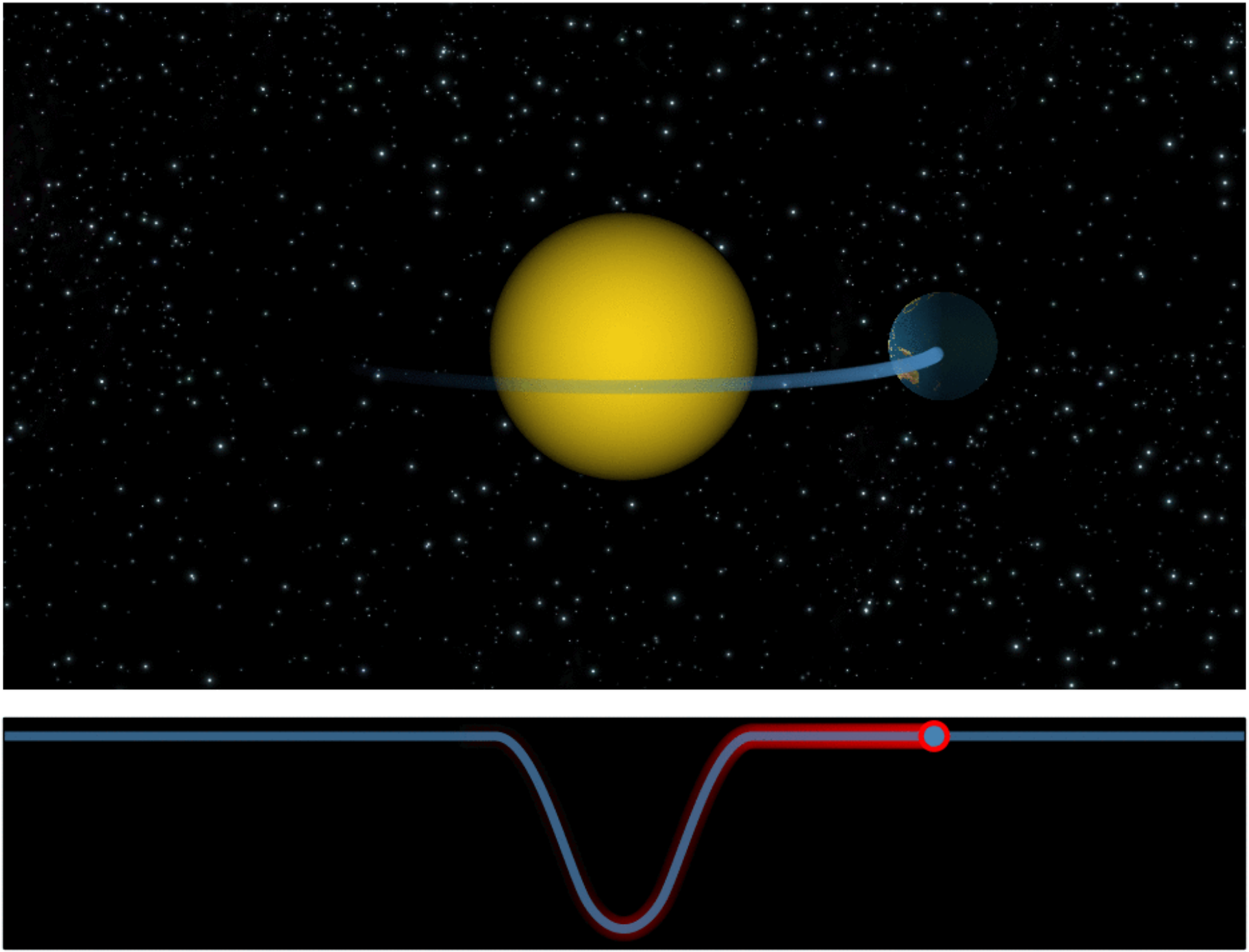
DETECTING PLANETS IN OUR SOLAR SYSTEM (EASY)



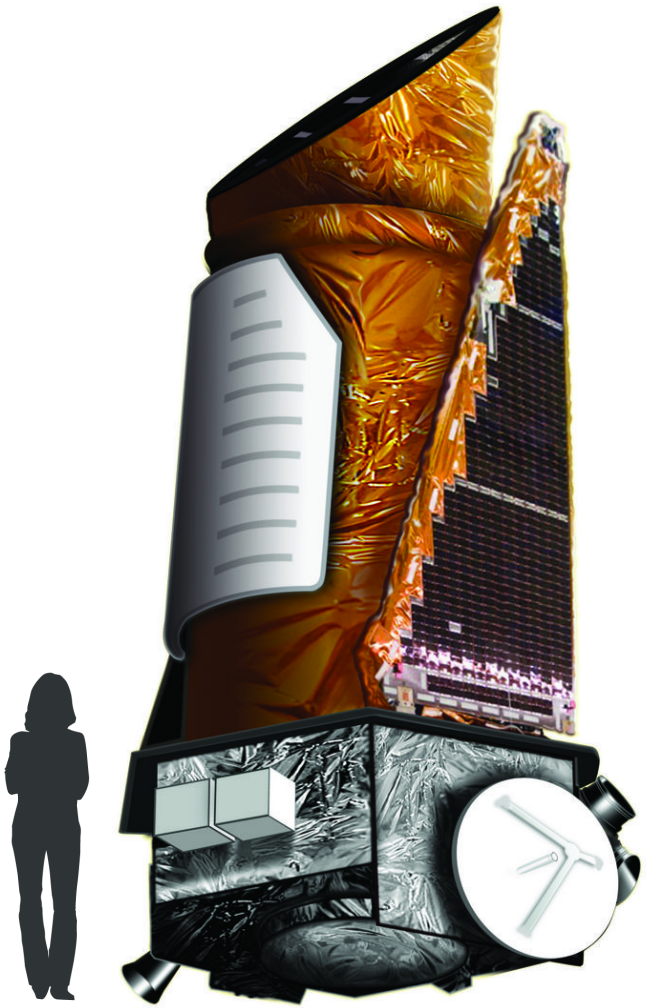
http://denik.astronomy.cz/photo2/120317_kozarov_960.jpg


DETECTING EXTRASOLAR PLANETS
STAR (NO PLANET)

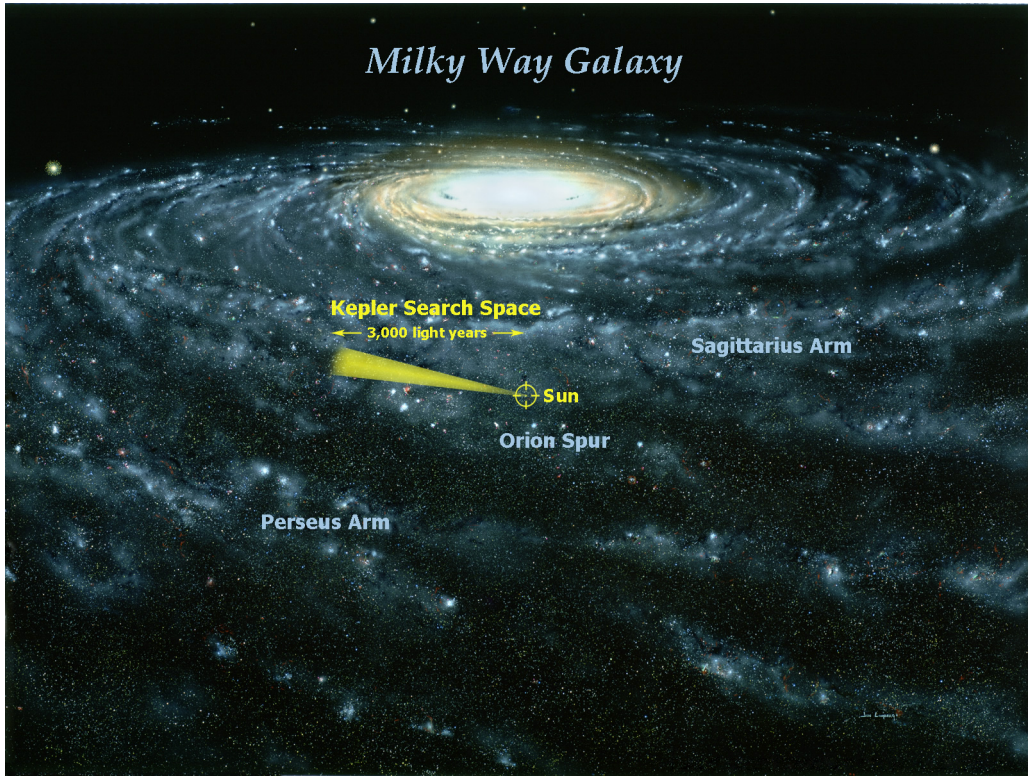

DETECTING EXTRASOLAR PLANETS
(HARD)
STAR (WITH PLANET)



