Speaker Contact Information

- Joe Huehnerhoff & Chris Laws: jwhueh@uw.edu, laws@astro.washington.edu
- Charli Sakari: sakaricm@u.washington.edu
- Michael Tremmel: mjt29@astro.washington.edu
- Emily Levesque: emsque@uw.edu
- Paul Szkody: szkody@astro.washington.edu
- Kolby Weisenburger: kweis@uw.edu
- 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

Undergraduate Opportunities in Telescopes and Instrumentation at UW

Chris Laws

Joseph Huehnerhoff

Manastash Ridge Observatory

2015-11-6

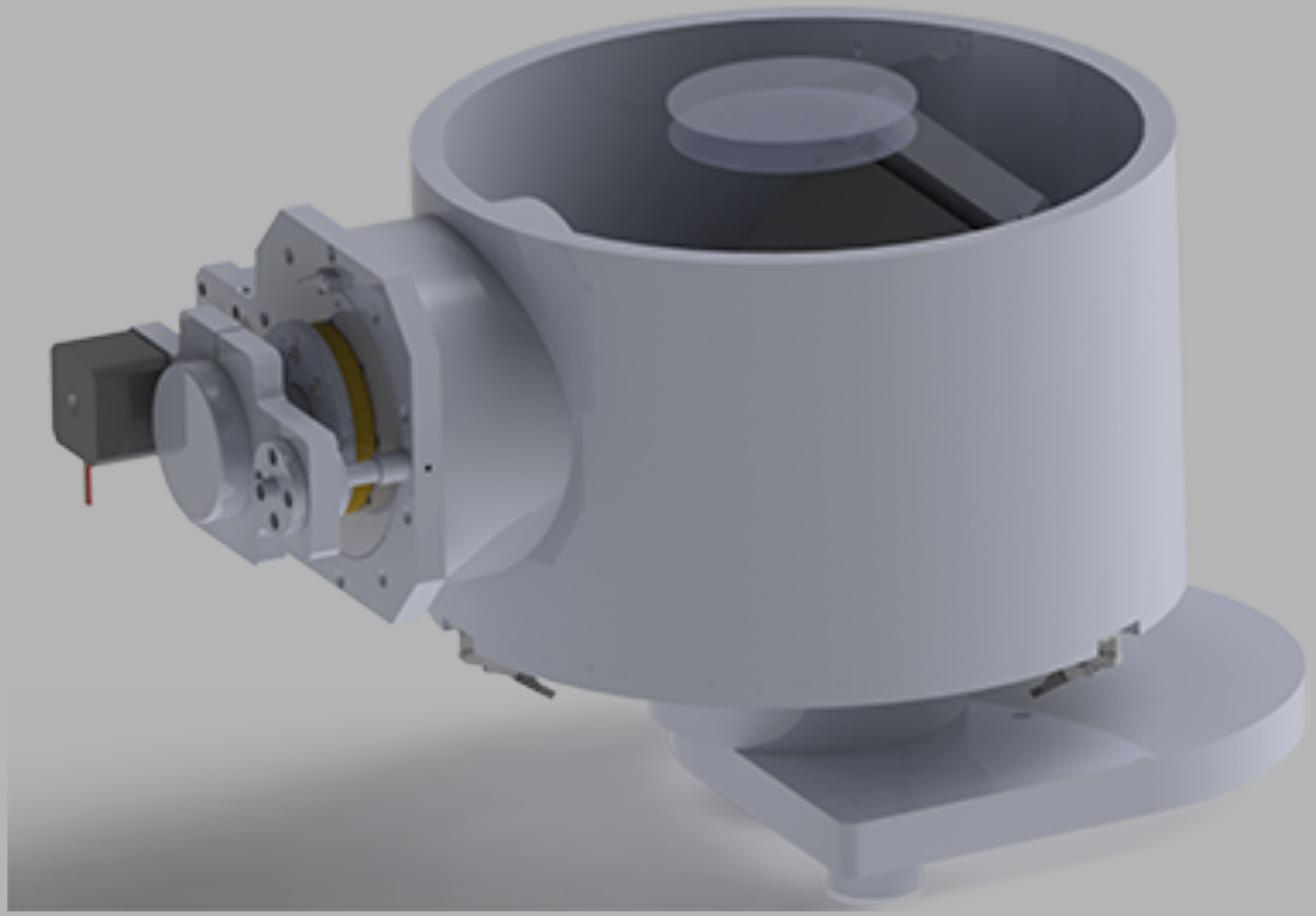
University of Washington
Department of Astronomy

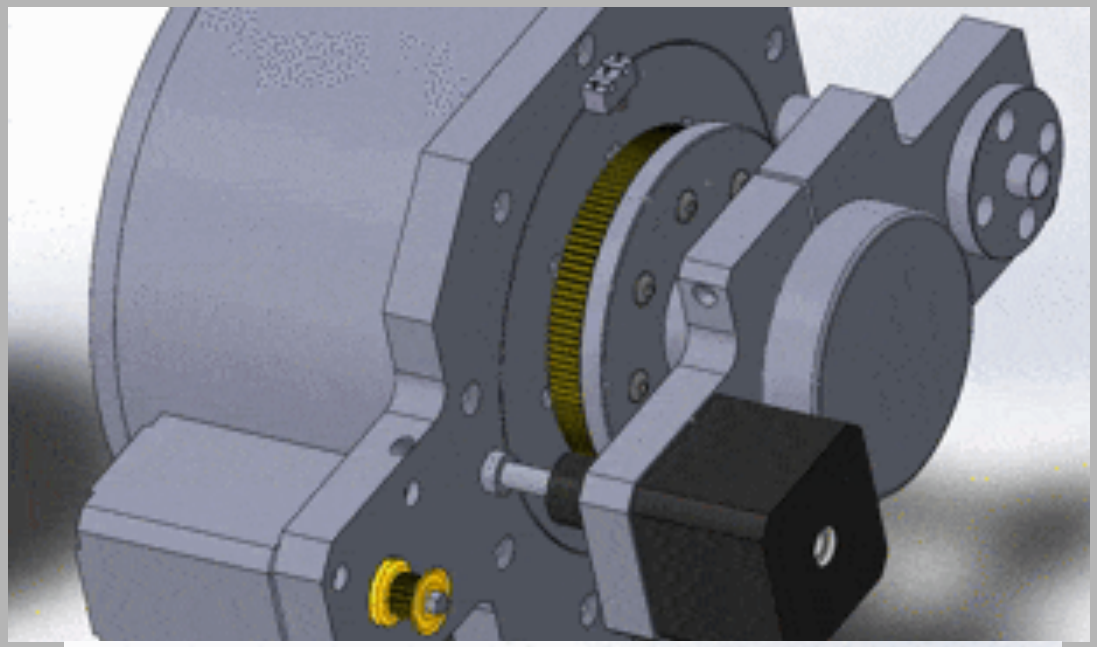
AUEG

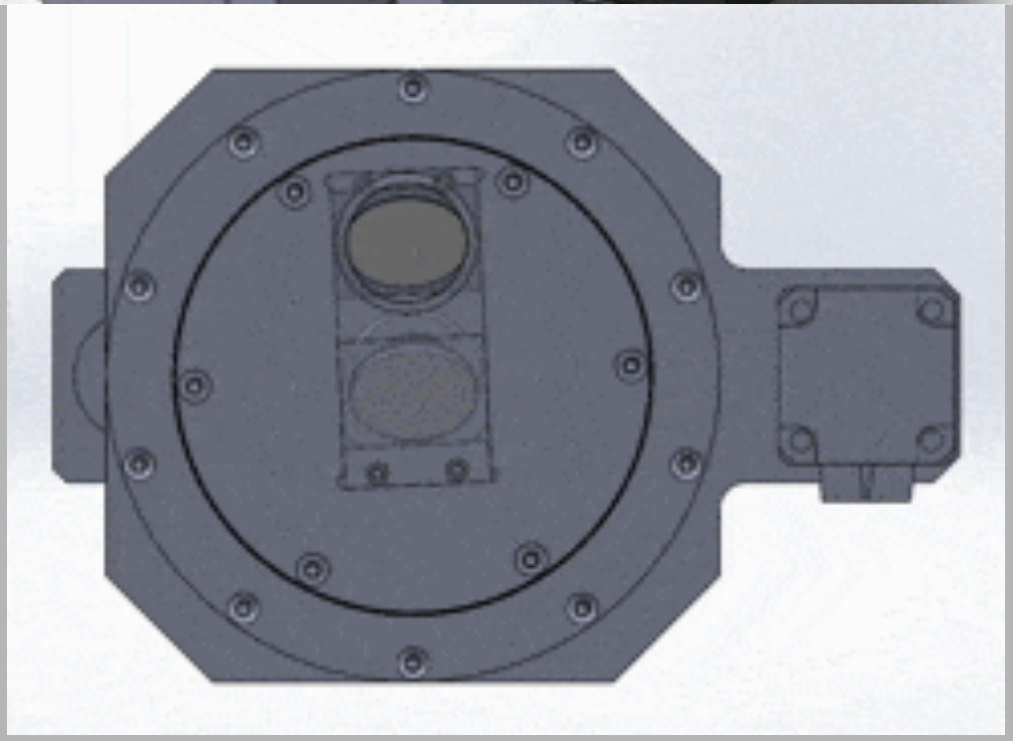
Astronomy Undergraduate Engineering Group

- Teach
  - Project Management – break into team
  - Industrial Skills
  - Professional Work Ethic
- MRO Projects
  - New Science Camera
  - Sustainability Upgrade
  - Guider Upgrade
  - TCC upgrade
  - Filter Wheel Replacement
- APO
  - Dome Flow Analysis 35m
  - Temp Sensor Replacement 25m
  - Summer Shutdown Support

http://staff.washington.edu/jwhueh/AUEG/



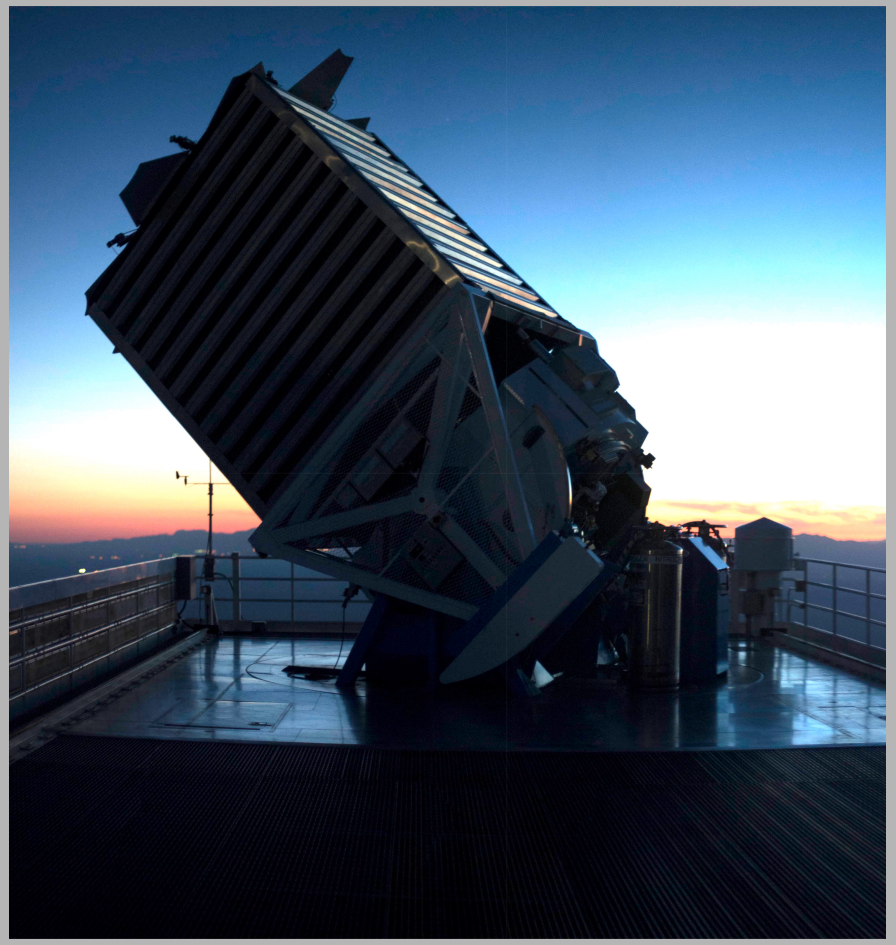




Fun with Mirrors

2015-11-6

- Provide Outlet for usage of advanced skills
- SDSS Common Corrector Cleaning



Talk to Us to Get More Info

- If you are interested in Astronomical instrumentation and engineering come talk with Chris or myself about the current opportunities available.

  Chris Laws - laws@astro.washington.edu

  Joseph Huehnerhoff – jwhueh@uw.edu

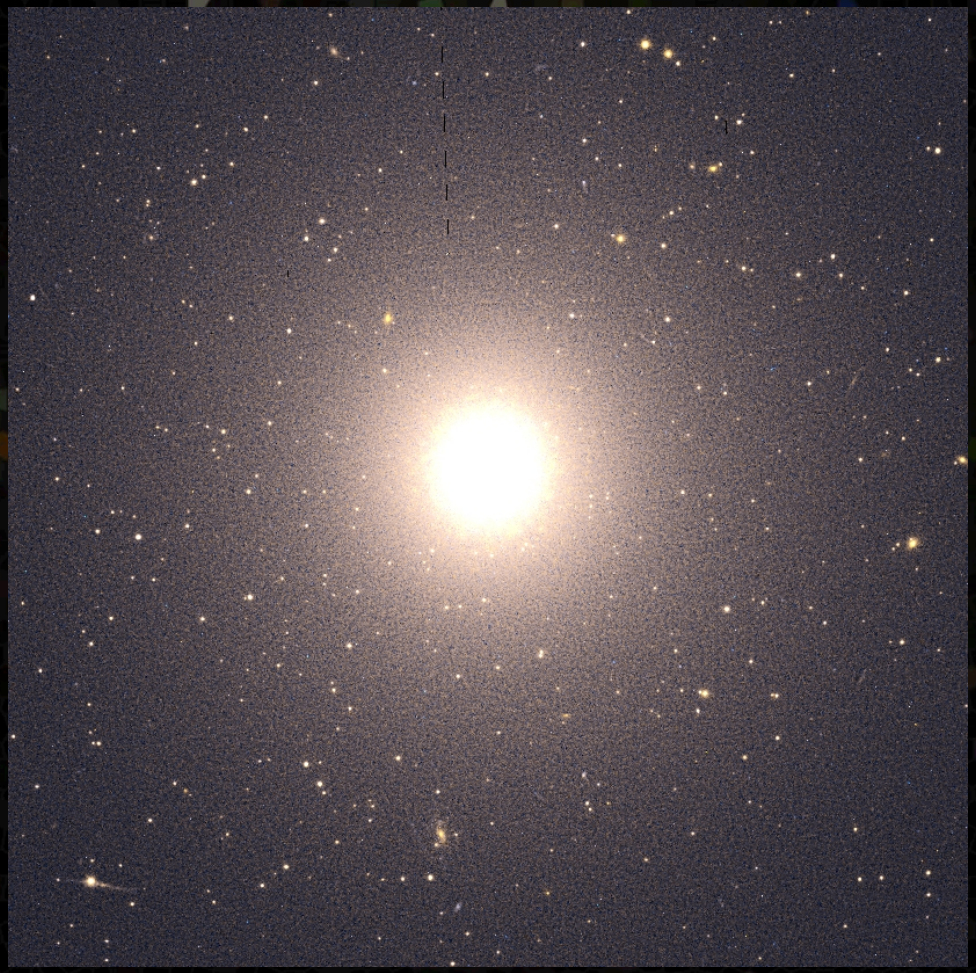
Chemical Abundances of Globular Cluster Stars