THE KEPLER SPACECRAFT

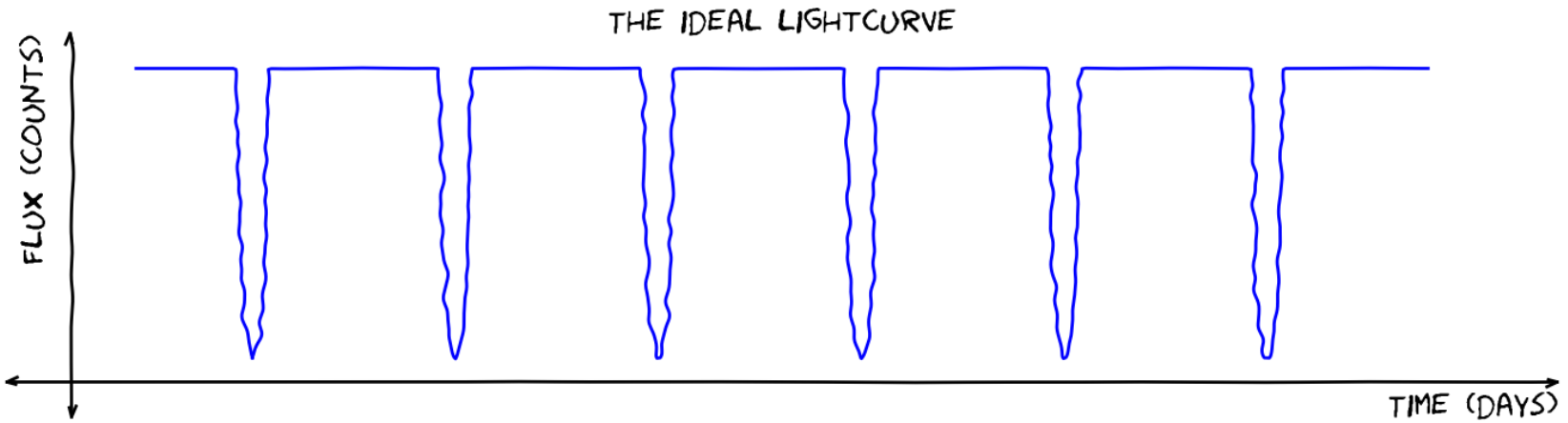


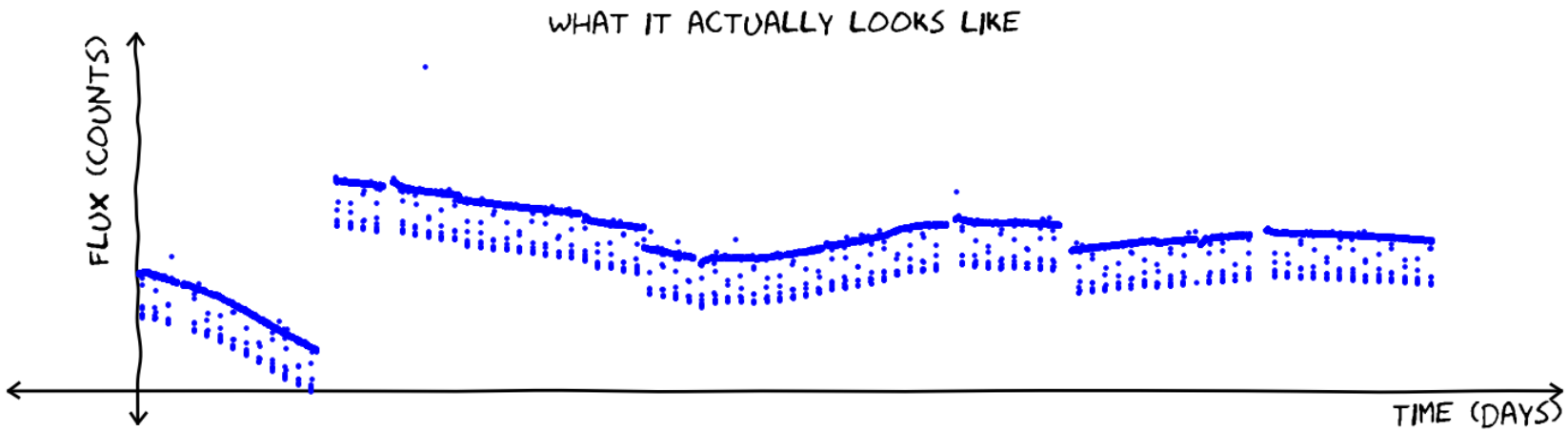
Credit: NASA

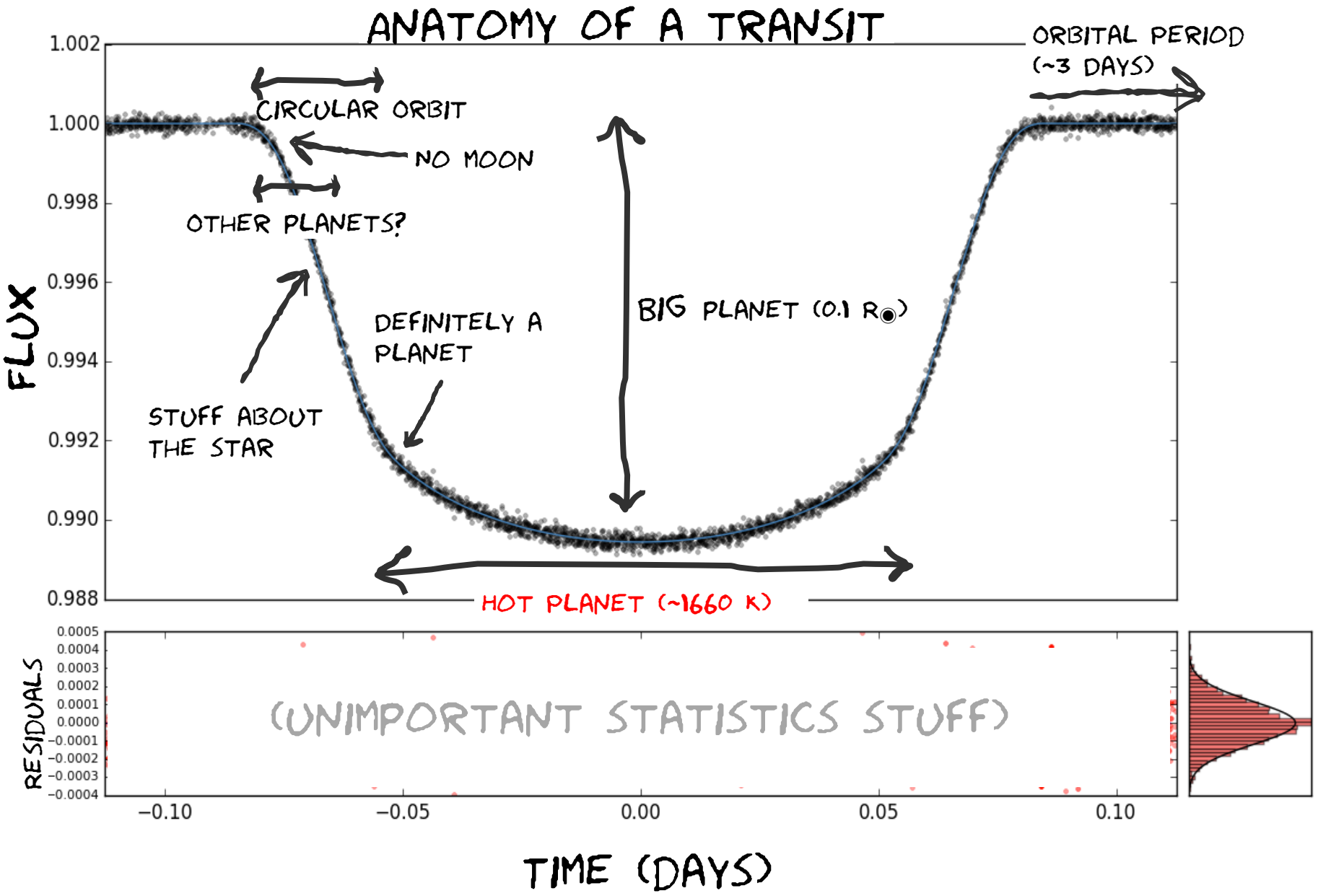


https://en.wikipedia.org/wiki/Kepler_(spacecraft)

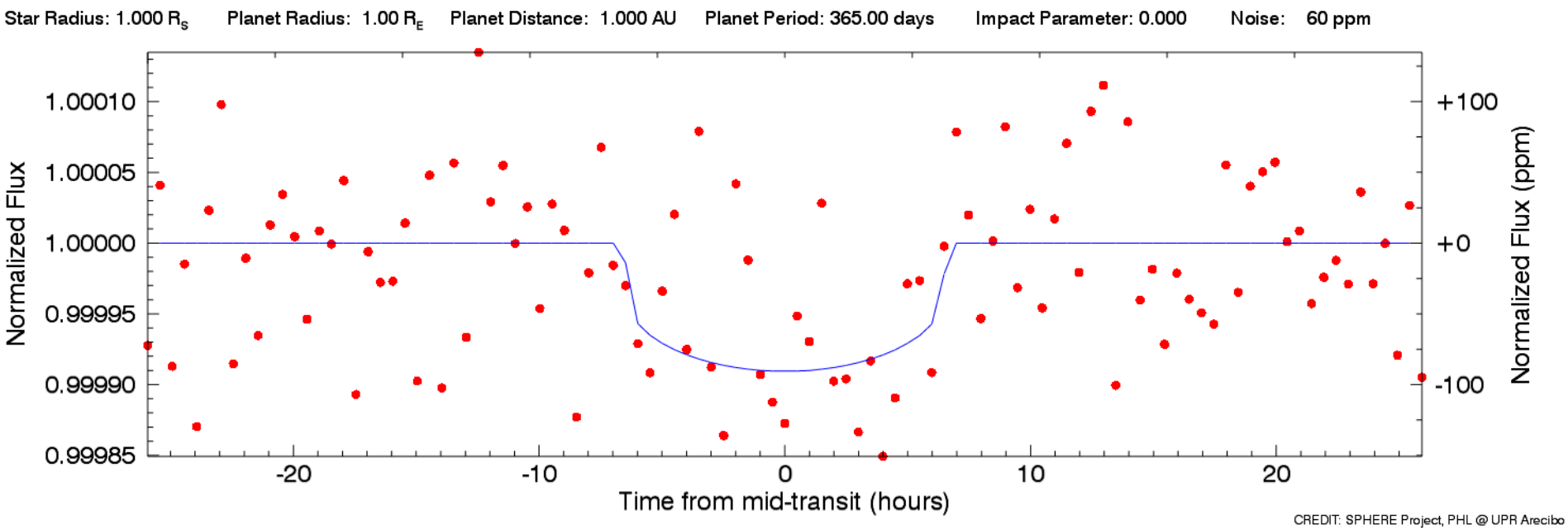
TRANSIT LIGHTCURVES






ANATOMY OF A TRANSIT
ORBITAL PERIOD
(~3 DAYS)
CIRCULAR ORBIT
NO MOON
OTHER PLANETS?
DEFINITELY A
PLANET
STUFF ABOUT
THE STAR
BIG PLANET (0.1 R⊙)
HOT PLANET (~1660 K)
FLUX
1.002
1.000
0.998
0.996
0.994
0.992
0.990
0.988
RESIDUALS
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
−0.0001
−0.0002
−0.0003
−0.0004
(UNIMPORTANT STATISTICS STUFF)
−0.10
−0.05
0.00
0.05
0.10
TIME (DAYS)

EARTH TRANSITING THE SUN

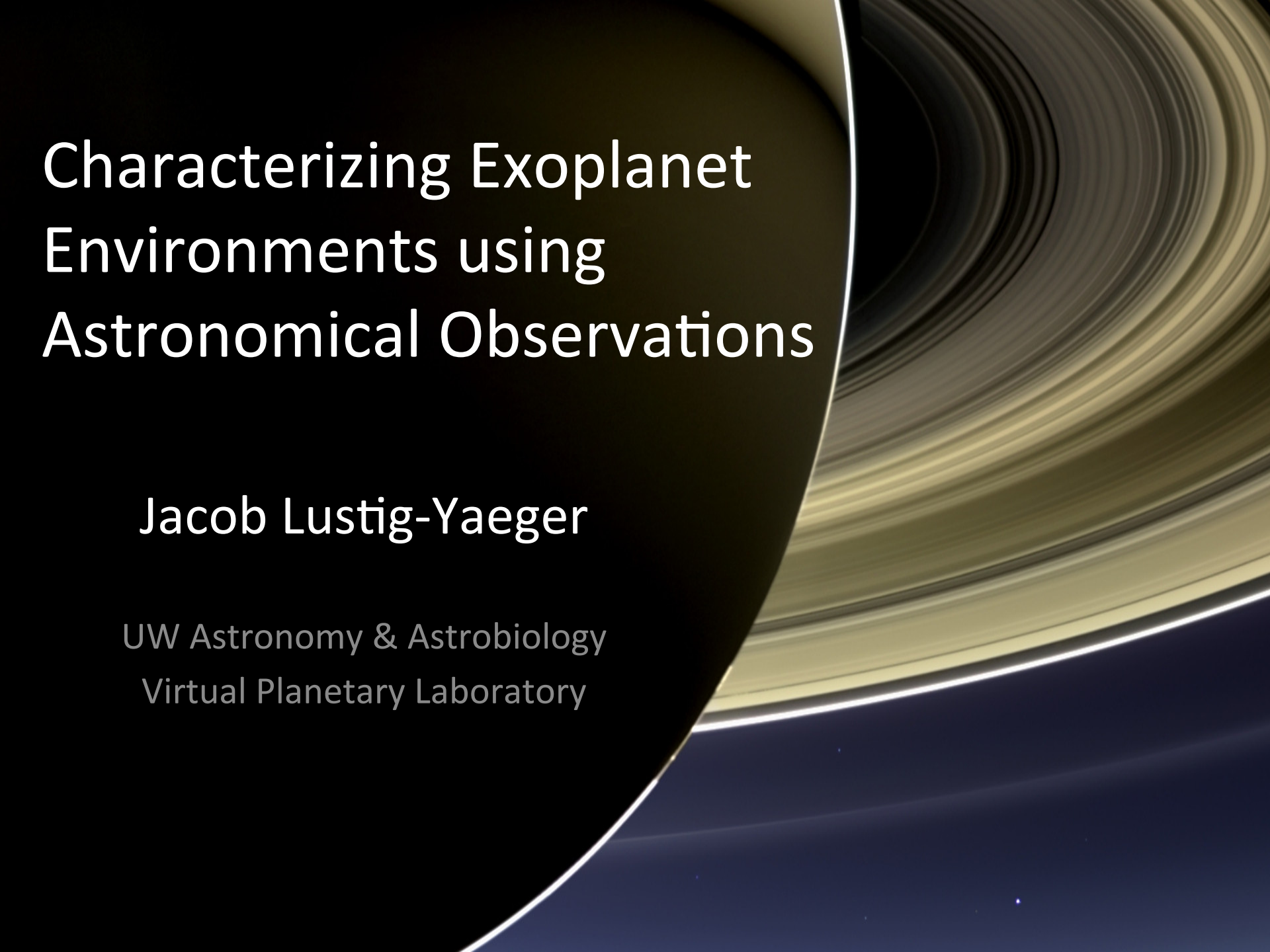


CREDIT: SPHERE Project, PHL @ UPR Arecibo

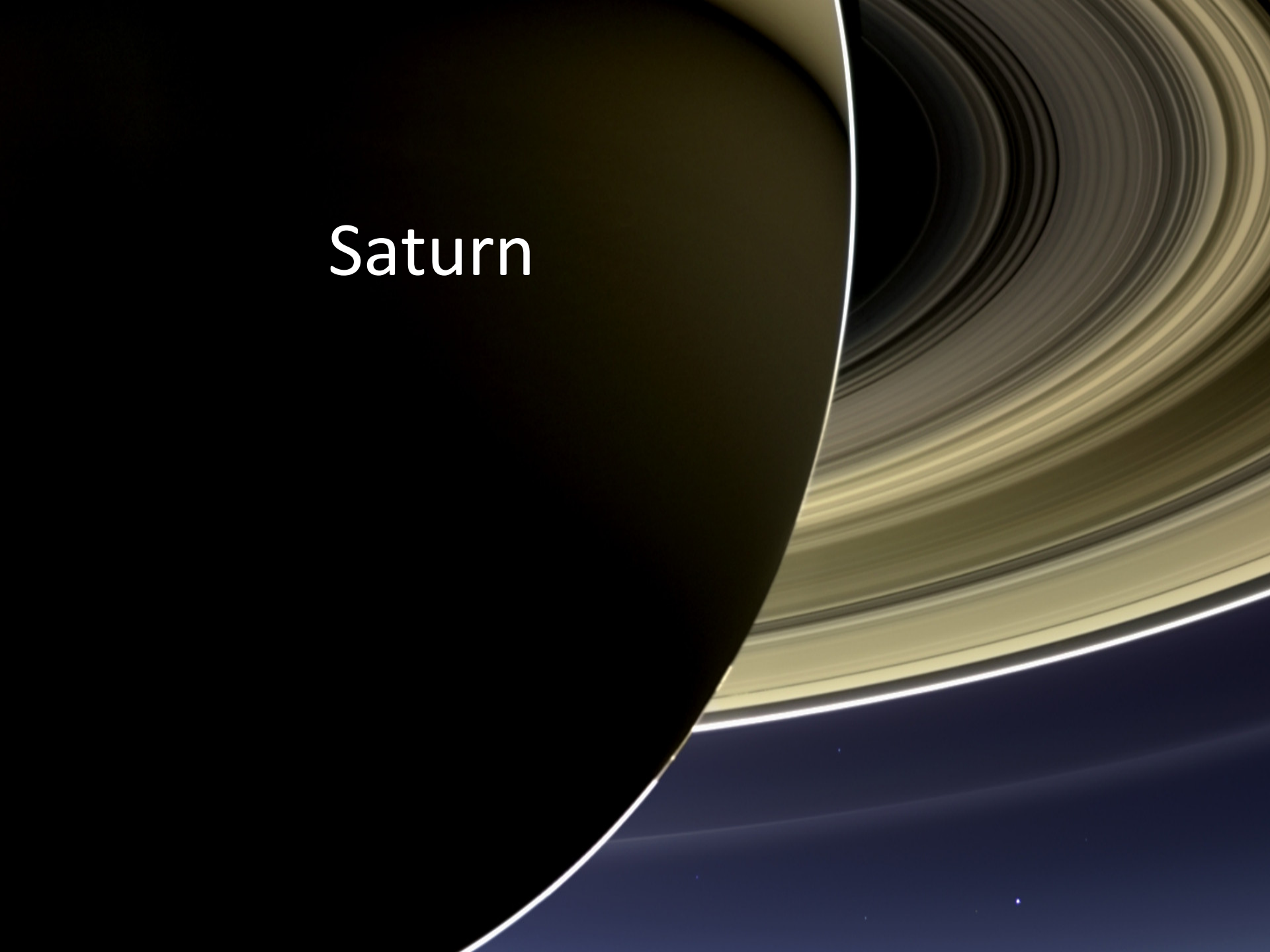
Characterizing Exoplanet Environments using Astronomical Observations