Charli Sakari

Post-doctoral Research Associate

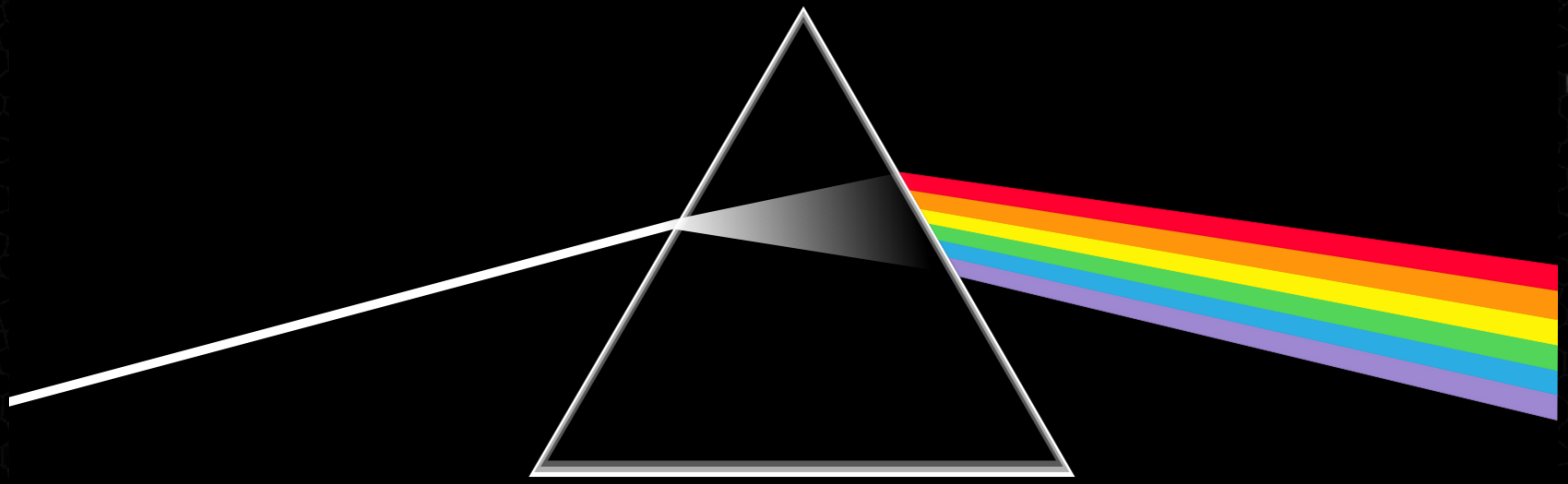
University of Washington

Distant GCs

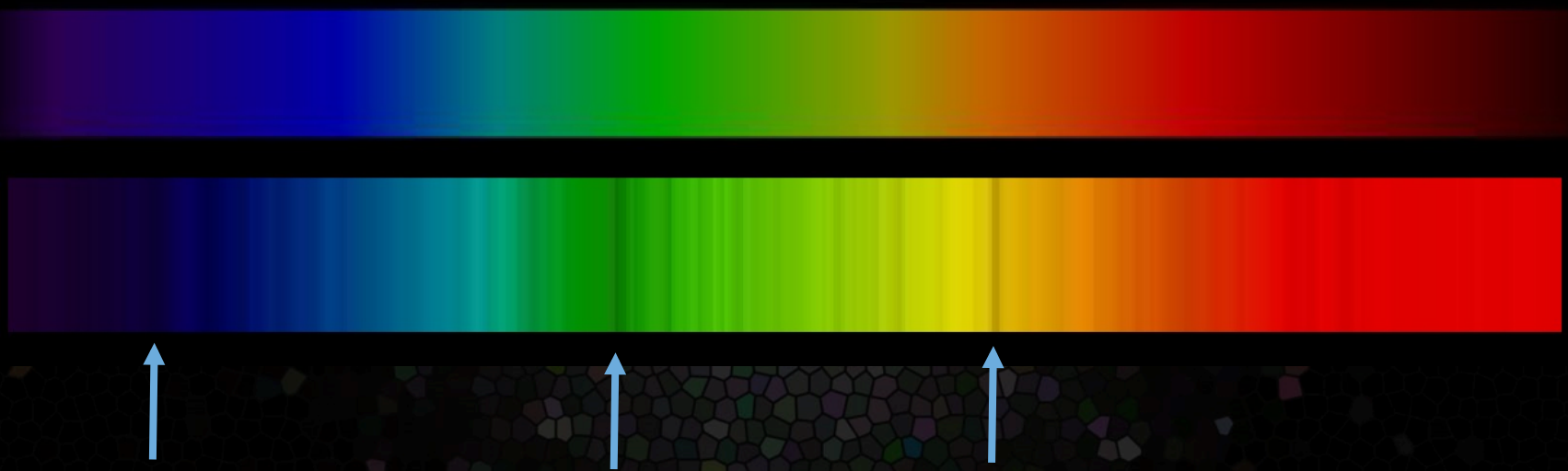


NGC 1407—Image from Harris et al. 2006

Spectroscopy



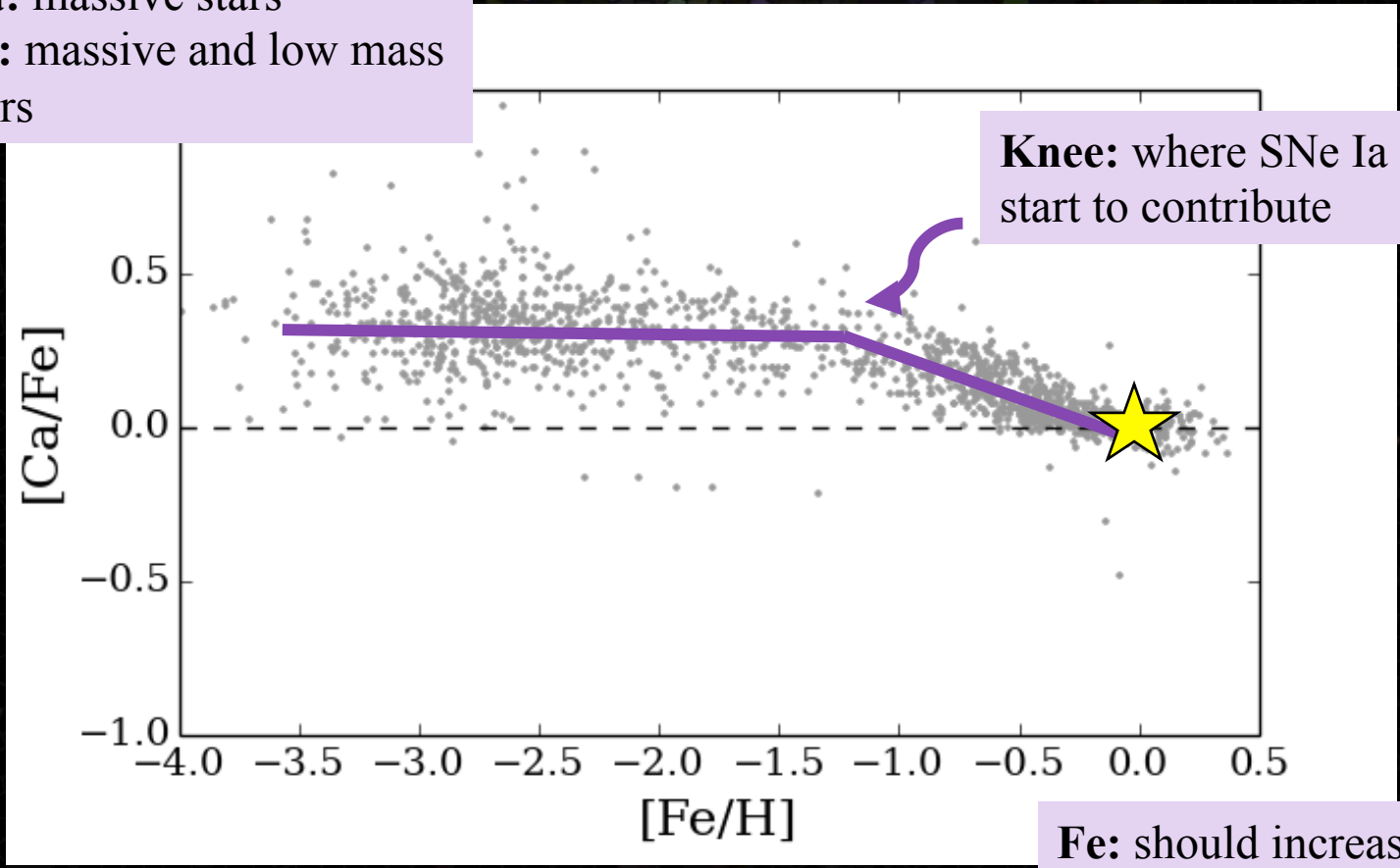
Spectroscopy



Dark bands = absorption lines

Chemical Tagging

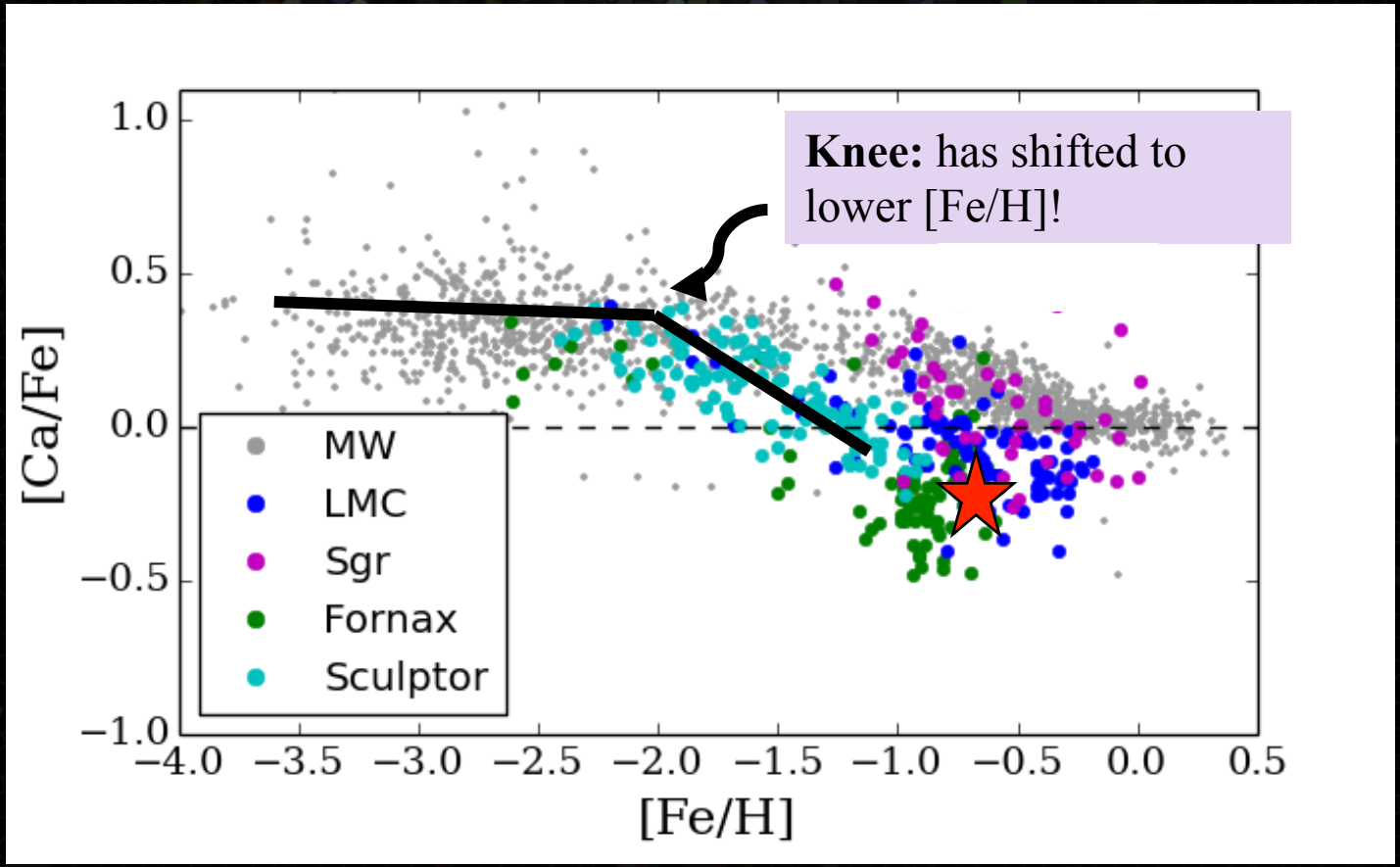
Ca: massive stars
Fe: massive and low mass stars