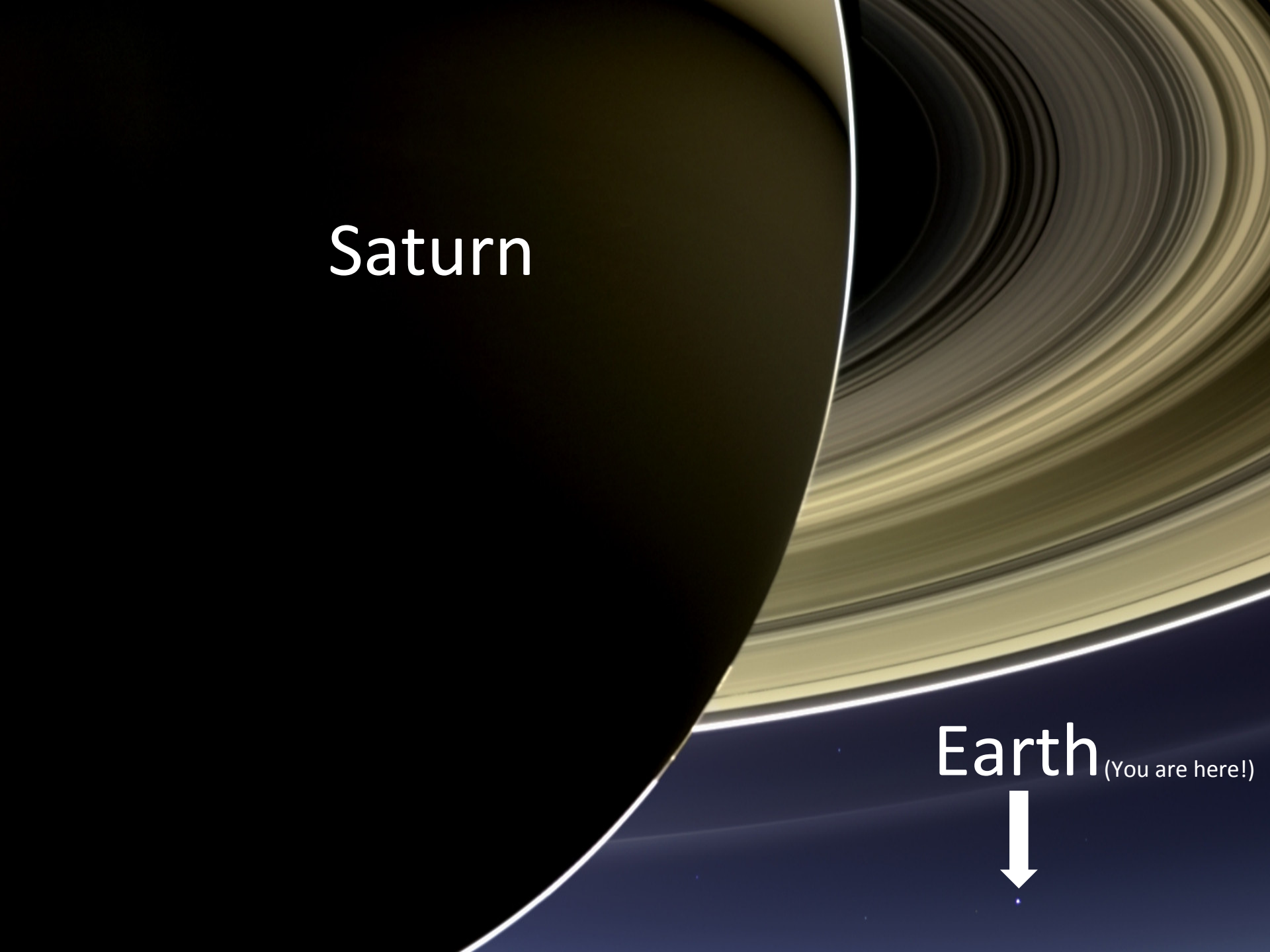
Jacob Lustig-Yaeger

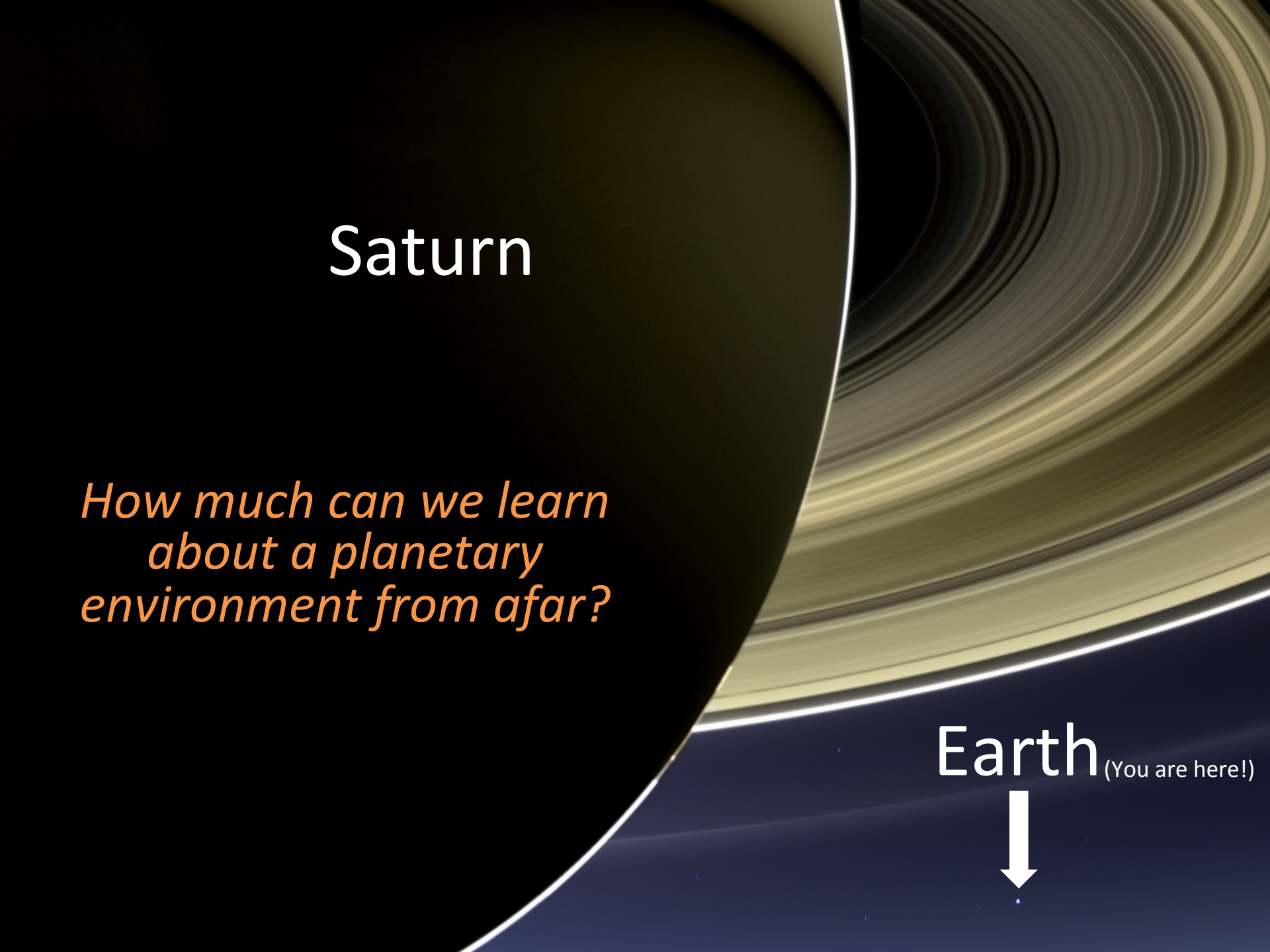
UW Astronomy & Astrobiology
Virtual Planetary Laboratory



Saturn

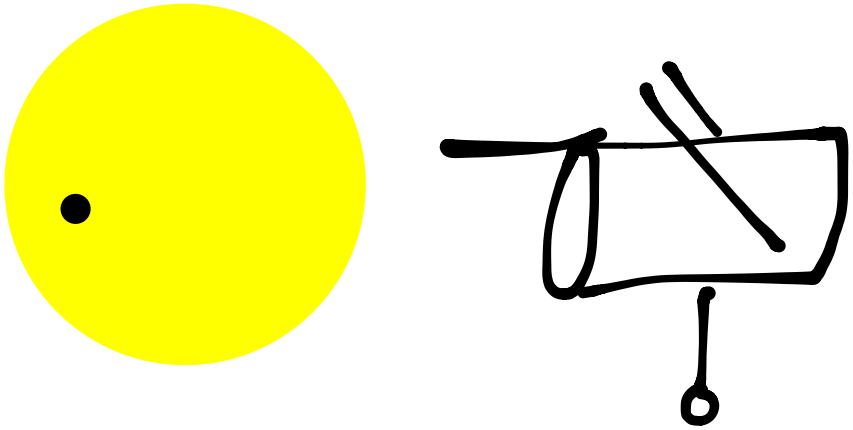



Saturn
Earth (You are here!)

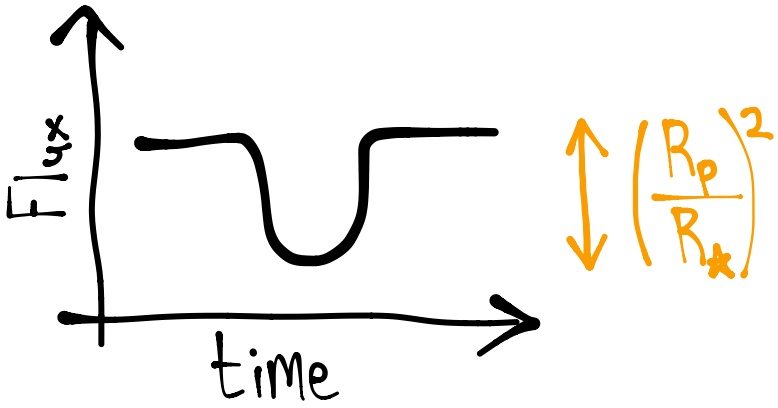

Saturn
How much can we learn about a planetary environment from afar?
Earth (You are here!)

Transiting Exoplanets

Observation:

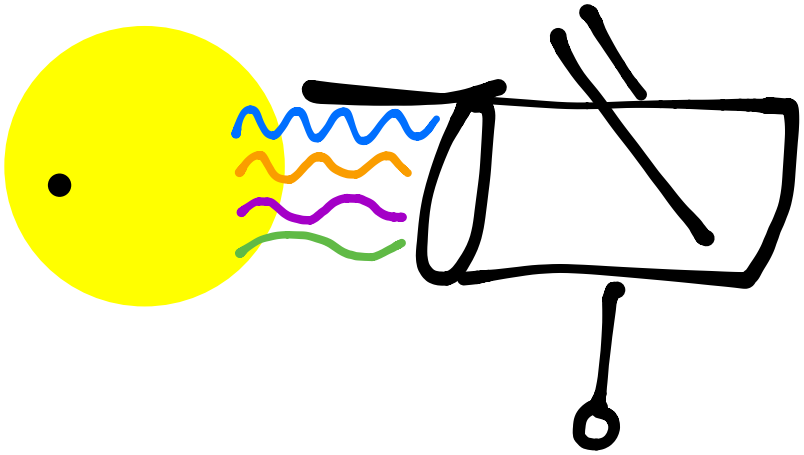


Measurement:

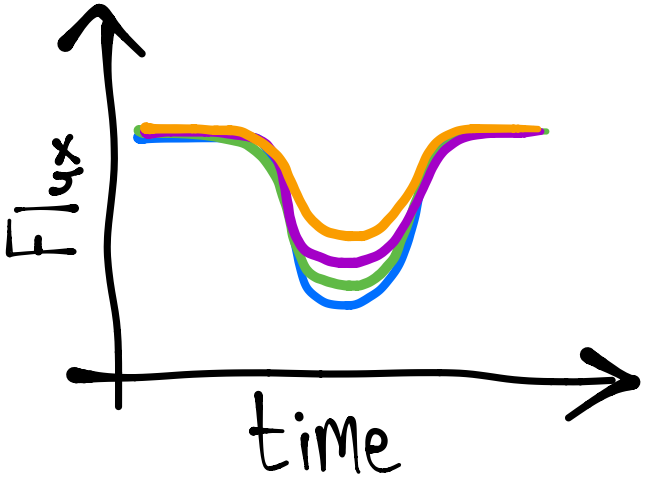


Transiting Exoplanets

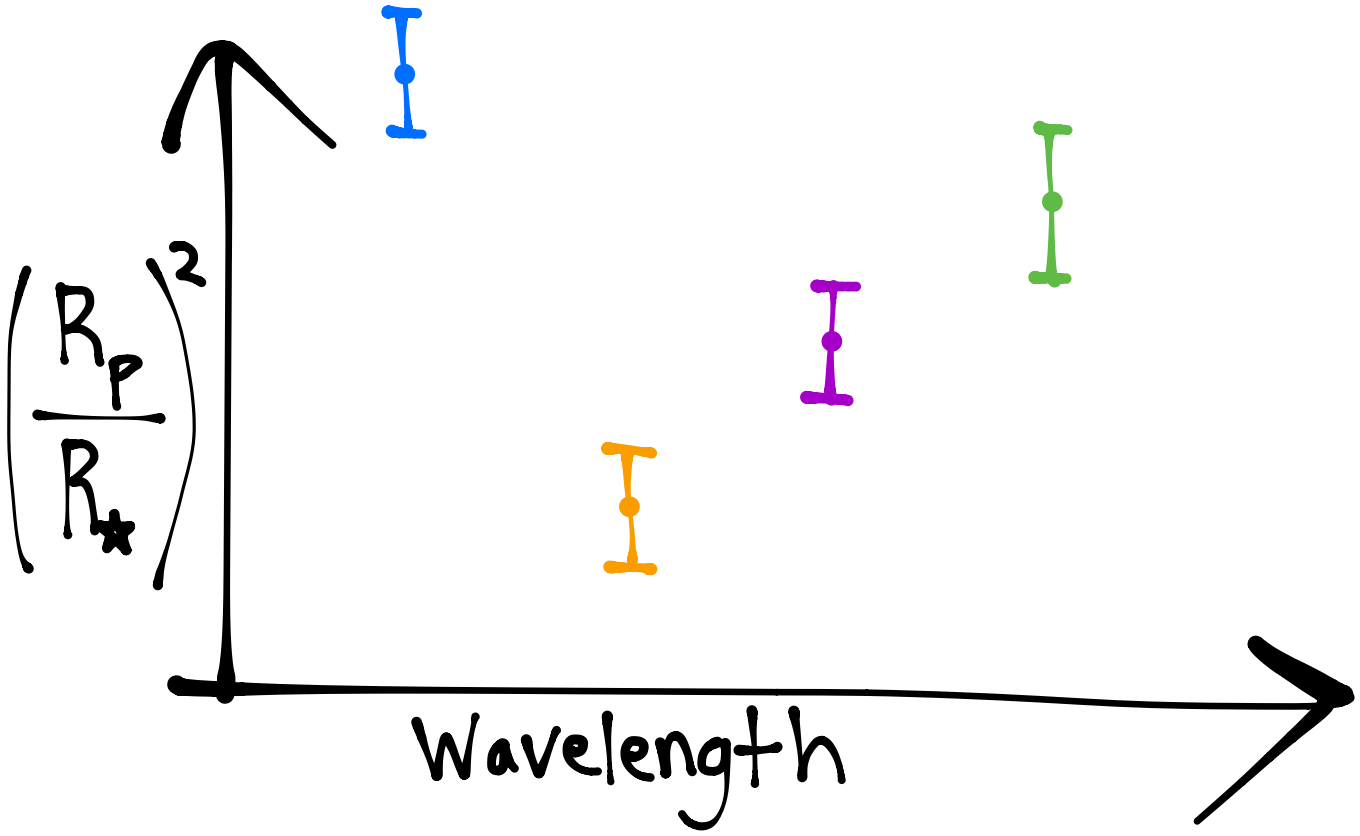
Observation:



Measurement:

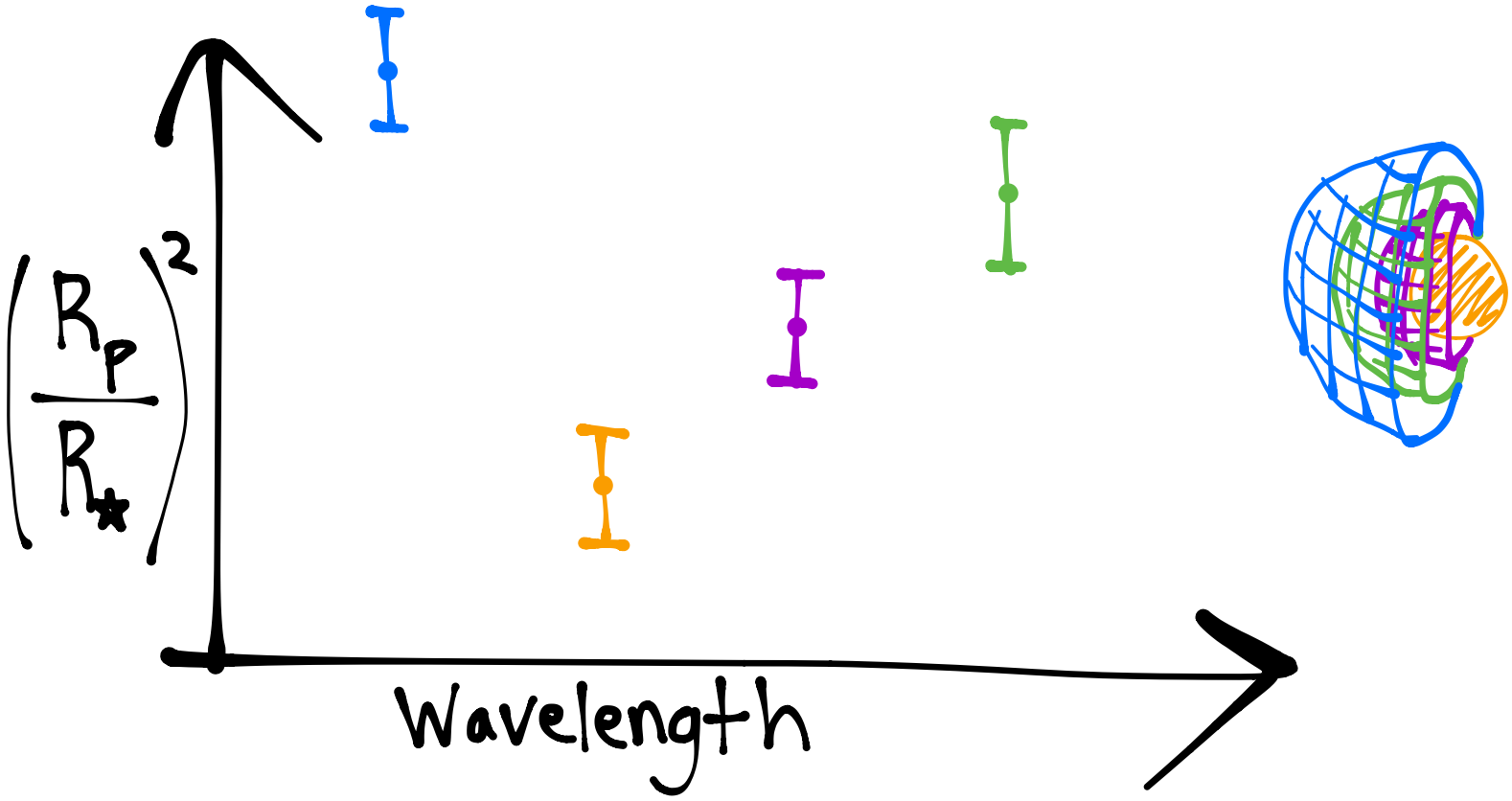


Transiting Exoplanets



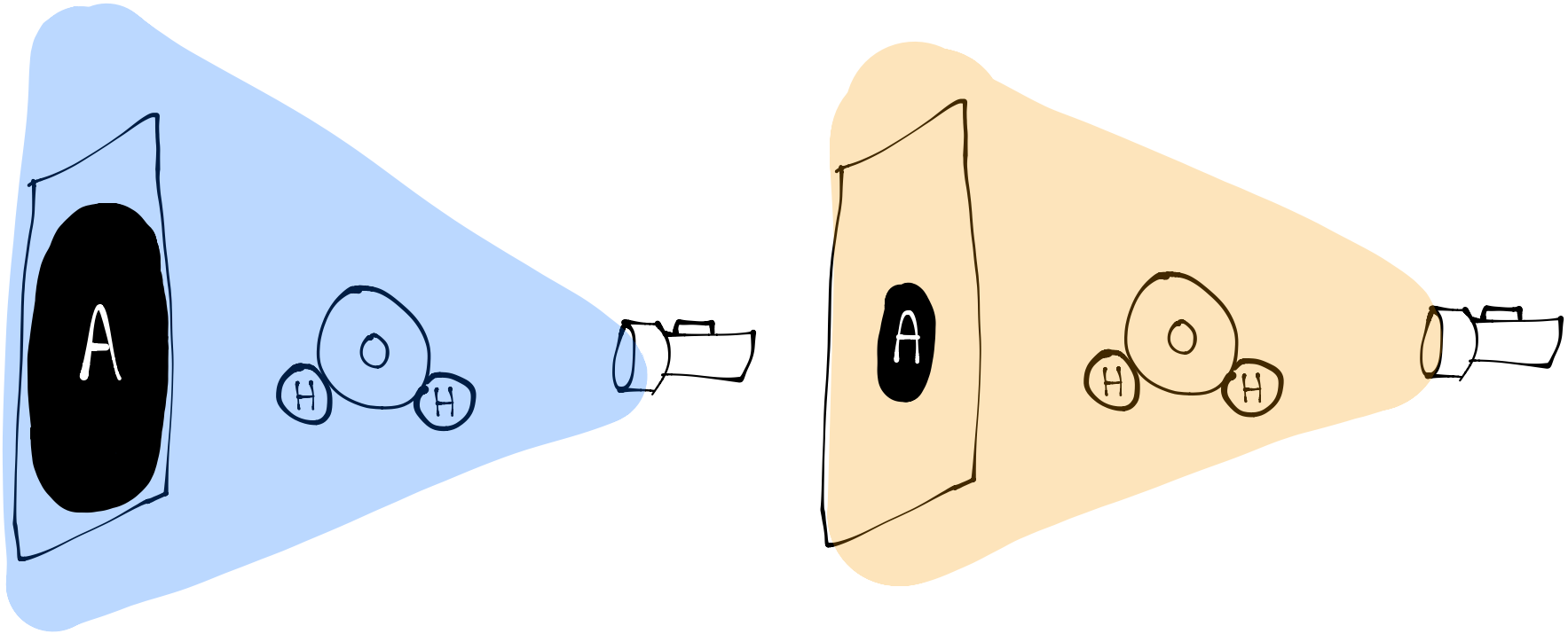
Transiting Exoplanets

Transmission Spectroscopy

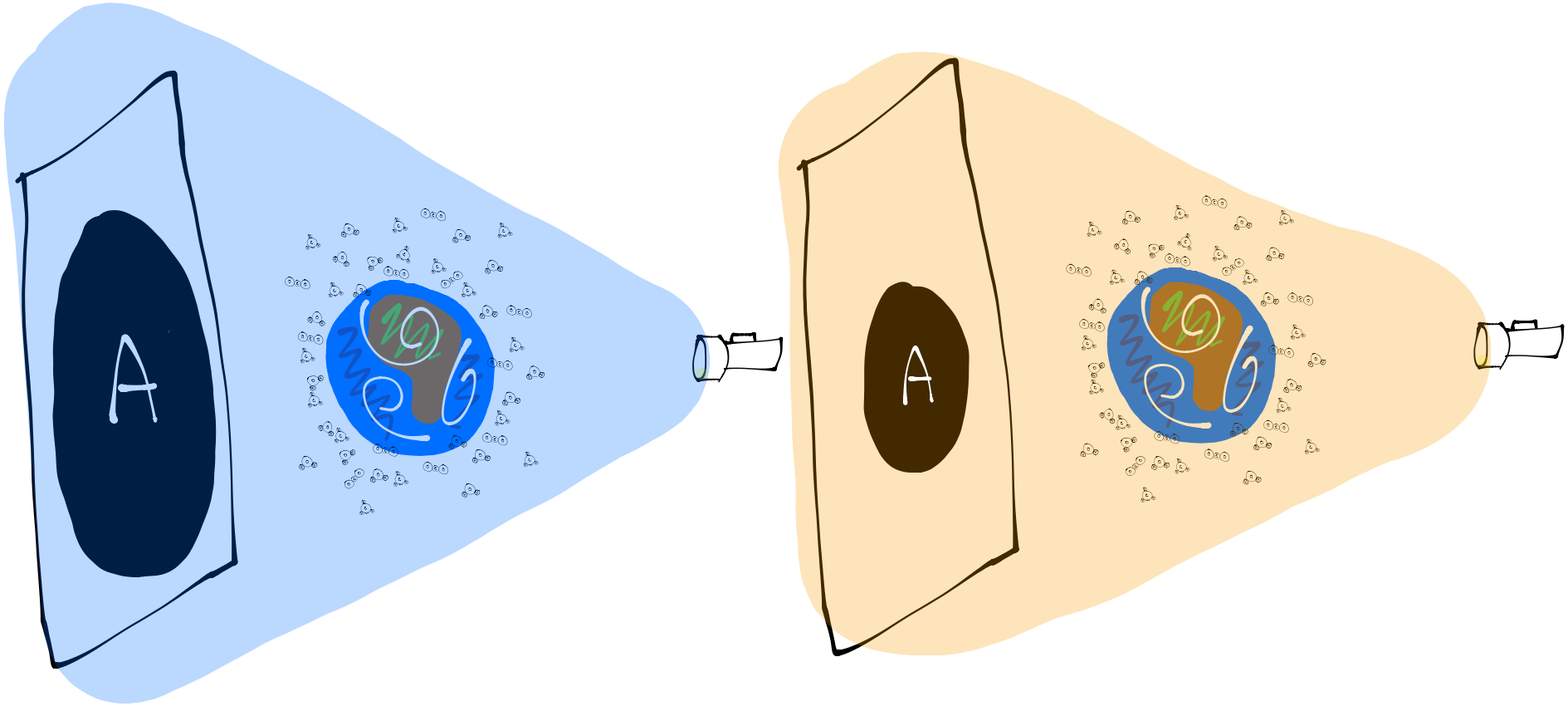


*What causes the **radius** of a planet to change as a function of the **wavelength** of light observed?*