Knee: where SNe Ia start to contribute

Fe: should increase over time

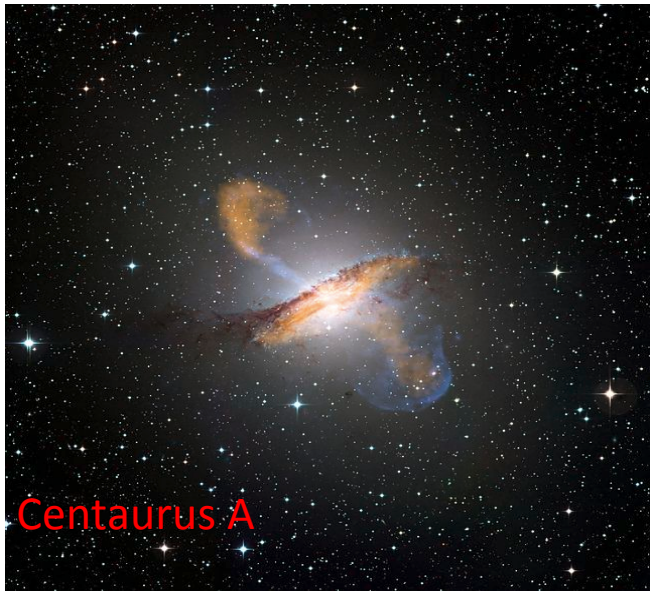
Chemical Tagging

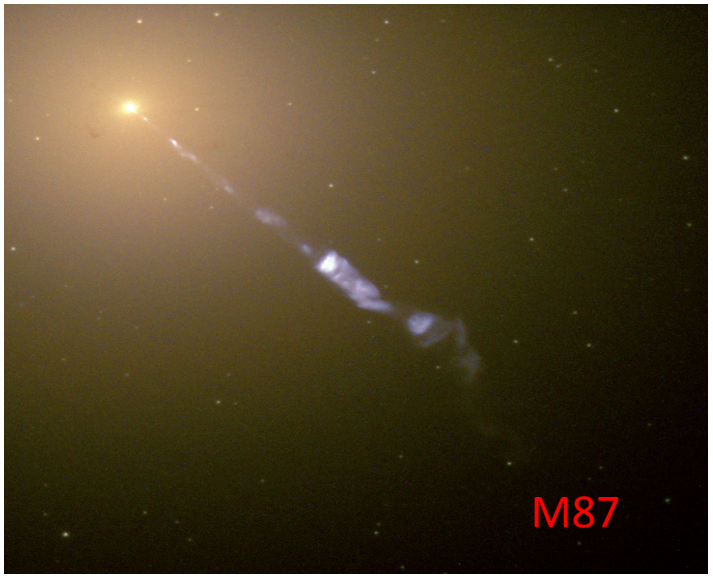


The Romulus Simulations

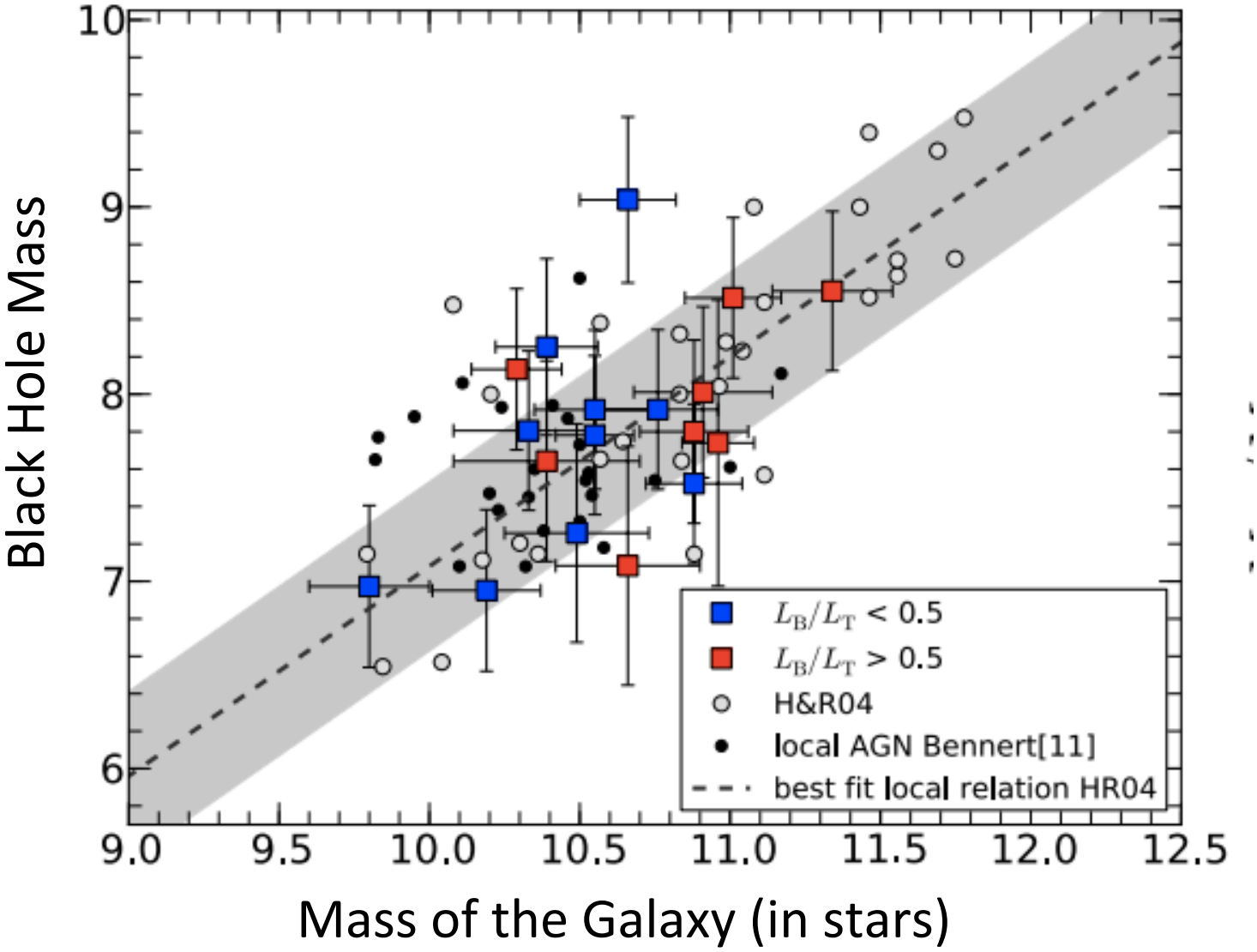
Studying the Co-Evolution of Galaxies and Supermassive Black Holes

Black Holes and Their Galaxies





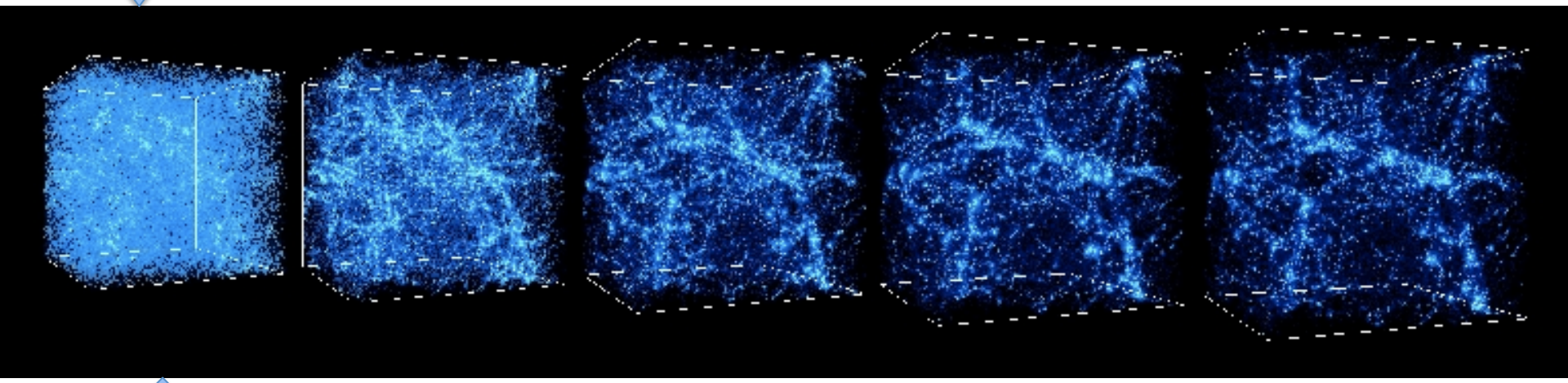
Black Holes and Their Galaxies



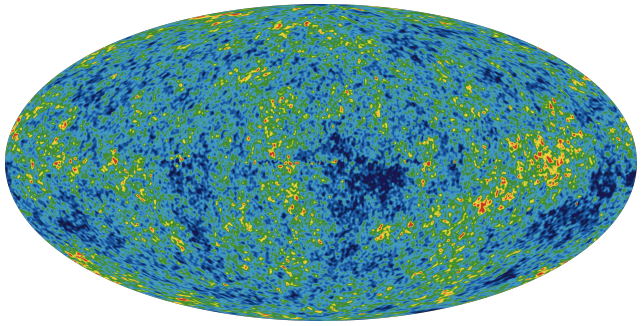
Cosmological Simulation Basics

Physics

- ✓ Gravity
- ✓ Hydrodynamics
- ✓ Star Formation, Supernovae
- ✓ Supermassive Black Holes

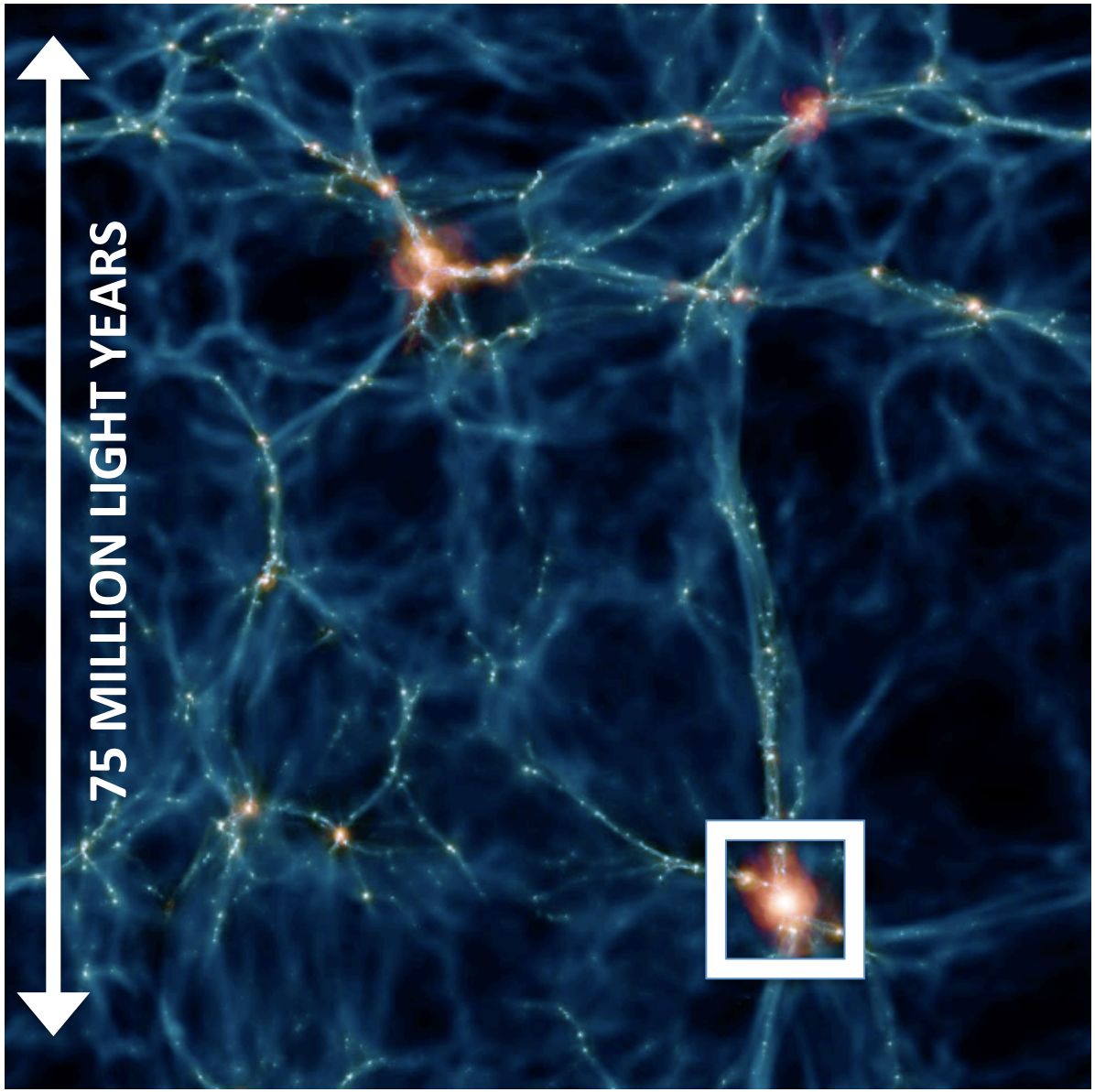


Initial Conditions



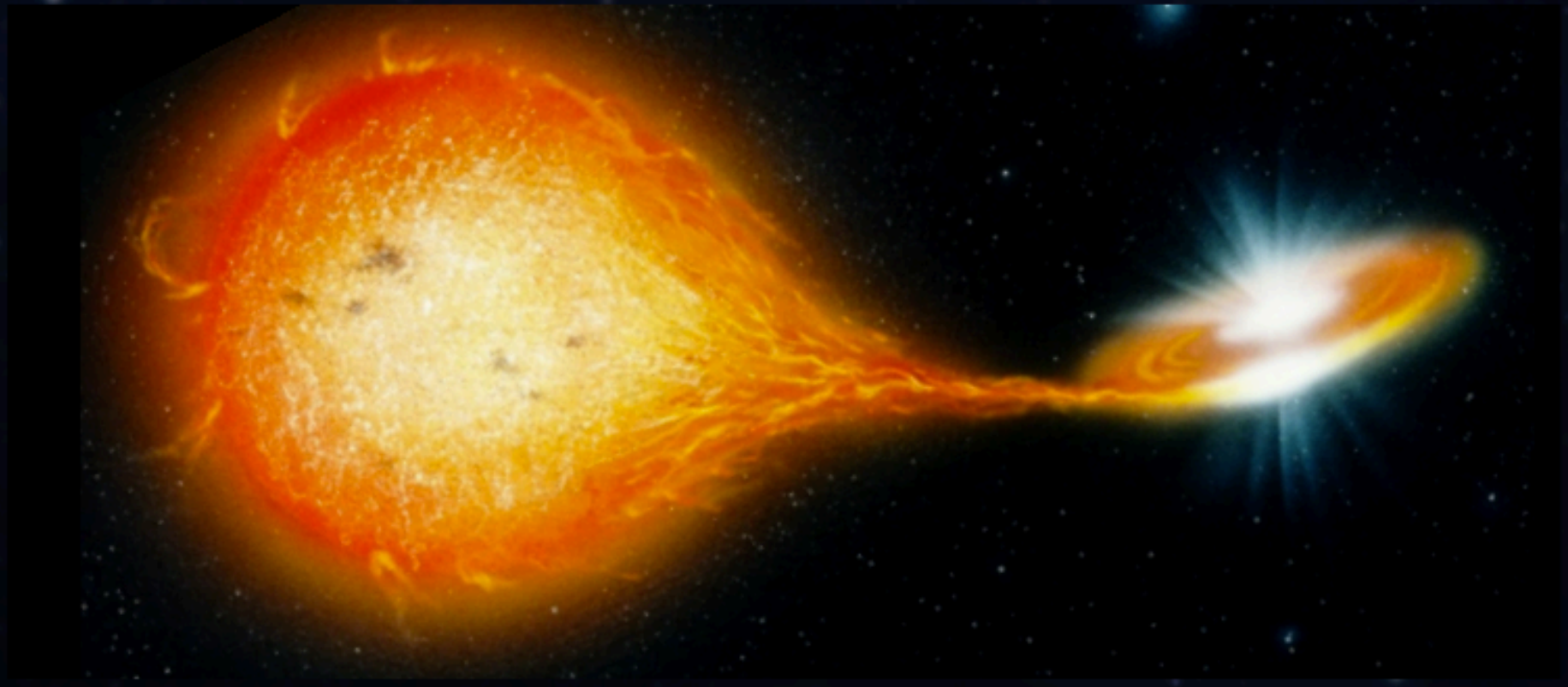
The Romulus Simulations

- ✓ High Resolution
- ✓ Well constrained physics
- ✓ **New Supermassive Black Hole Physics**