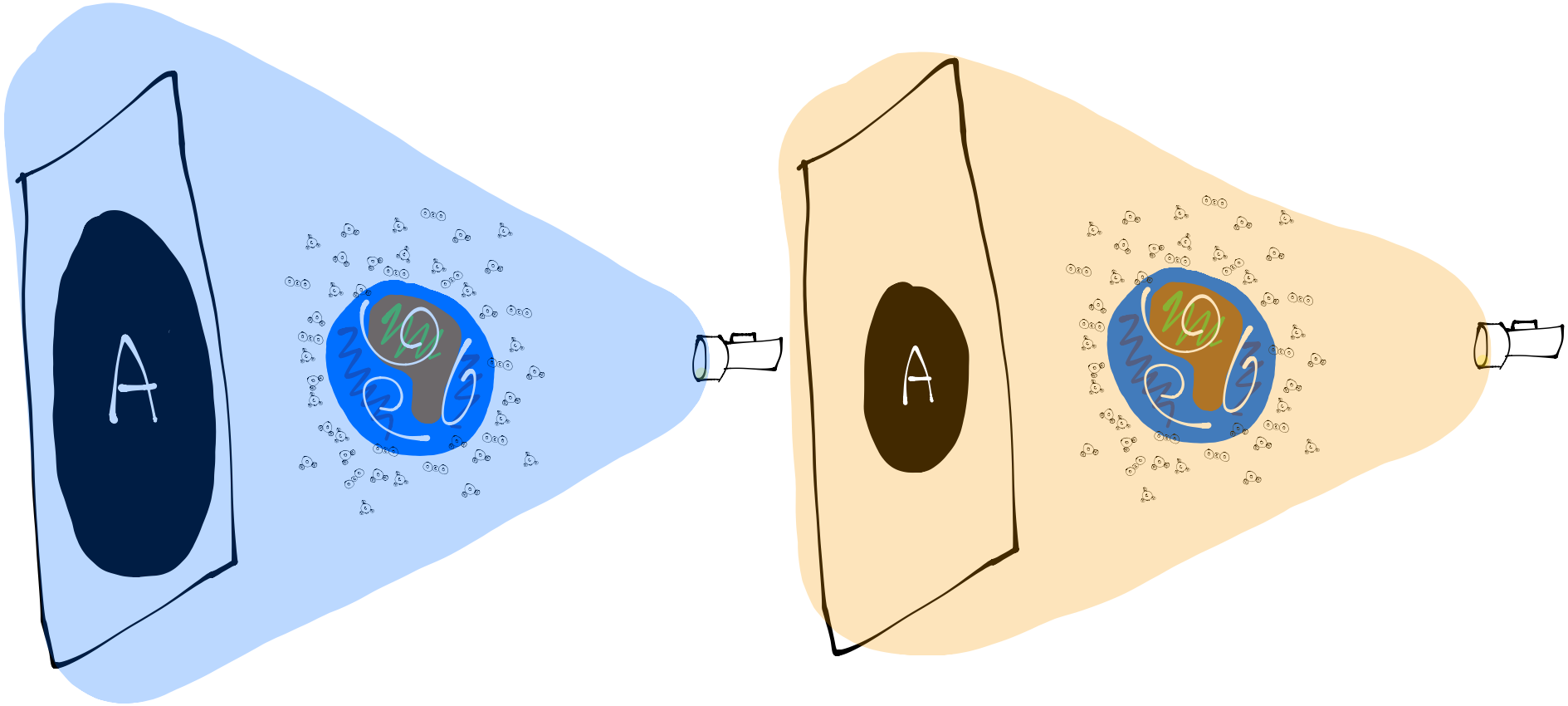
Molecular Absorption



Molecular Absorption



Molecular Absorption

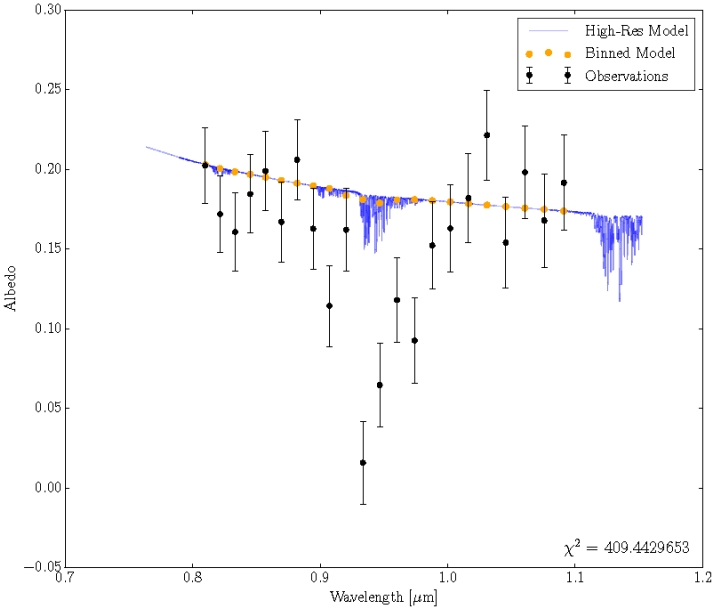


*The **composition** of the planet causes observed changes in radius!*

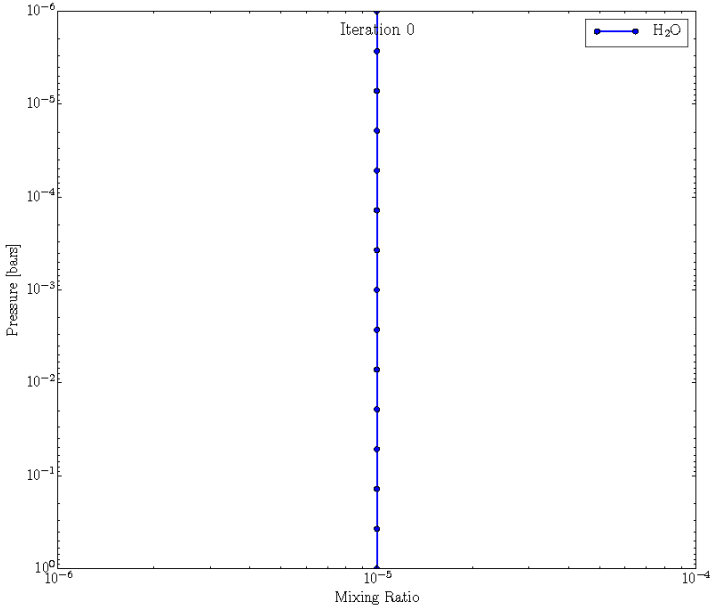
Fitting a model to data

Discovering *the underlying* ***physical environment*** *that gives rise to an observation*

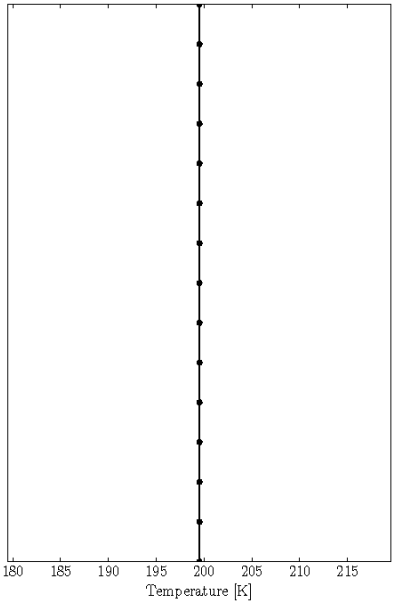
Model vs Data



Amount of water



Temperature

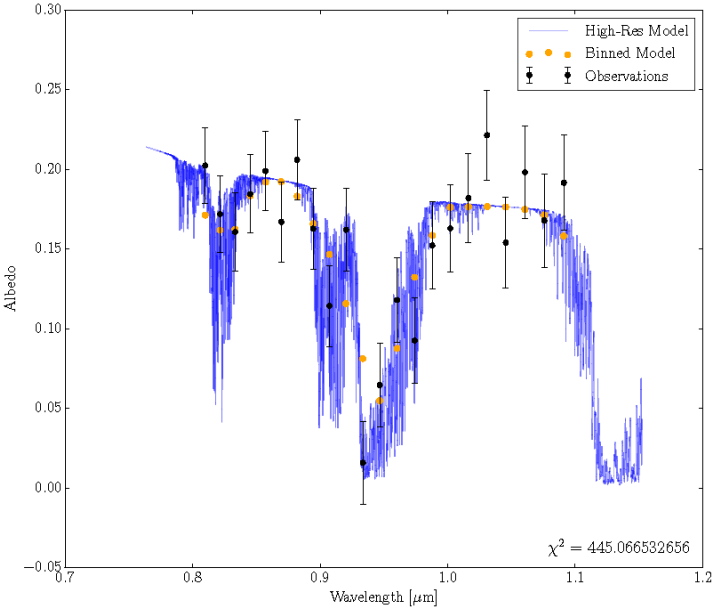


Initial Conditions

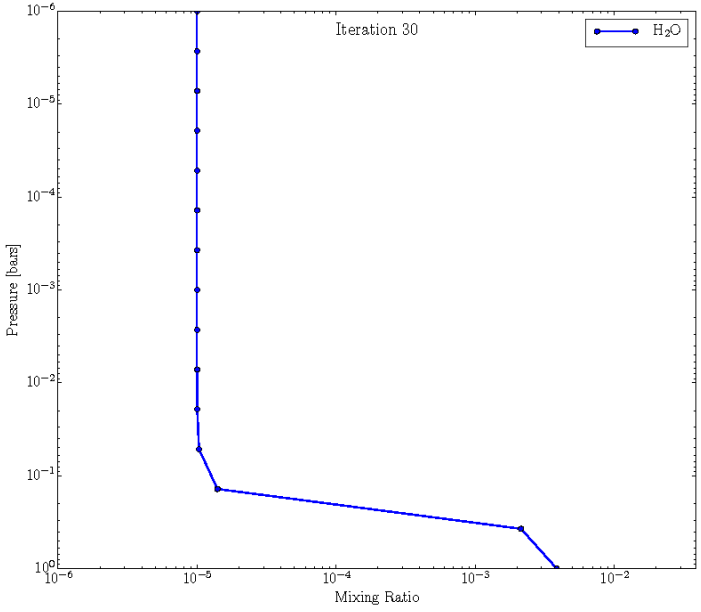
Fitting a model to data

Discovering *the underlying* ***physical environment*** *that gives rise to an observation*

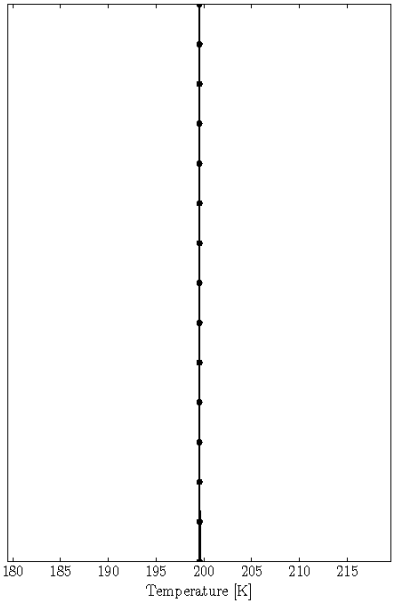
Model vs Data



Amount of water



Temperature



Best Fitting Solution

The Virtual Planetary Laboratory

Earth as an Exoplanet

Earth Observations
GCM Results

The Earth Through Time

Field Work
Lab Studies
Computer Models

The Habitable Planet

Planet Formation
1-D/3-D Climate/Chemistry
Orbital Dynamics
Stellar Observations

The Living Planet

Field Work
Lab Studies
Computer Models

Observer

Products

Validation

Disk-averaged spectra over a full year for Earth and other planets

Environmental constraints

Climate, Biosignatures

Disk-averaged spectra at several stages of evolution

Habitability assessment

Disk-averaged spectra

Climate and limits of the habitable zone for plausible extrasolar planets

Limits of photosynthesis

Impact of life on planetary environments

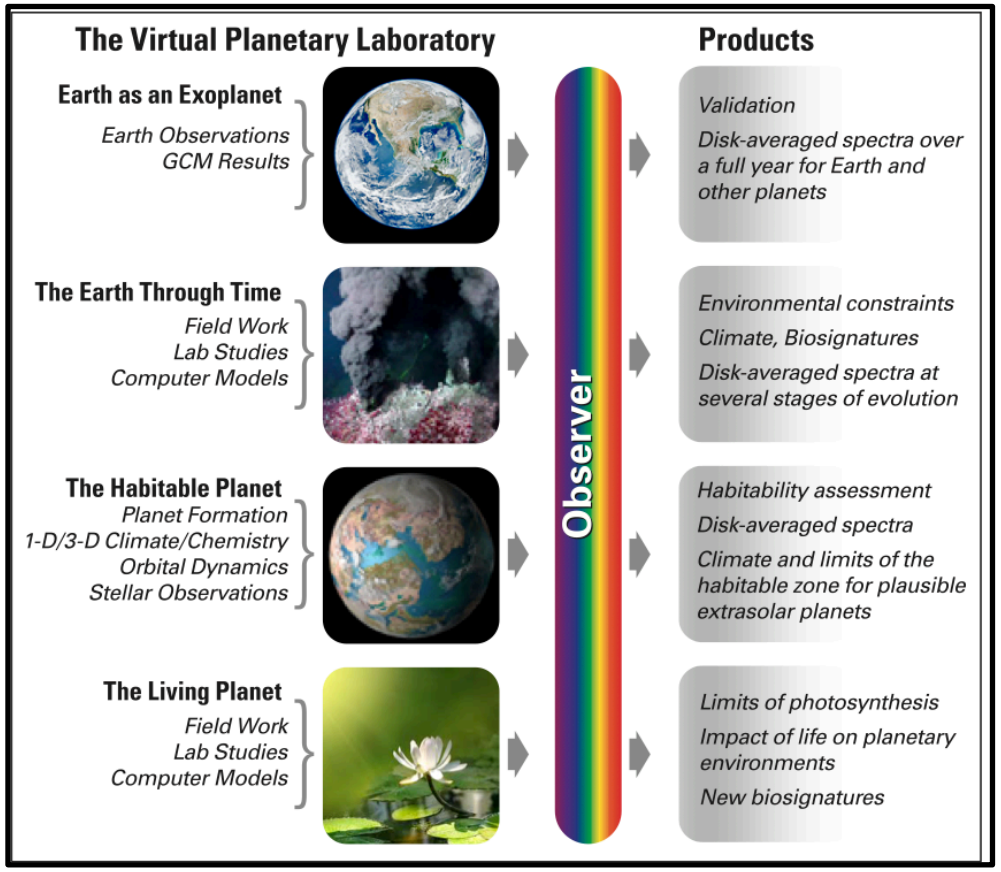
New biosignatures

Eddie's Research: Astronomical Biosignatures & Habitability Markers

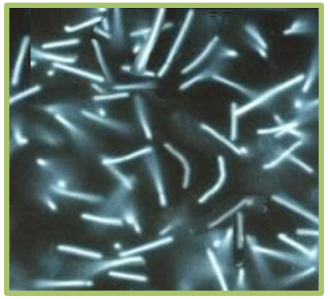
Some of my projects

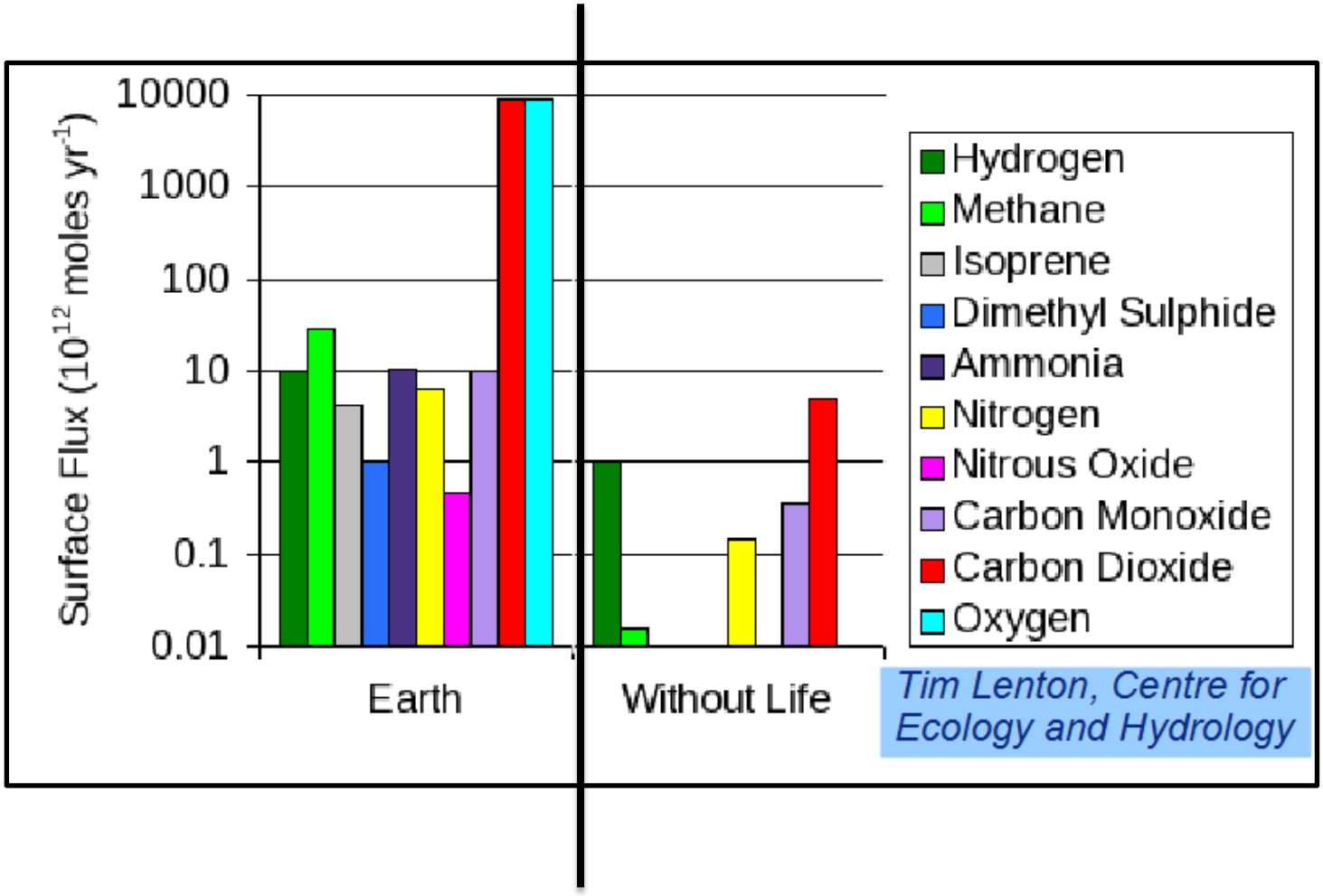
- Detecting N_2 in planetary atmospheres*
- Non-photosynthetic pigments as biosignatures
- Phase-resolved spectral Earth (Earth through a Lunar Month)*
- Spectral modeling of diverse planetary atmospheres*
- **TOOLS:** Radiative transfer model, VPL Earth model, climate model, photochemistry code