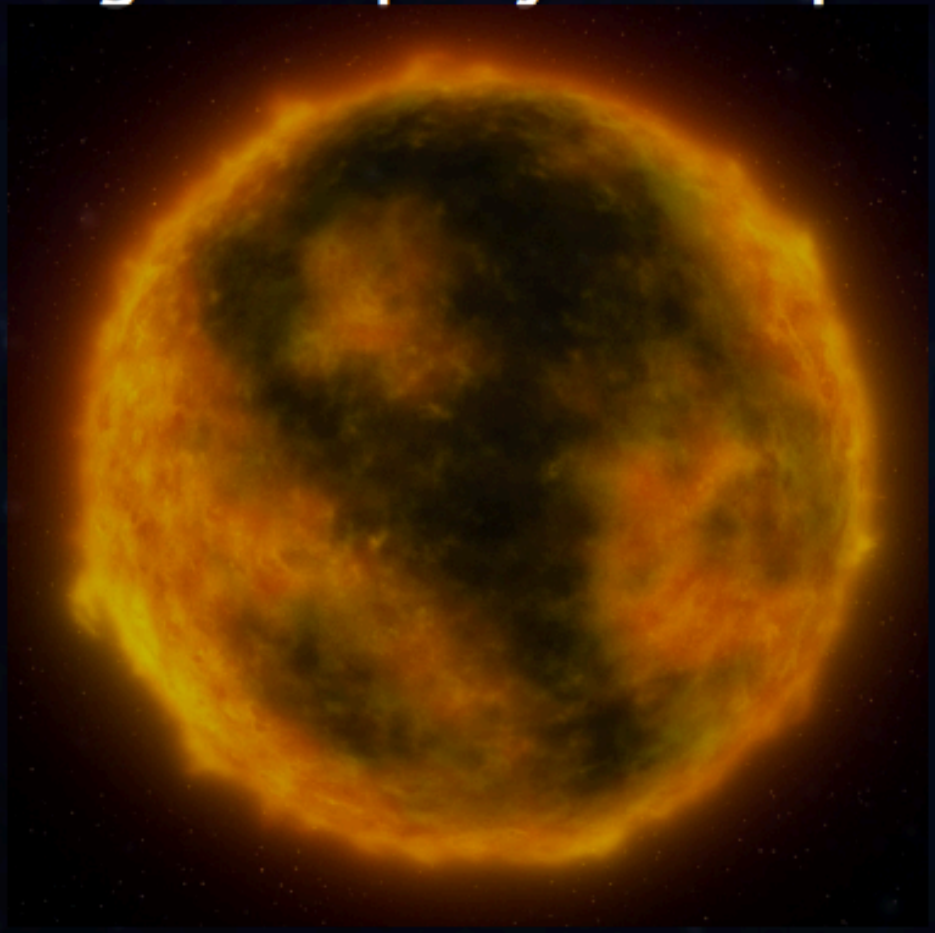
Thorne-Żytkow Objects: The Weirdest Stars in the Universe

Emily Levesque emsque@uw.edu



11.20.2015

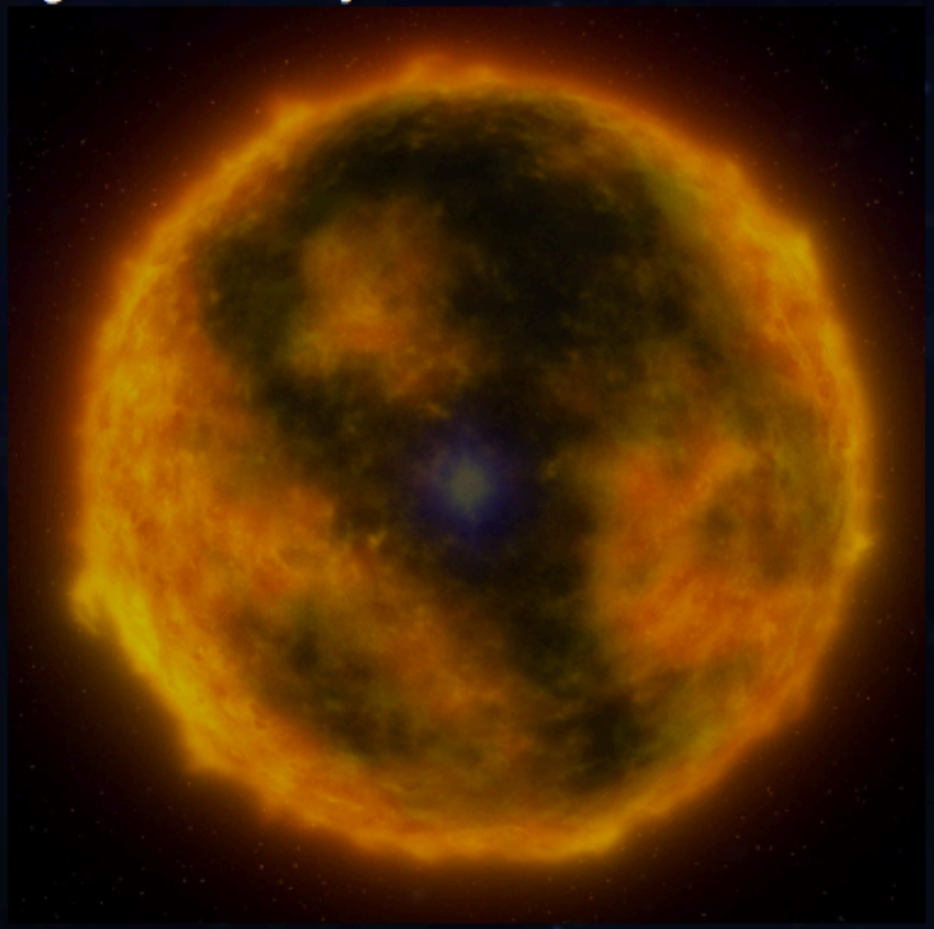
Thorne-Żytkow Objects (TŻOs) are a theoretical class of star: a neutron star "core" surrounded by a large cold puffy envelope.



red supergiant

neutron star

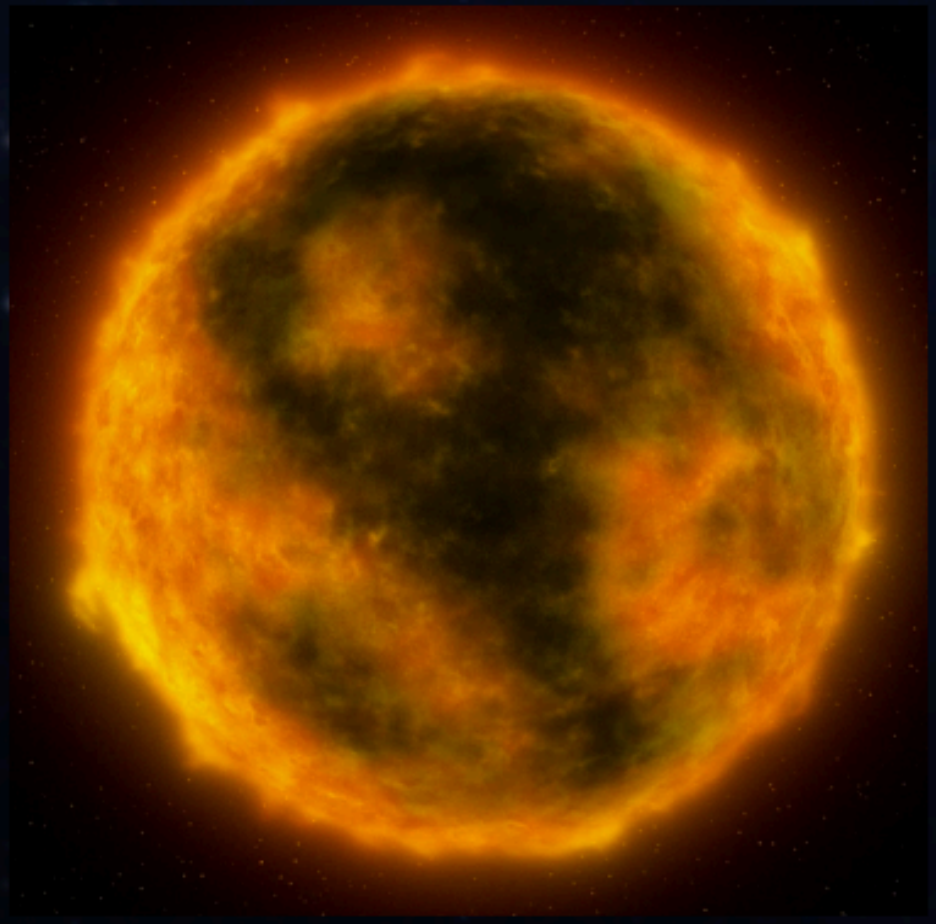
Thorne-Żytkow Objects (TŻOs) are a theoretical class of star: a neutron star "core" surrounded by a large cold puffy envelope.



For years TŻOs were just a theory;
nobody had ever observed one.

TŻOs look exactly like red supergiants...

almost!

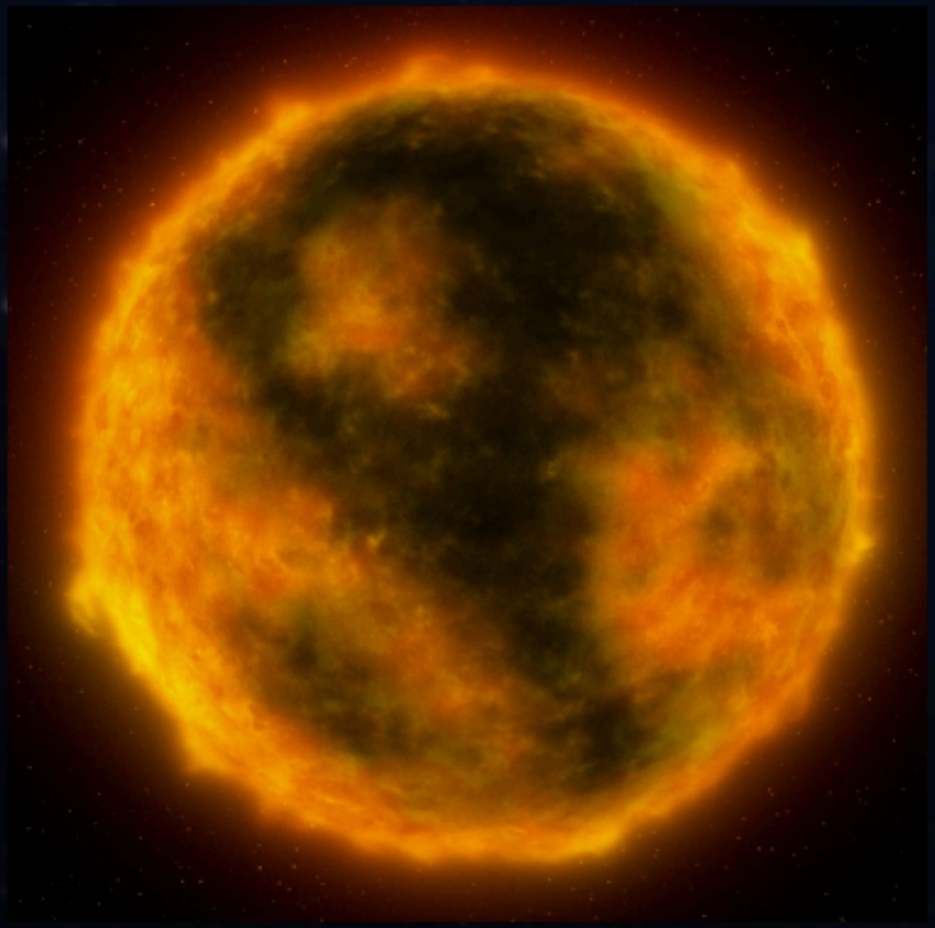


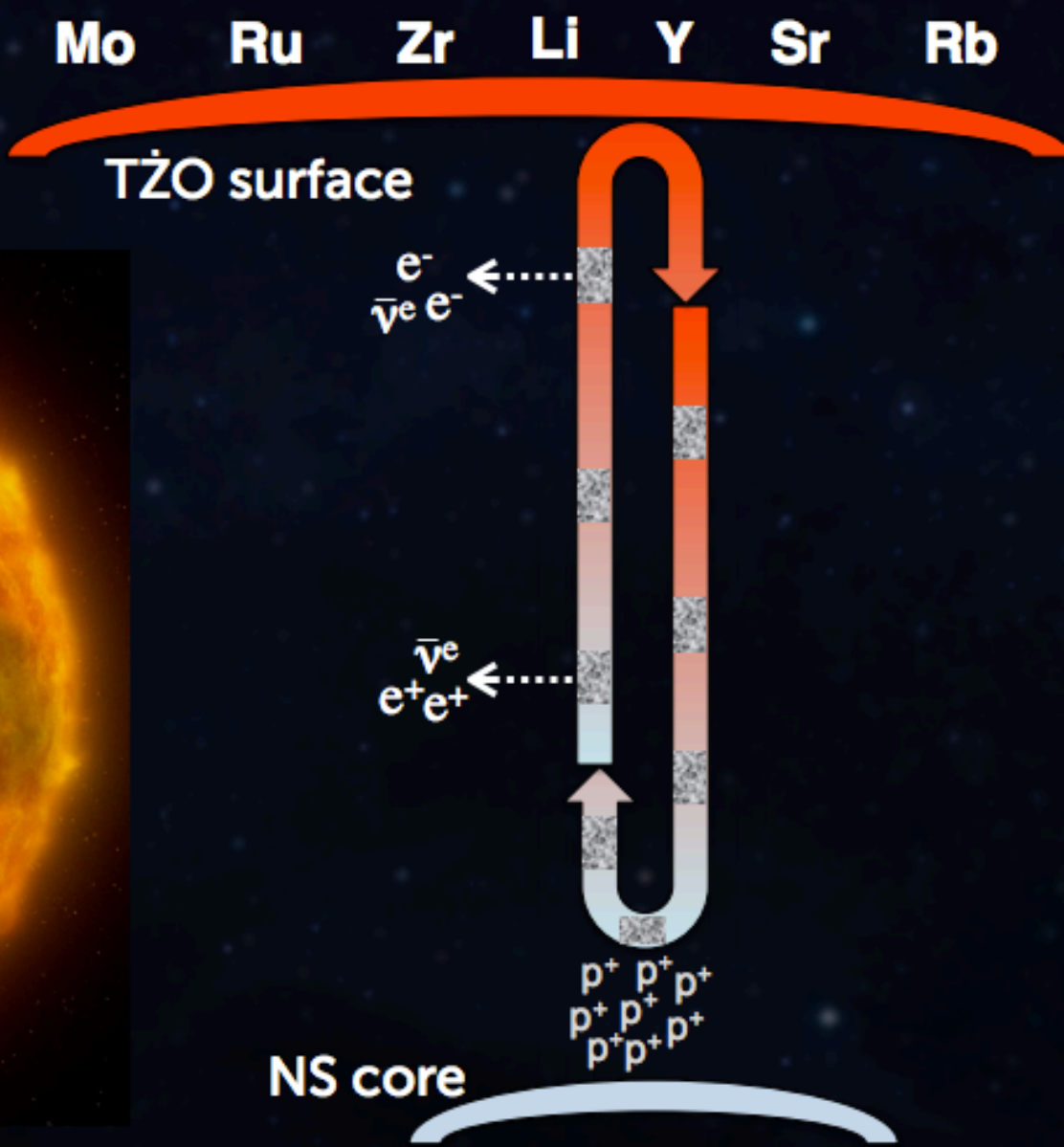
RSG surface

He-burning core

TŻOs look exactly like red supergiants...

almost!