VPL Tasks

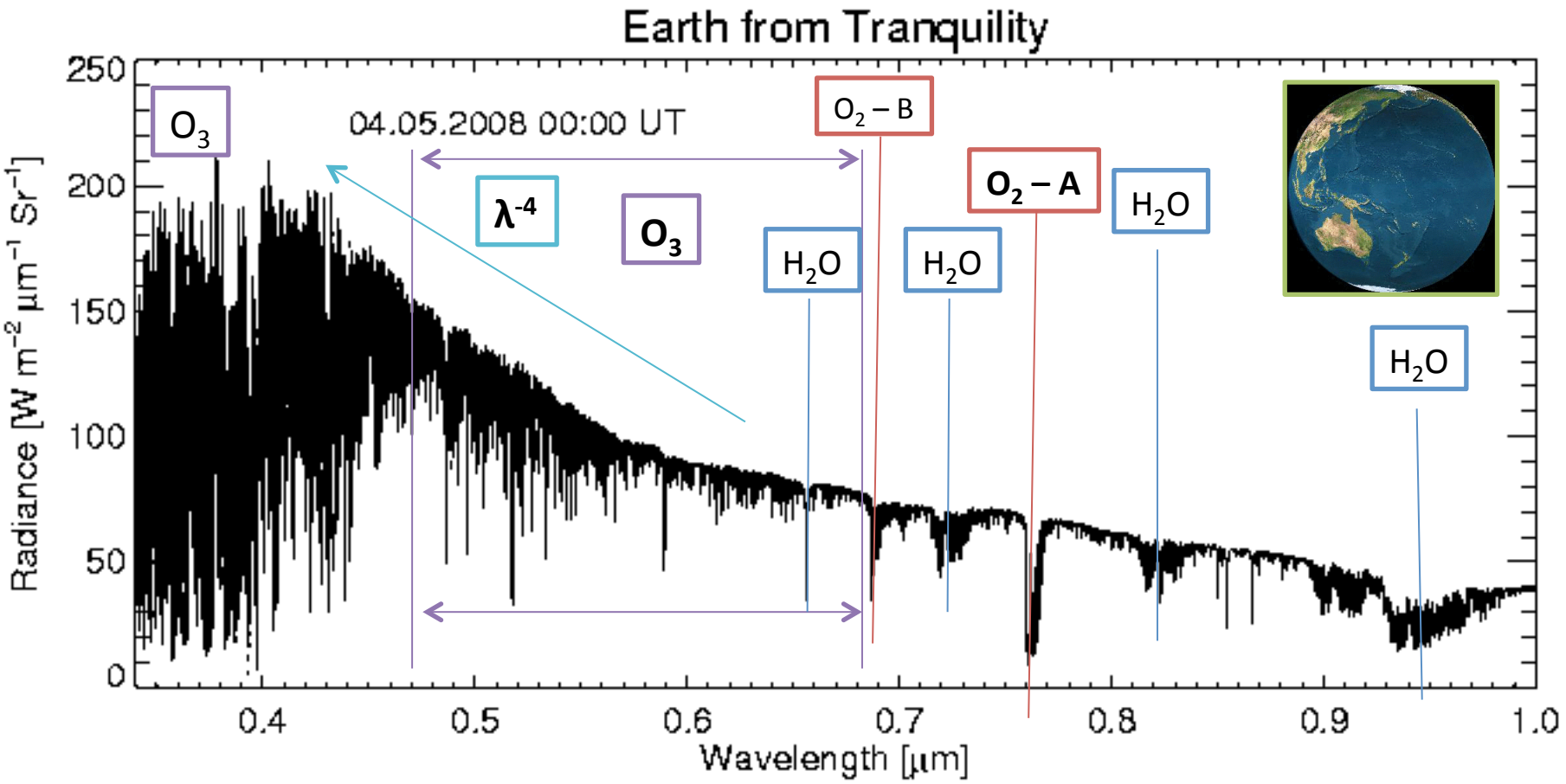


Biology Has Changed Our Atmosphere

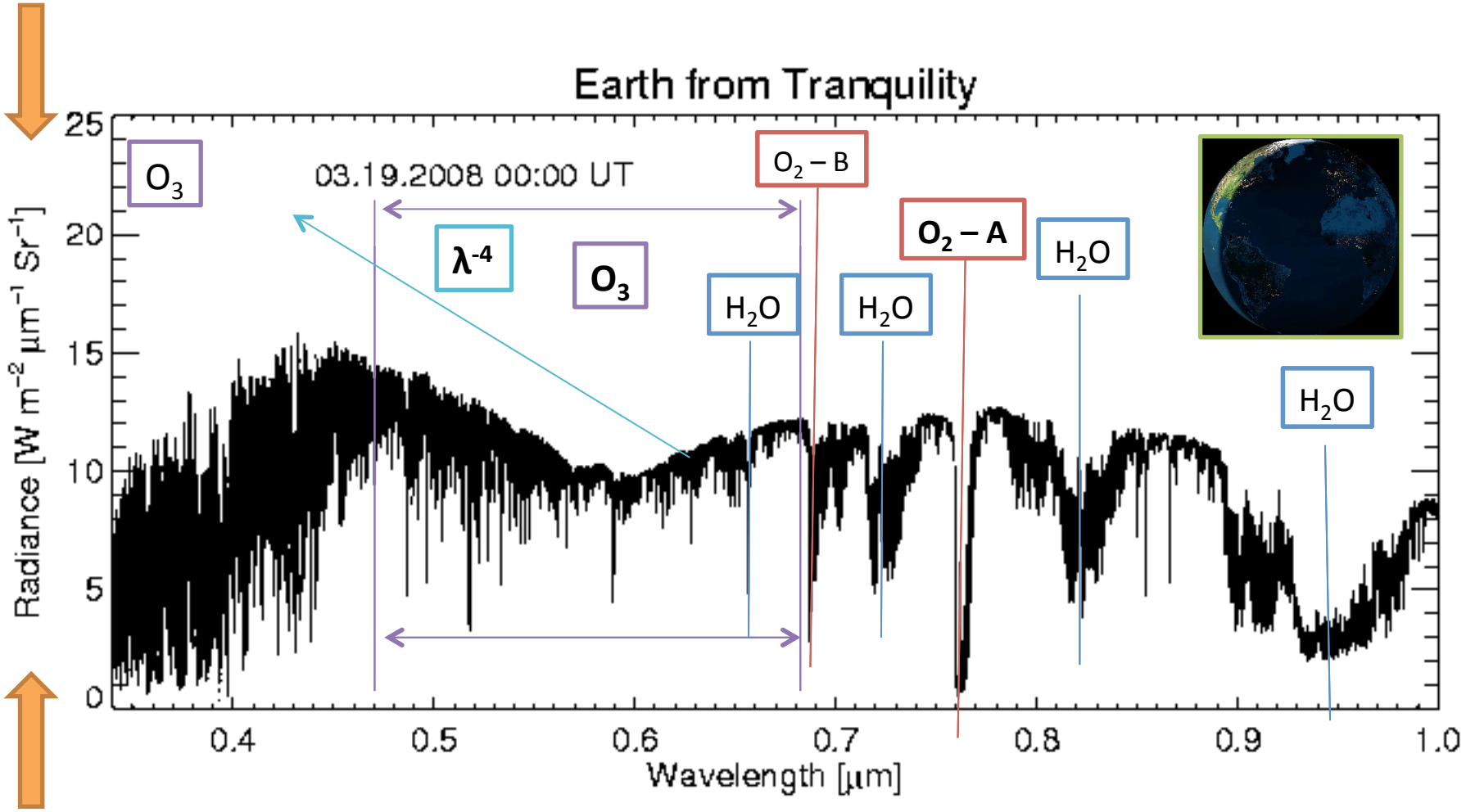




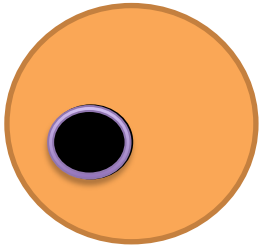
The VPL Earth Model

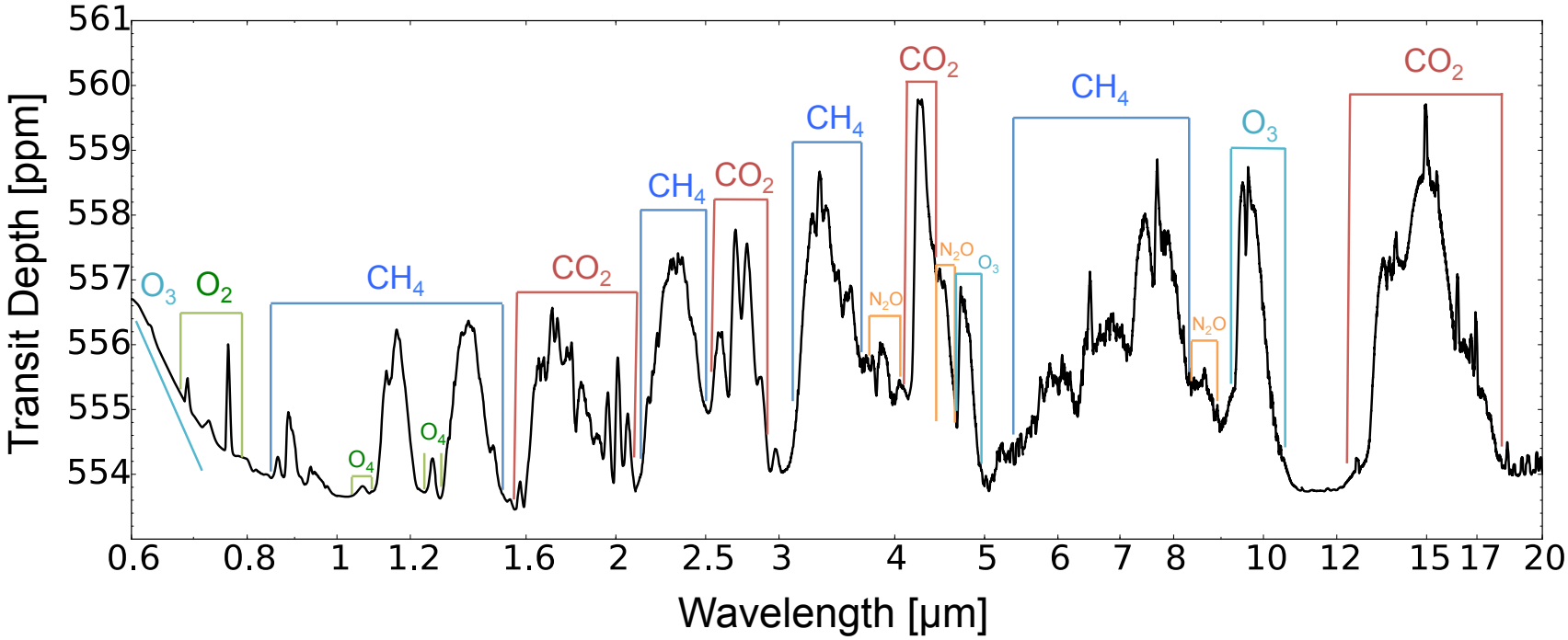


The VPL Earth Model



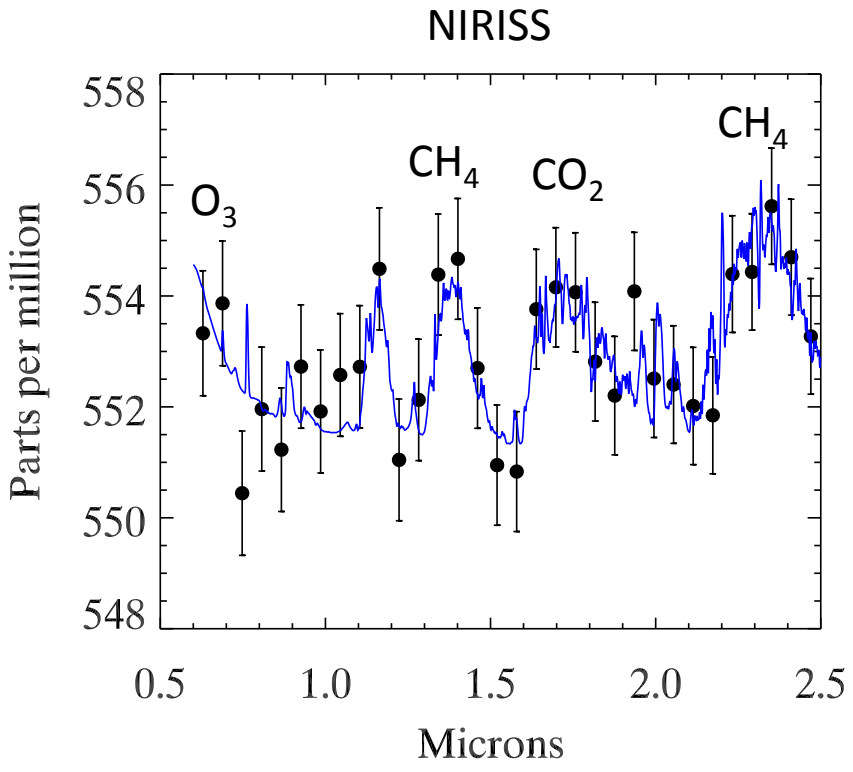
Transmission Spectrum of an Earth around an M dwarf

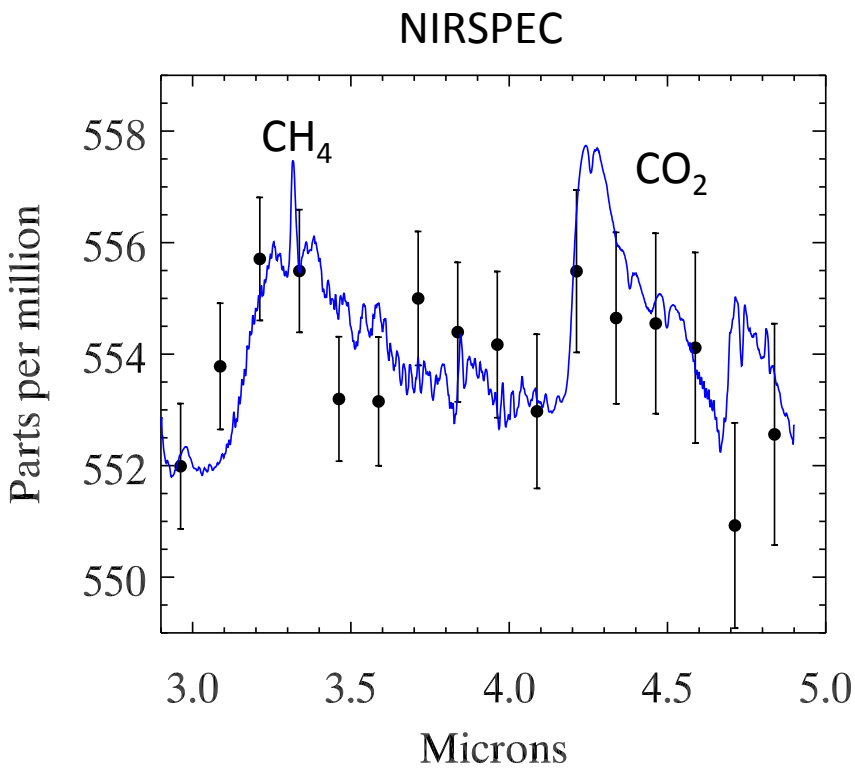




Atmosphere chemical profile from Segura et al. 2005

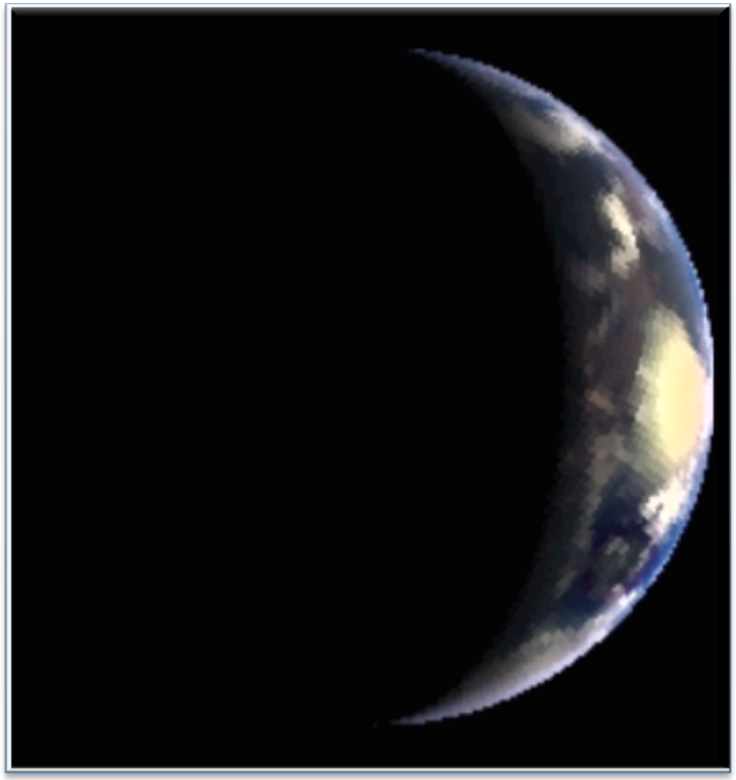
Earth around an M dwarf: Simulated JWST Observation



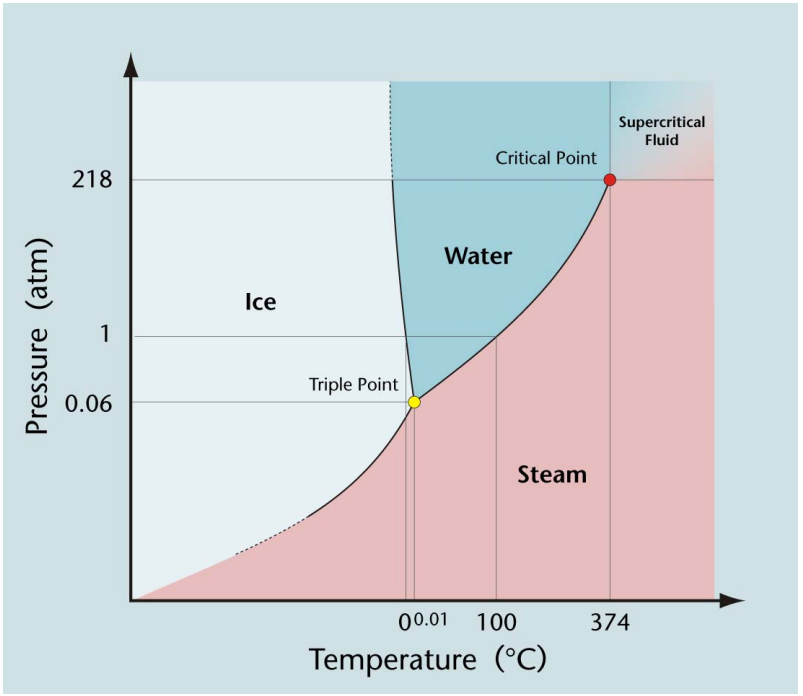


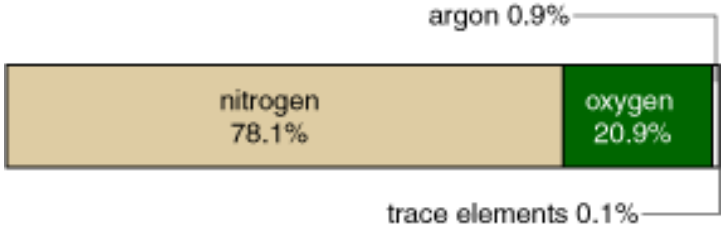
Noise calculation courtesy of Drake Deming, UMD

Detecting Habitability

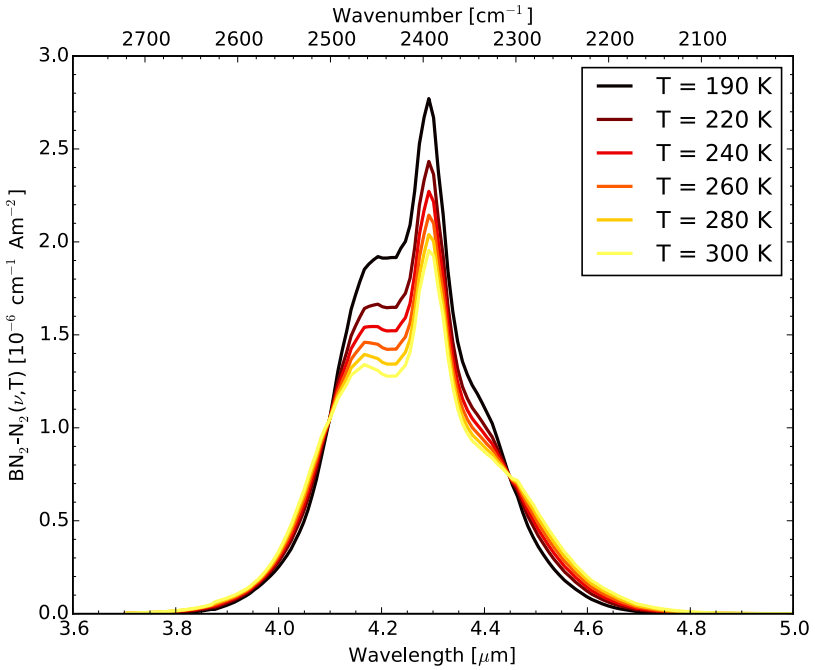


Robinson et al. 2010, 2014





Detecting N_2 and the Bulk Atmosphere



Schwieterman et al. 2015; coefficients from Lafferty et al. 1996

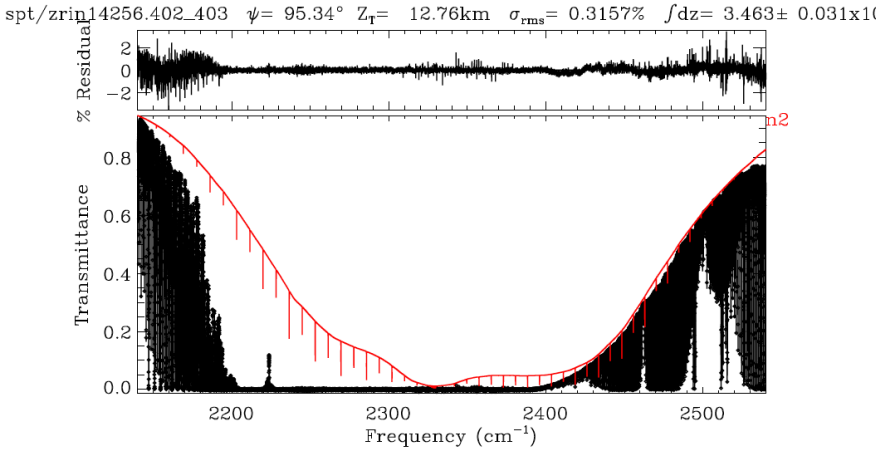
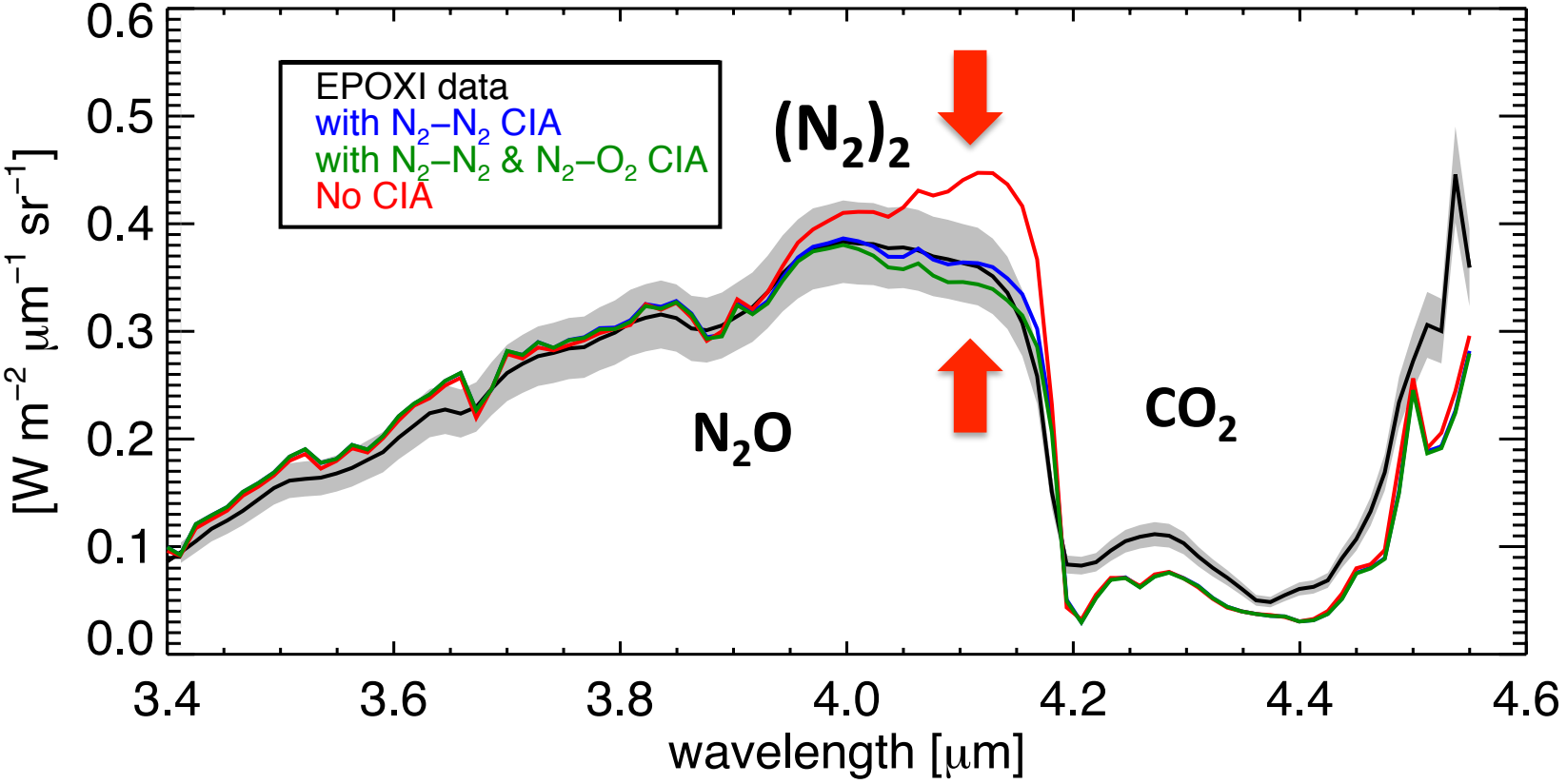


Figure credit:
Geoffrey Toon

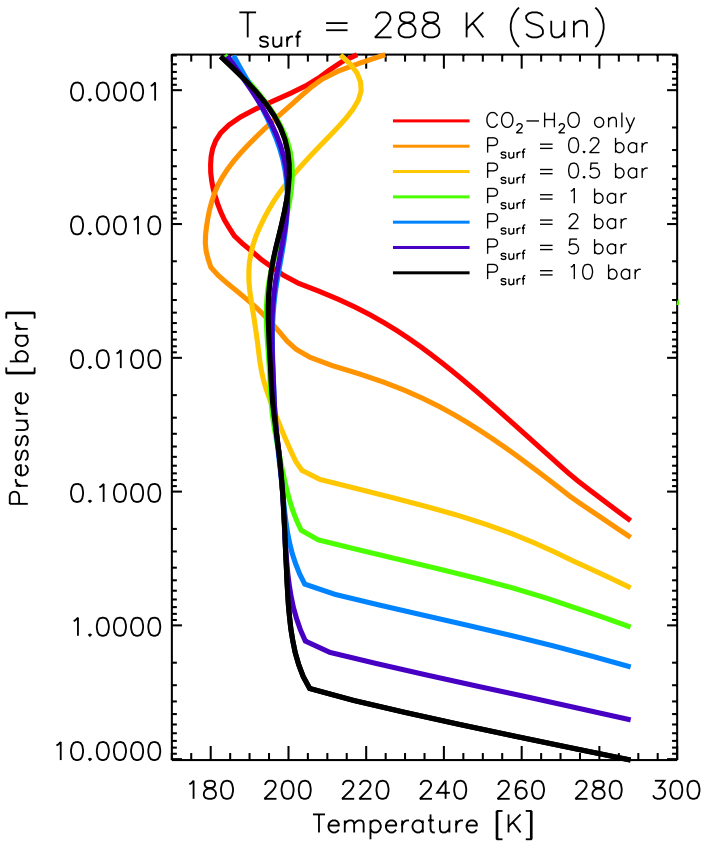
MkIV Sounding balloon with interferometer

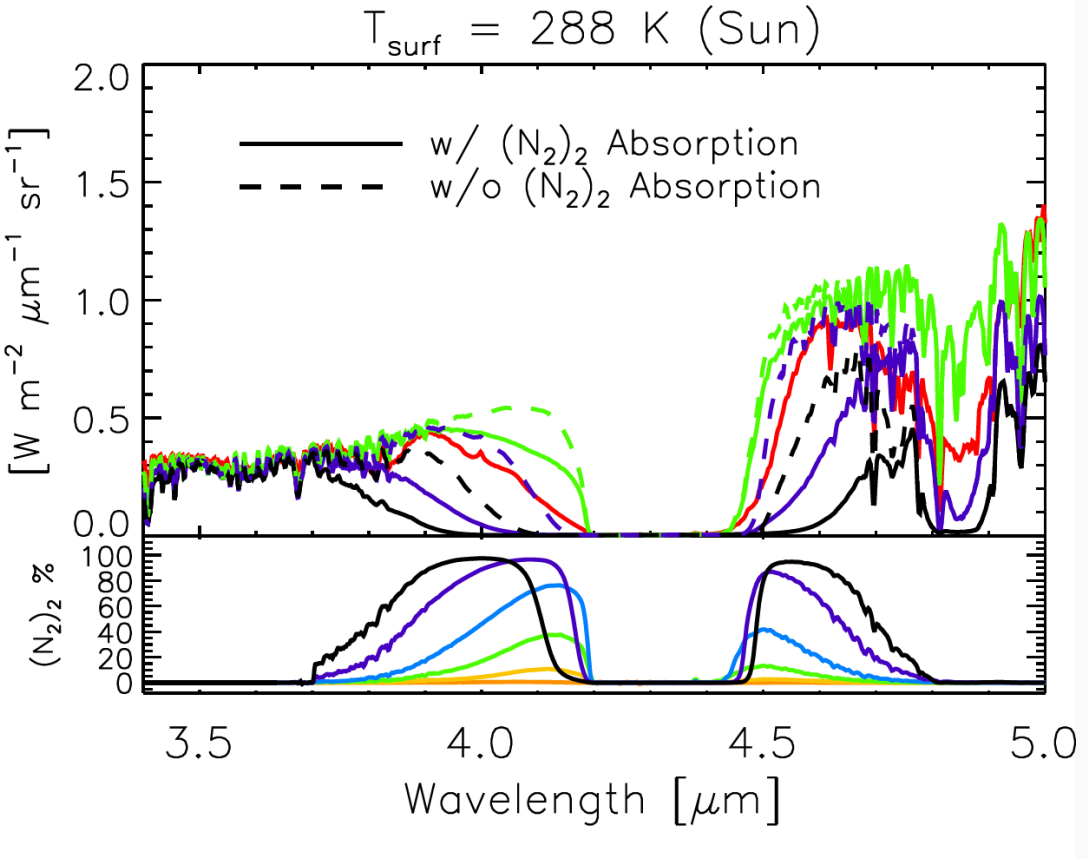
Validation: $(N_2)_2$ directly detected in Earth's disk-integrated spectrum



Schwieterman et al. 2015b, ApJ

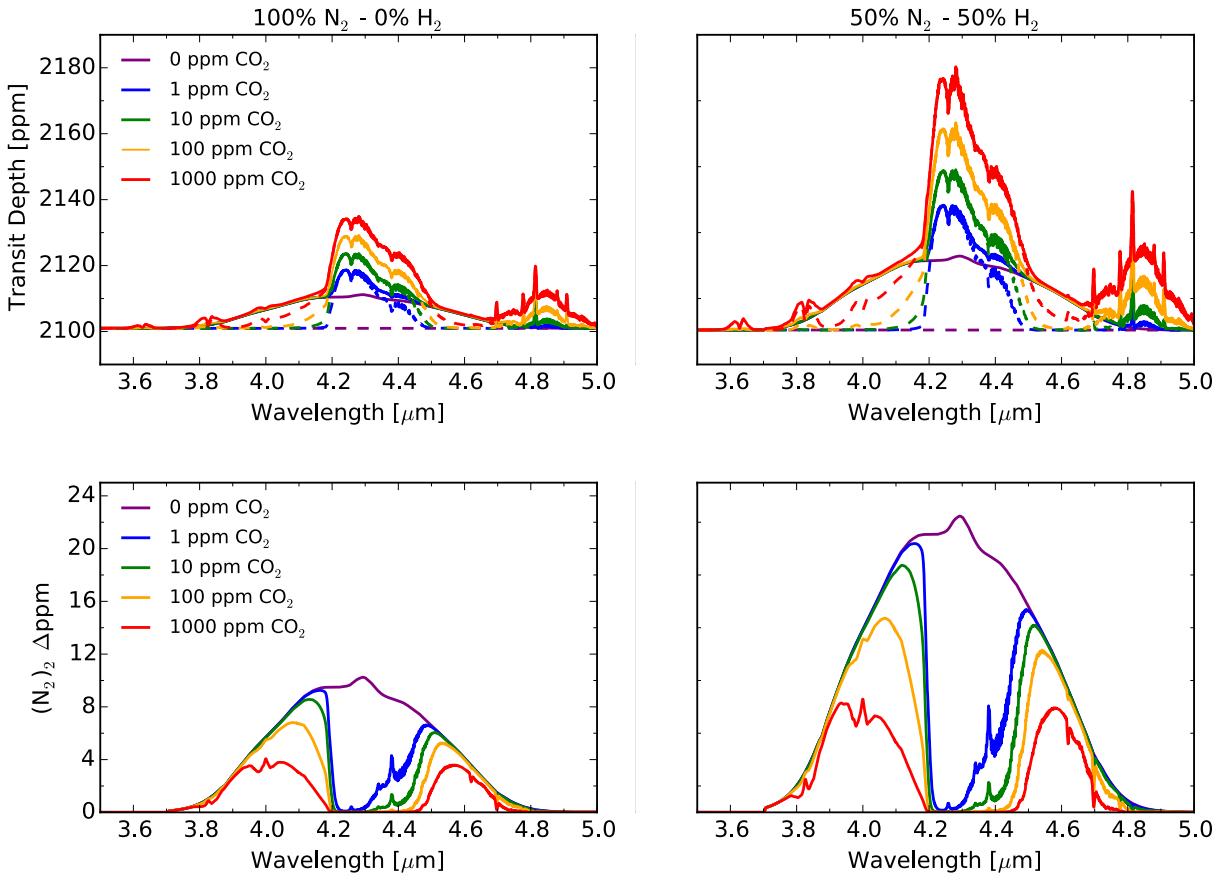
Simulated N_2 Radiance Spectra

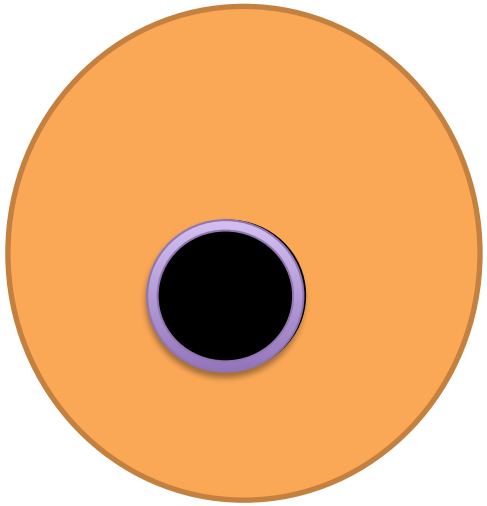




Schwieterman et al. 2015b, ApJ

Simulated N_2 Transmission Spectra





Schwieterman et al. 2015b, ApJ