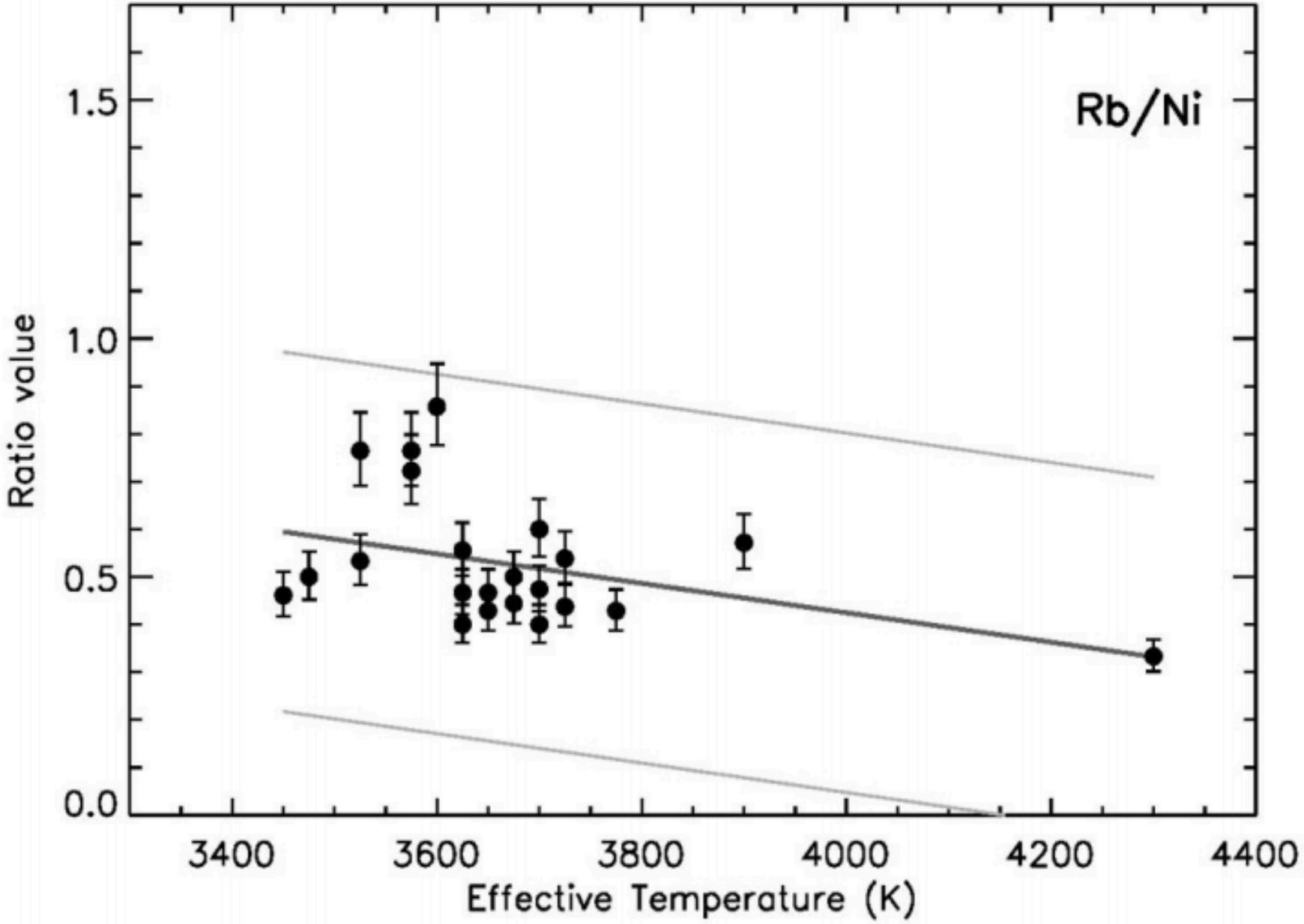




TŻOs look exactly like red supergiants...

A search for TŻOs: high-resolution spectroscopy of RSGs in nearby galaxies

NS core


Rb/Ni
Ratio value
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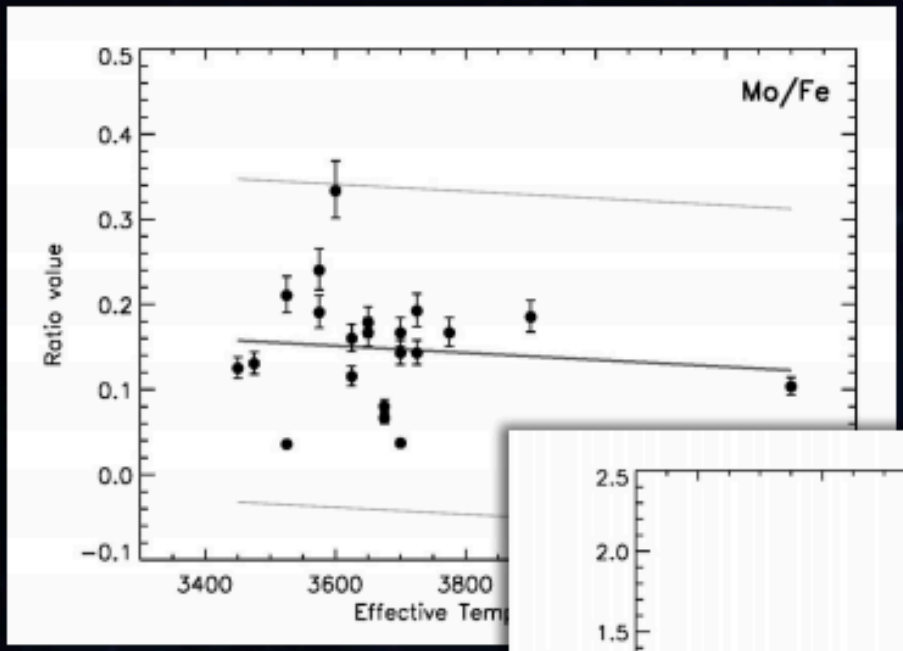
1.0
0.5
0.0
3400
3600
3800
4000
4200
4400
Effective Temperature (K)


Mo/Fe
Ratio value
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3600
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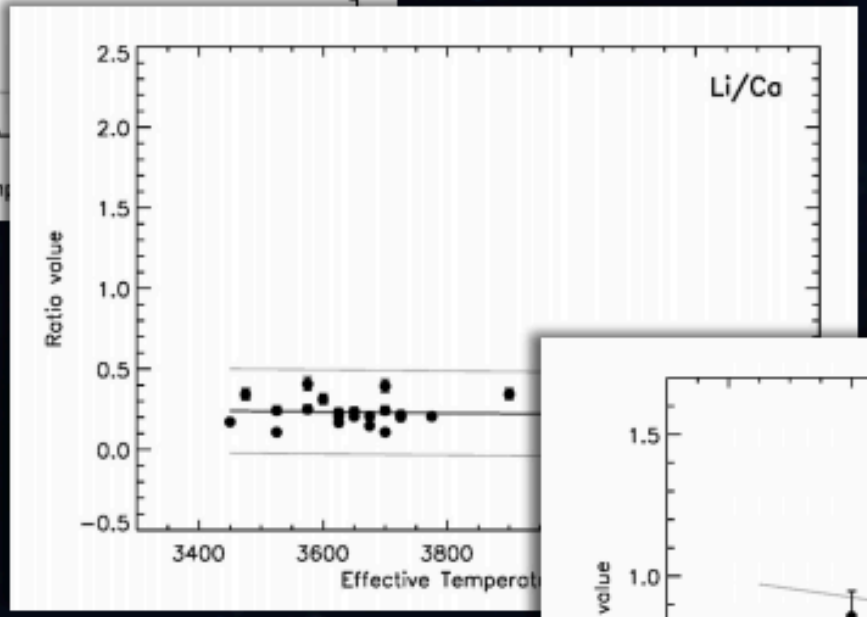
Effective Tem


Li/Ca
Ratio value
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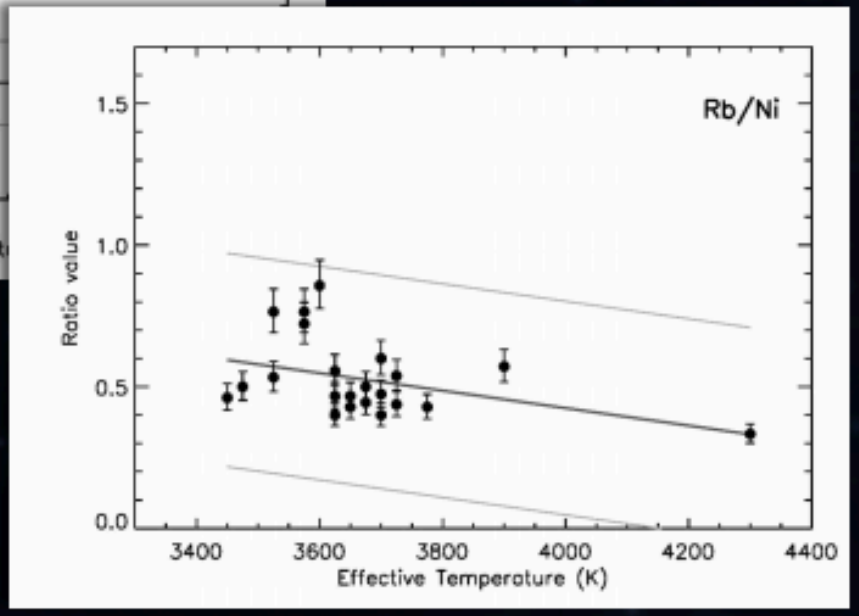
2.0
1.5
1.0
0.5
0.0
−0.5
3400
3600
3800
Effective Temperat


Rb/Ni
Ratio value
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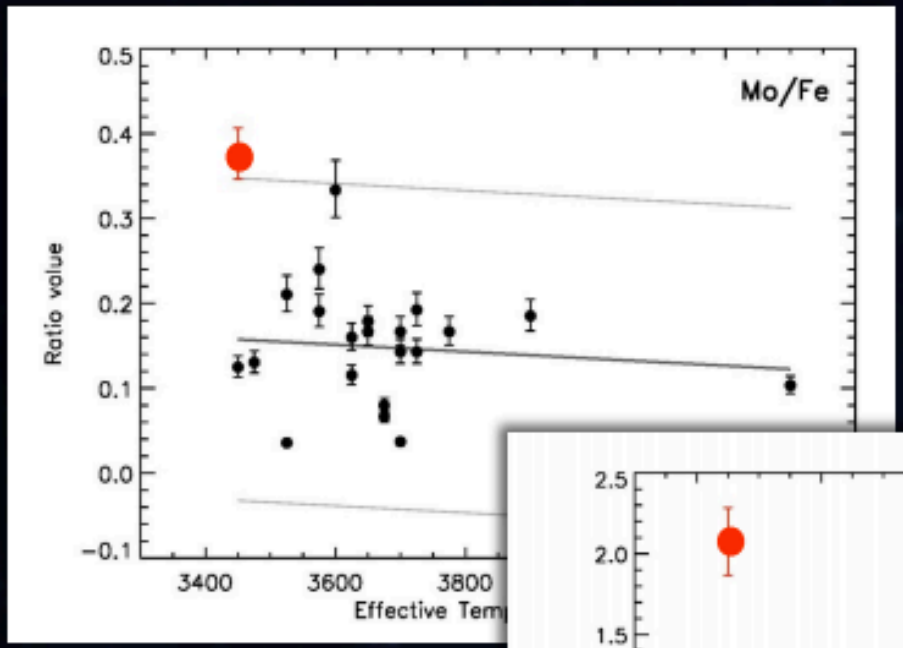
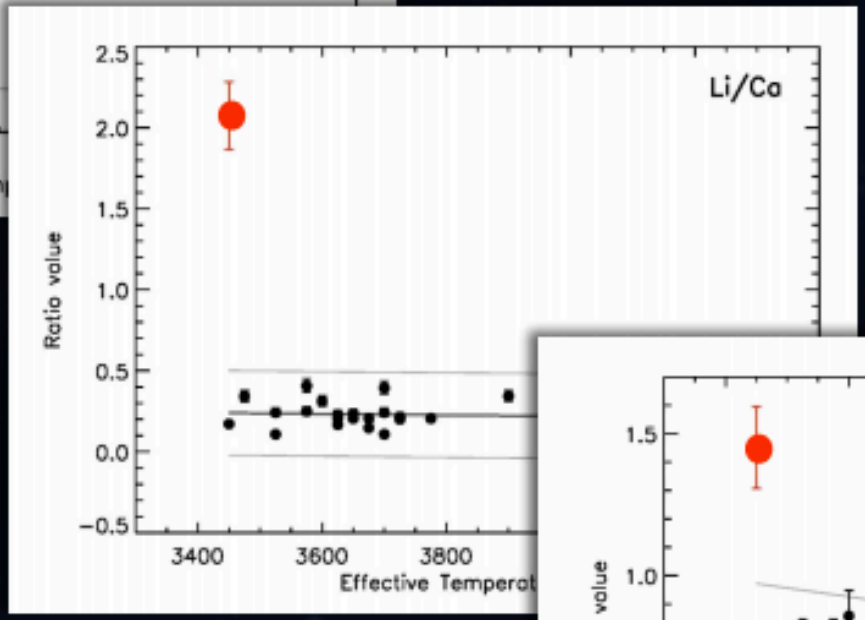
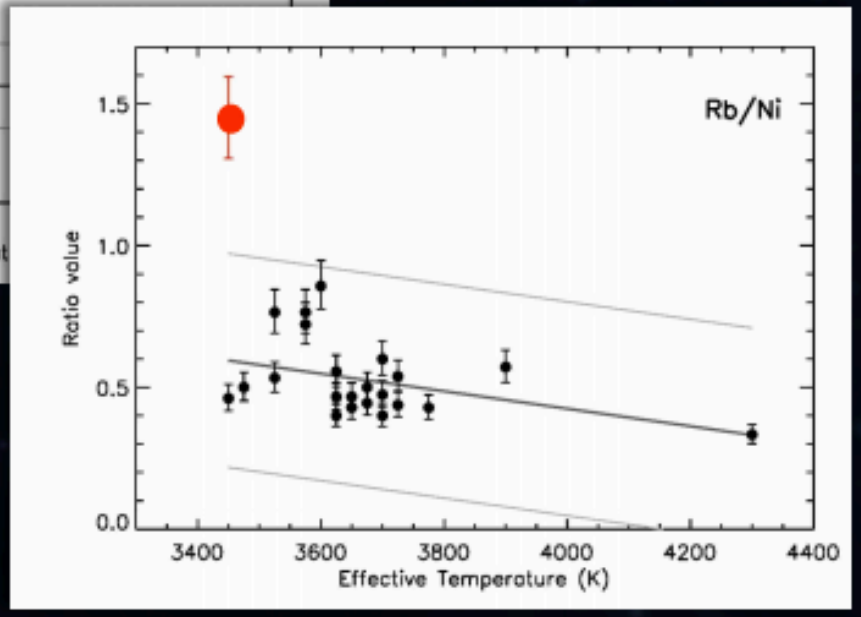
1.0
0.5
0.0
3400
3600
3800
4000
4200
4400
Effective Temperature (K)



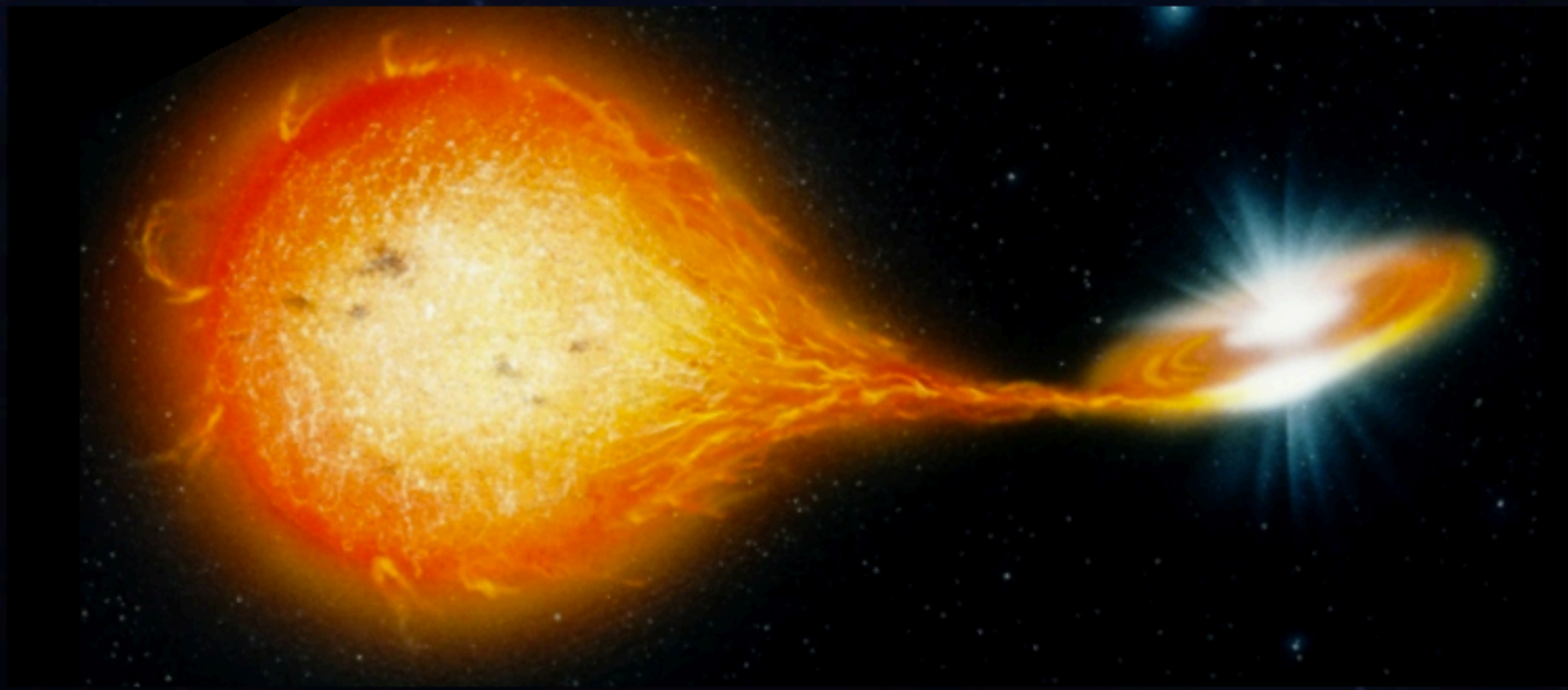




TŻO candidate!

The existence of TŻOs would have profound implications for astronomy.

- completely new model of stable stellar interiors
- a new fate for massive binary systems
- new ways to make Li and heavy elements in our universe



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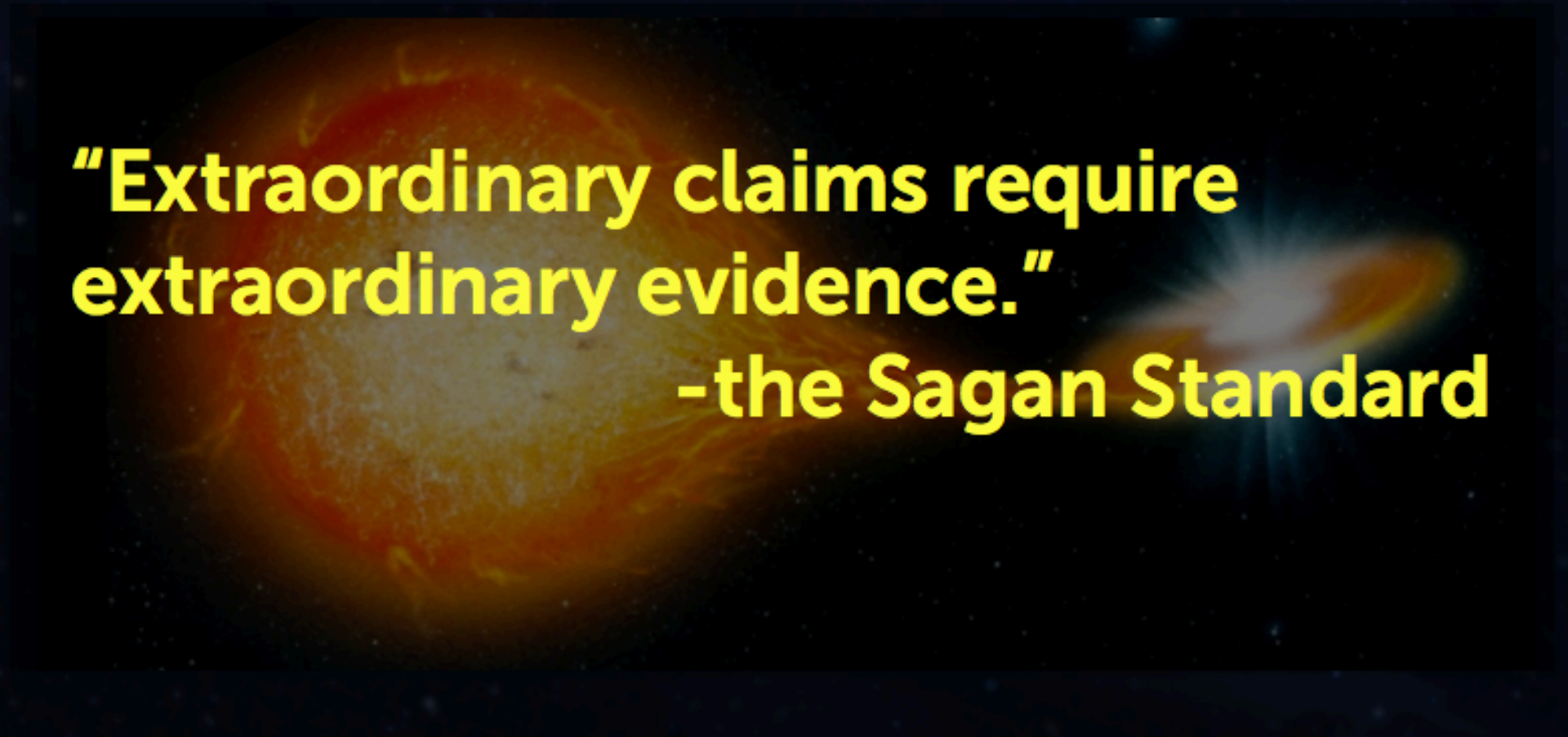


The existence of TŻOs would have profound implications for astronomy

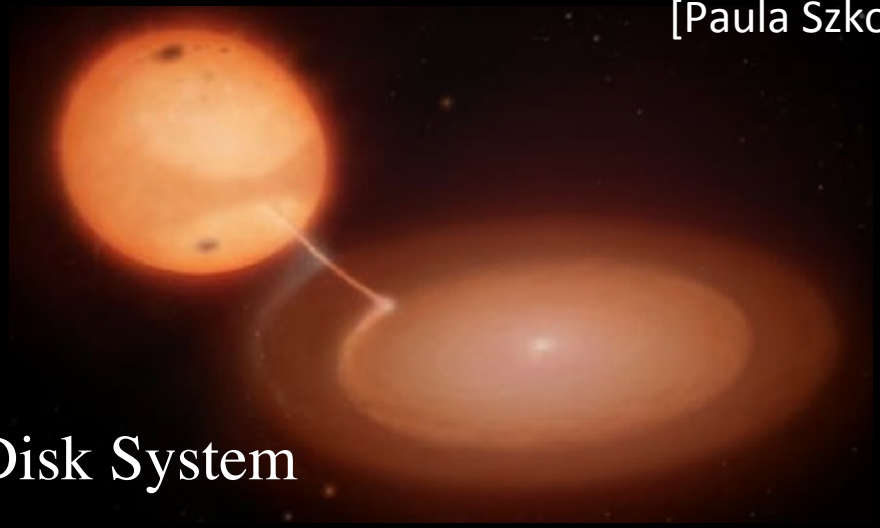
What's next?

- New models of TŻO interiors (dynamics, chemistry, etc.)
- New predictions of observables
- Search for pre- and post-TŻO signatures (supernova remnants, binaries, "naked" TŻO cores...)

emsque@uw.edu

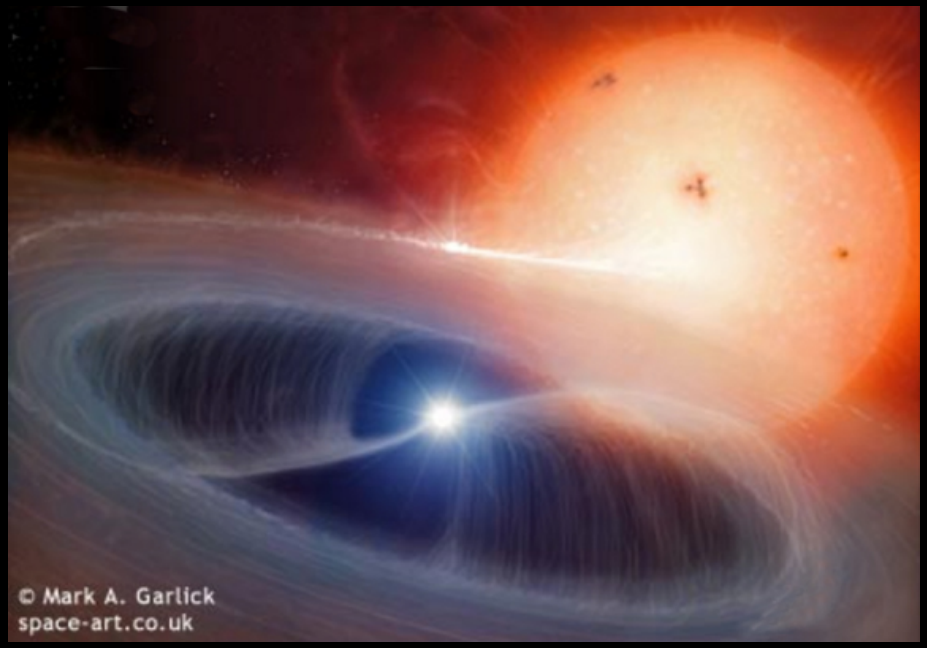
Cataclysmic Variables

[Paula Szkody]

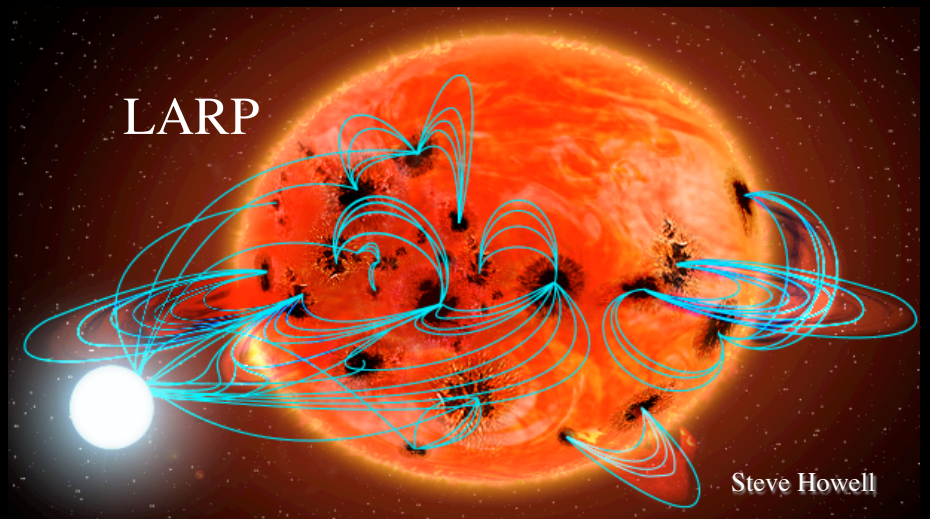


Disk System

Polar



Intermediate Polar



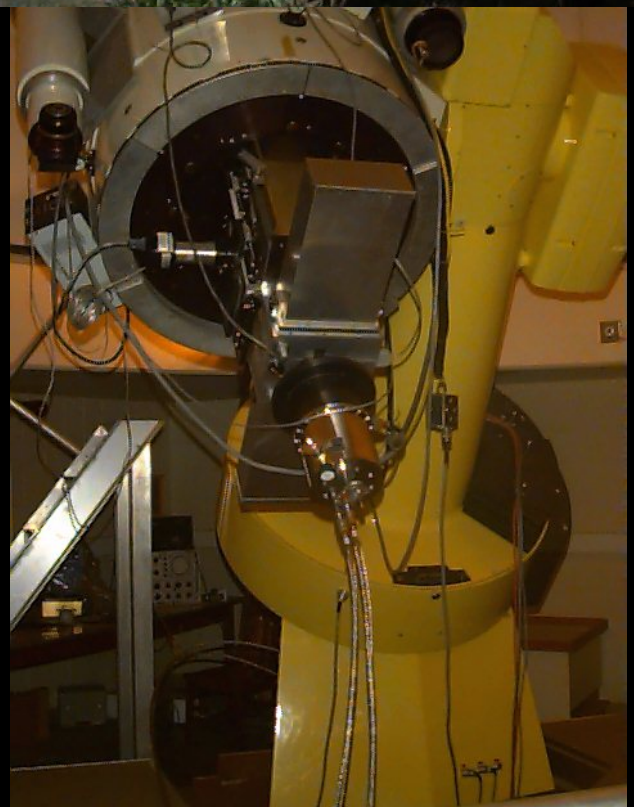
Key Questions:

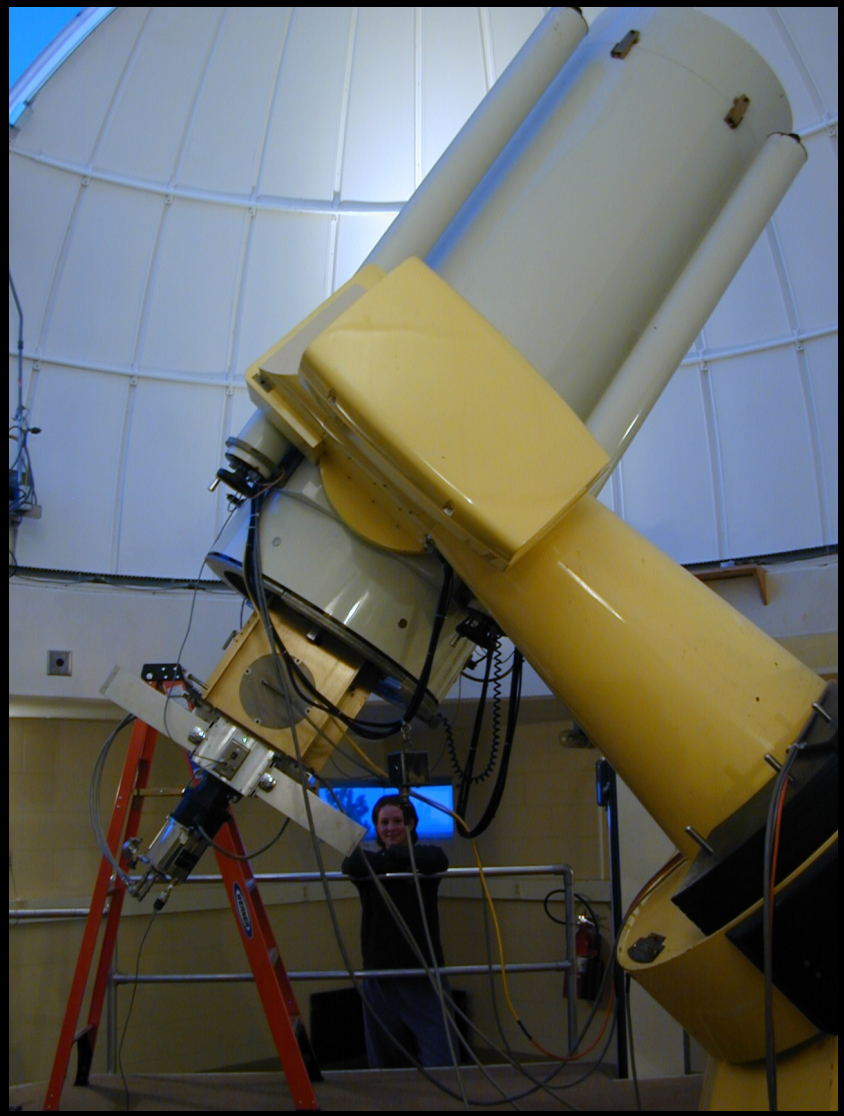
- How many are there?
- How do they evolve?
- What are the effects of mass transfer, accretion?

Optical Gives Info on:

- numbers from surveys
- types of systems
- timescale of phenomena

U of W 30 inch reflector at Manastash Ridge Observatory outside Ellensburg Lat=+47



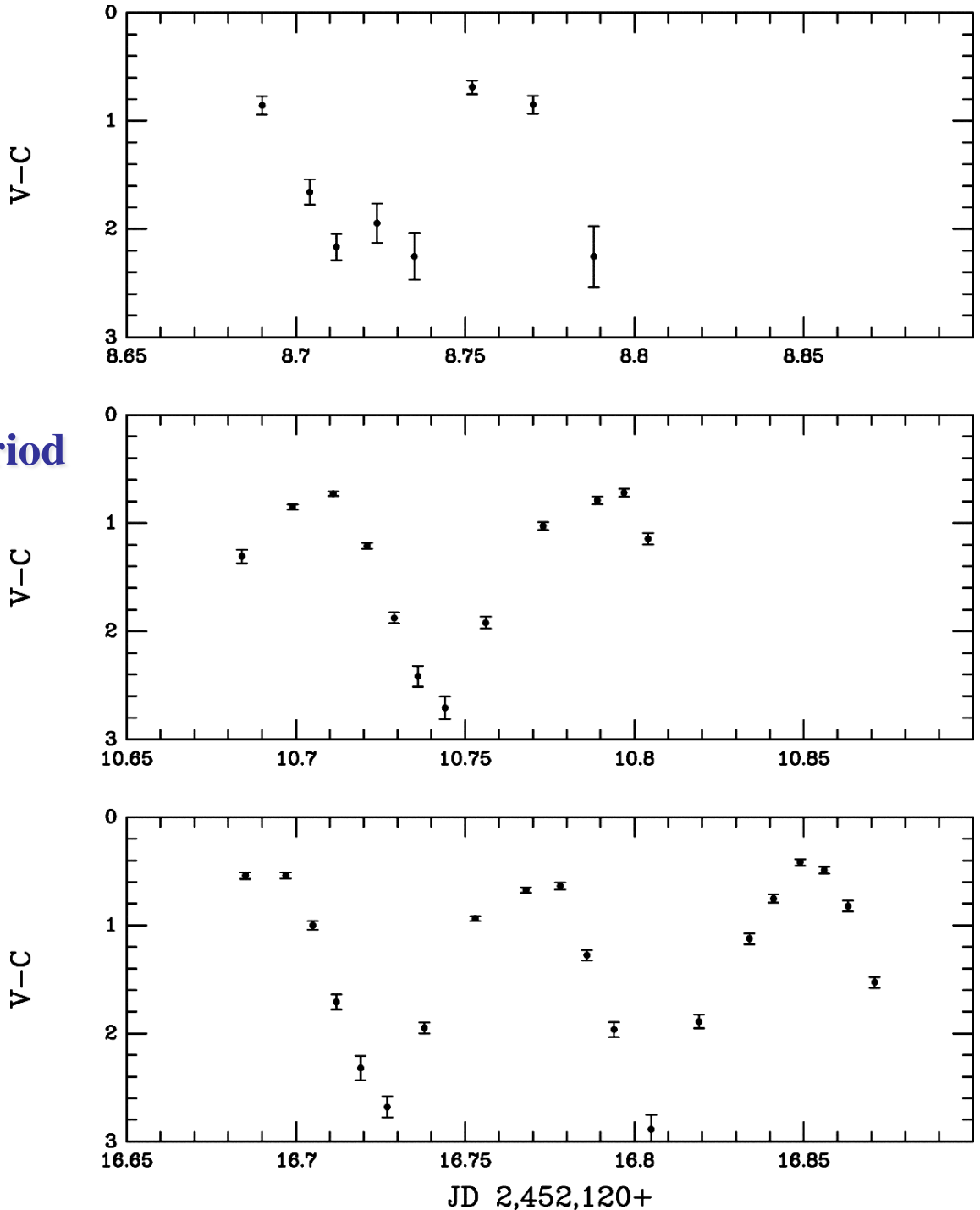


SDSS1700

MRO photometry

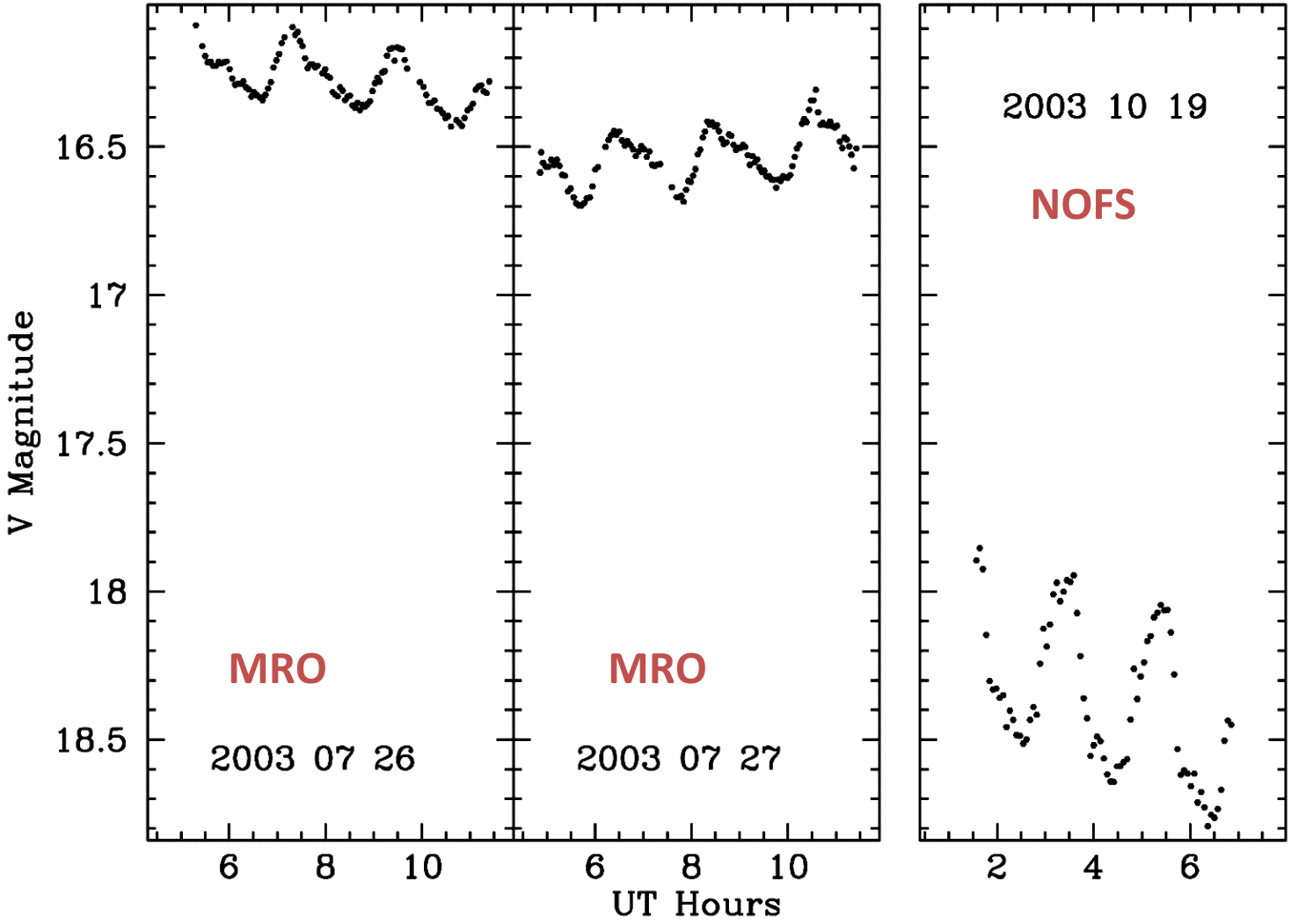
Found Orbital Period

P=115 min



Positive SH

P= 1.9 hr

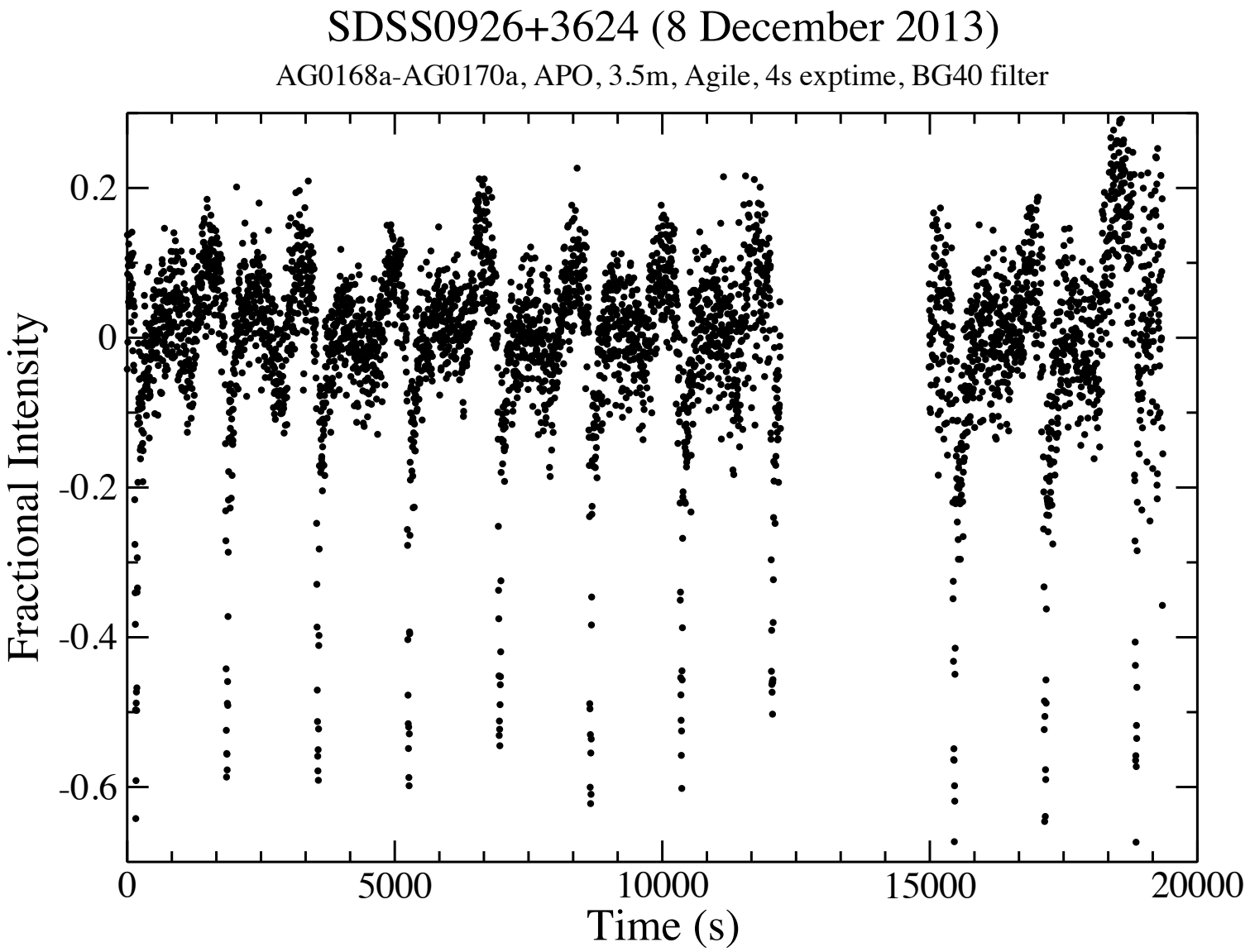


Tramposch et al. 2005, PASP 117, 262

Negative SH

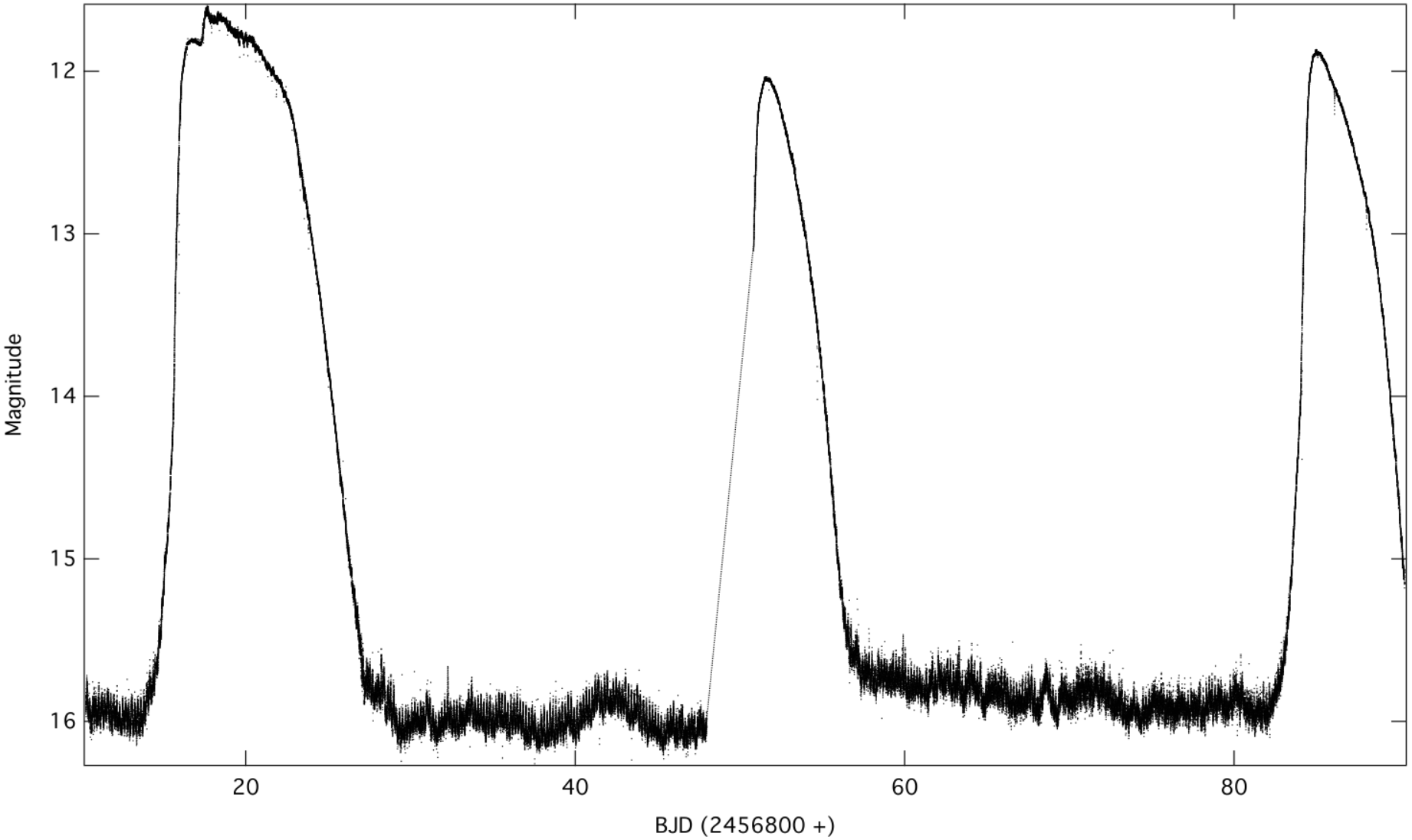

Apache Point Observatory New Mexico
Lat =+33
3.5m
2.5m

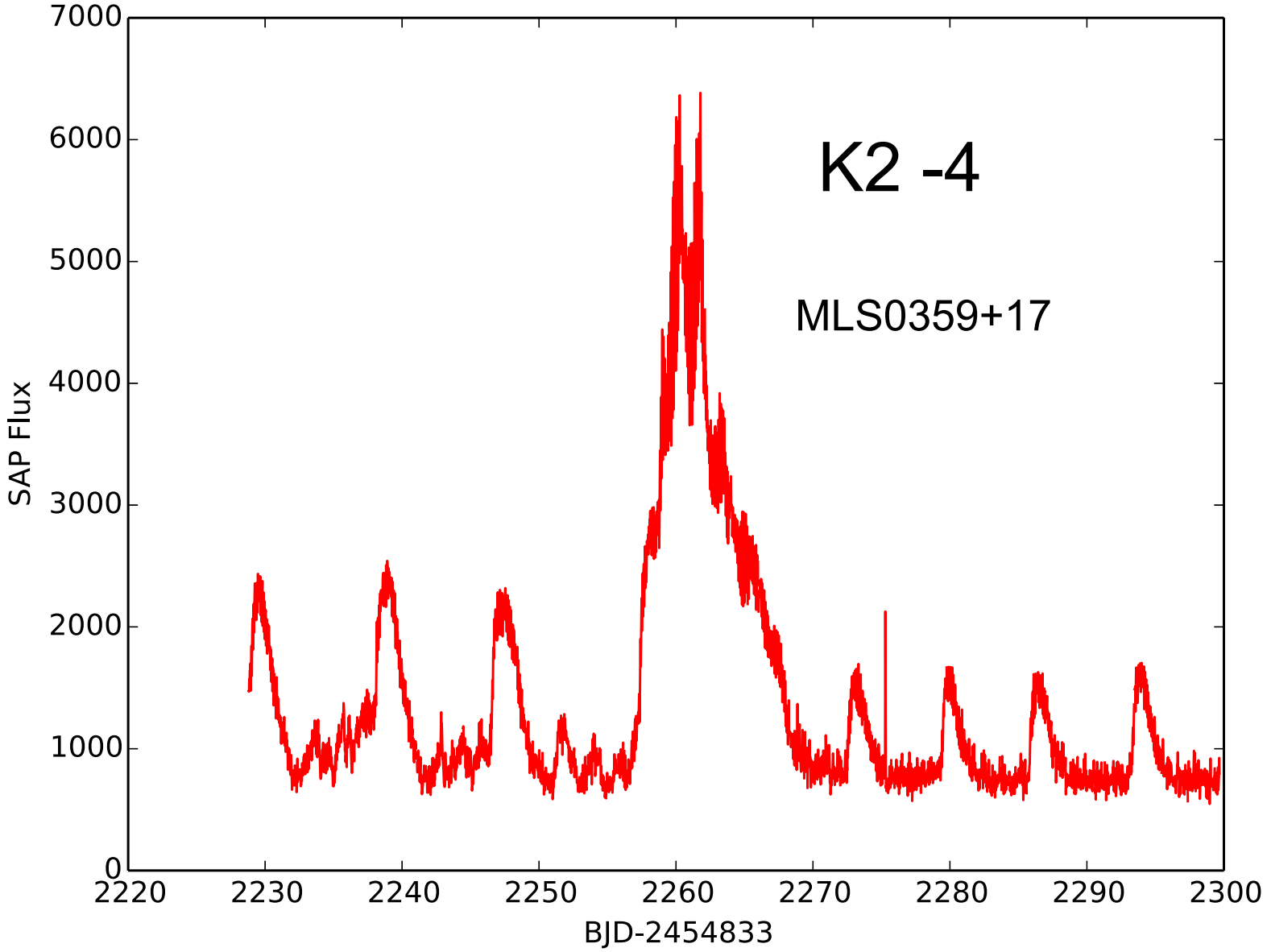
Eclipsing AM CVn P=28 min, eclipse=1 min



Kepler Satellite Data

K2-1 TW Vir




K2 -4
MLS0359+17
SAP Flux
BJD-2454833
0
1000
2000
3000
4000
5000
6000
7000
2220
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2240
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2270
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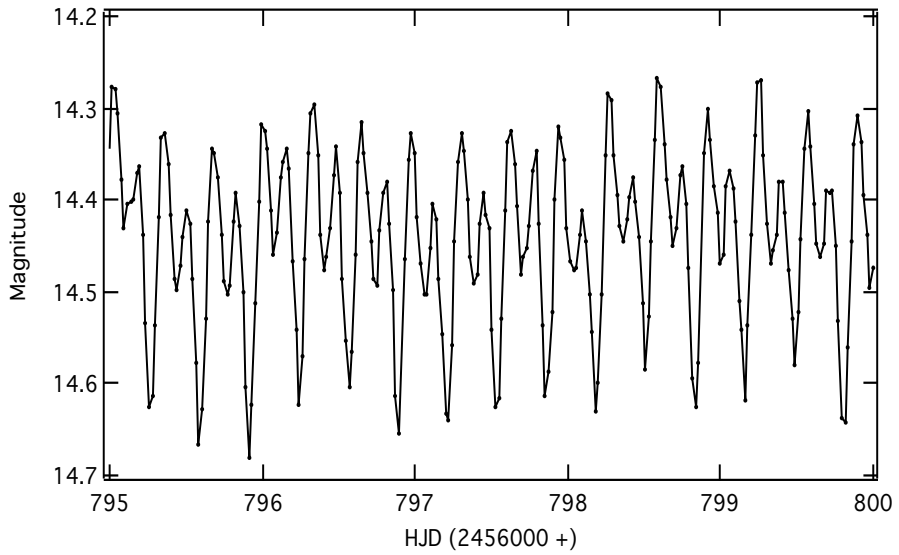
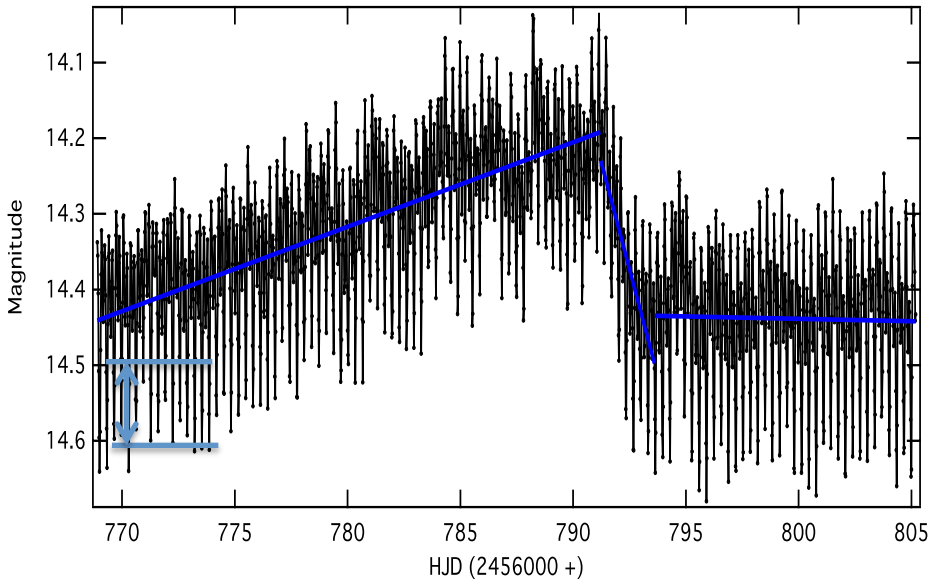
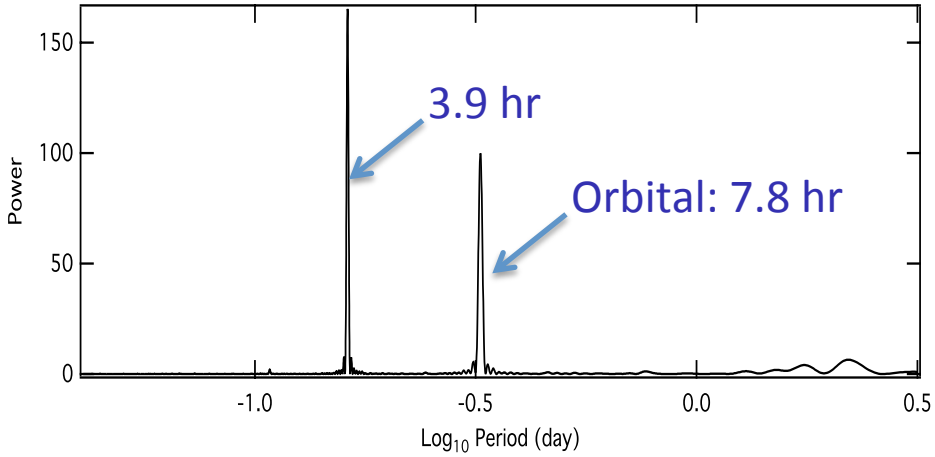
2300

SDSS J0632+25

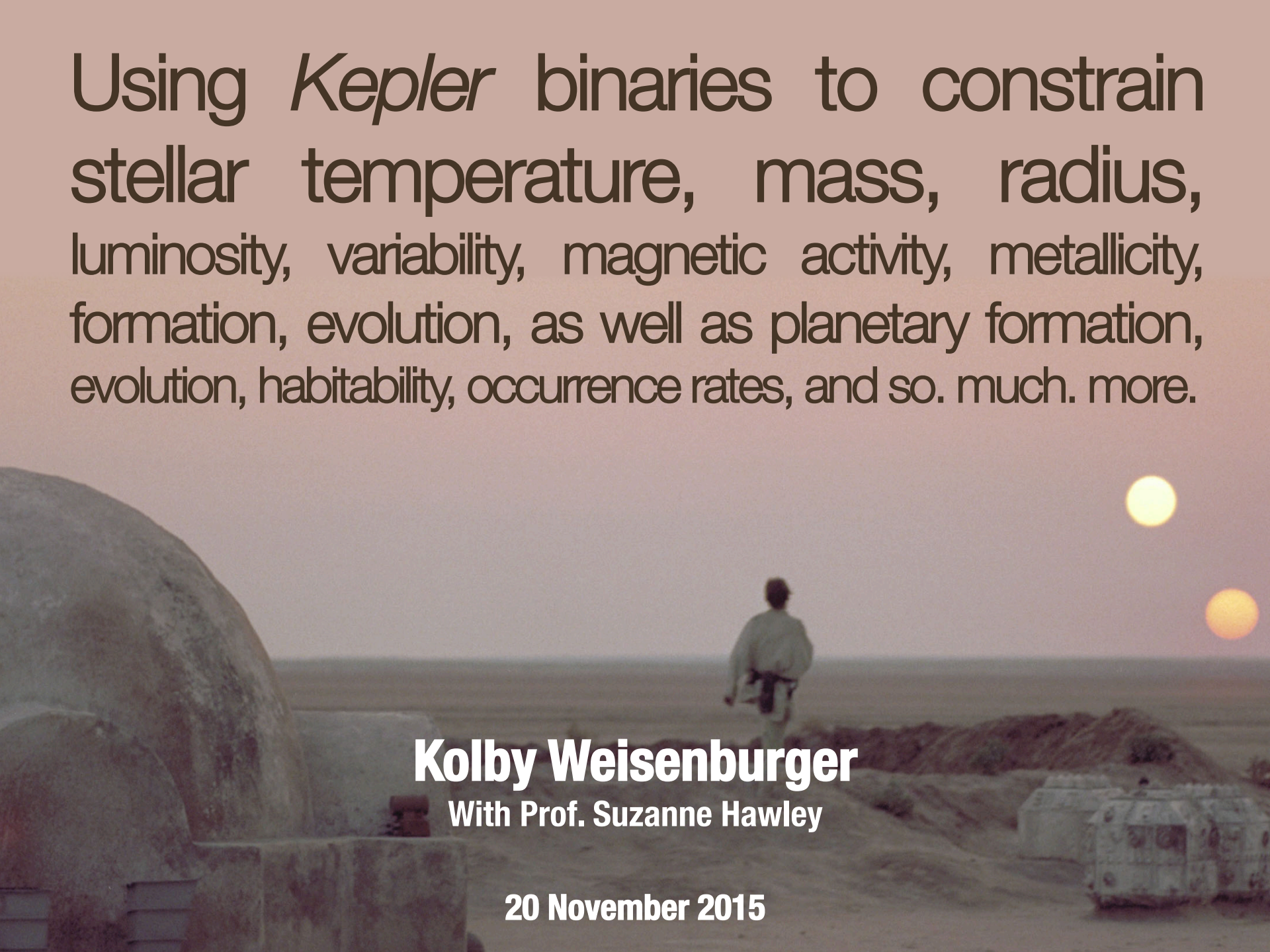






The Far Future: LSST (2022-2032)

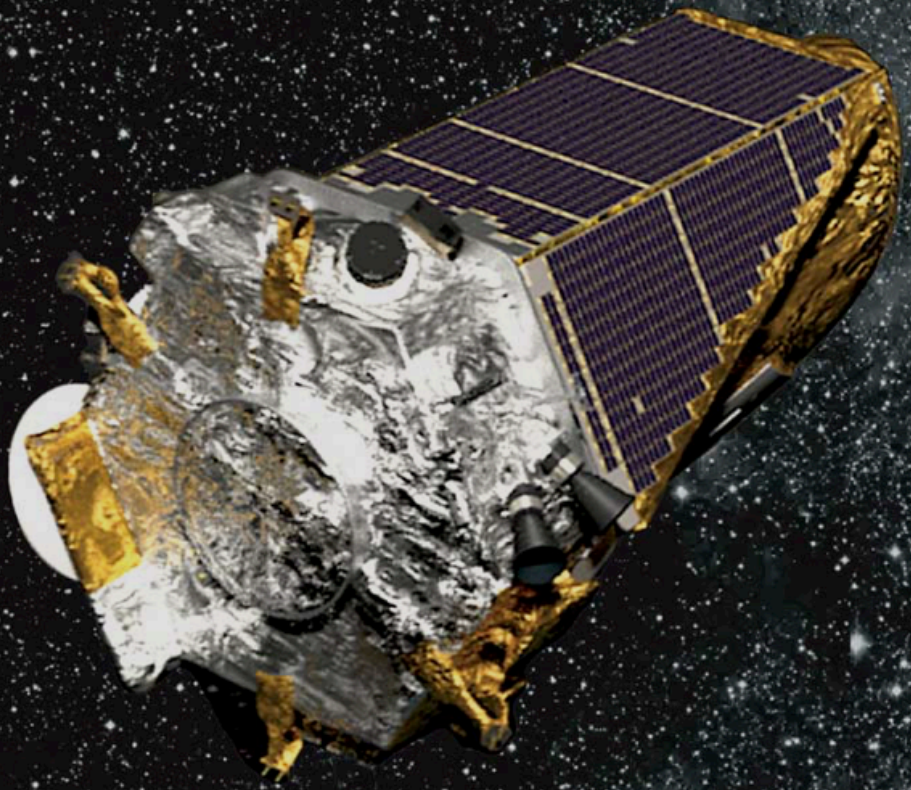
Using *Kepler* binaries to constrain stellar temperature, mass, radius, luminosity, variability, magnetic activity, metallicity, formation, evolution, as well as planetary formation, evolution, habitability, occurrence rates, and so. much. more.



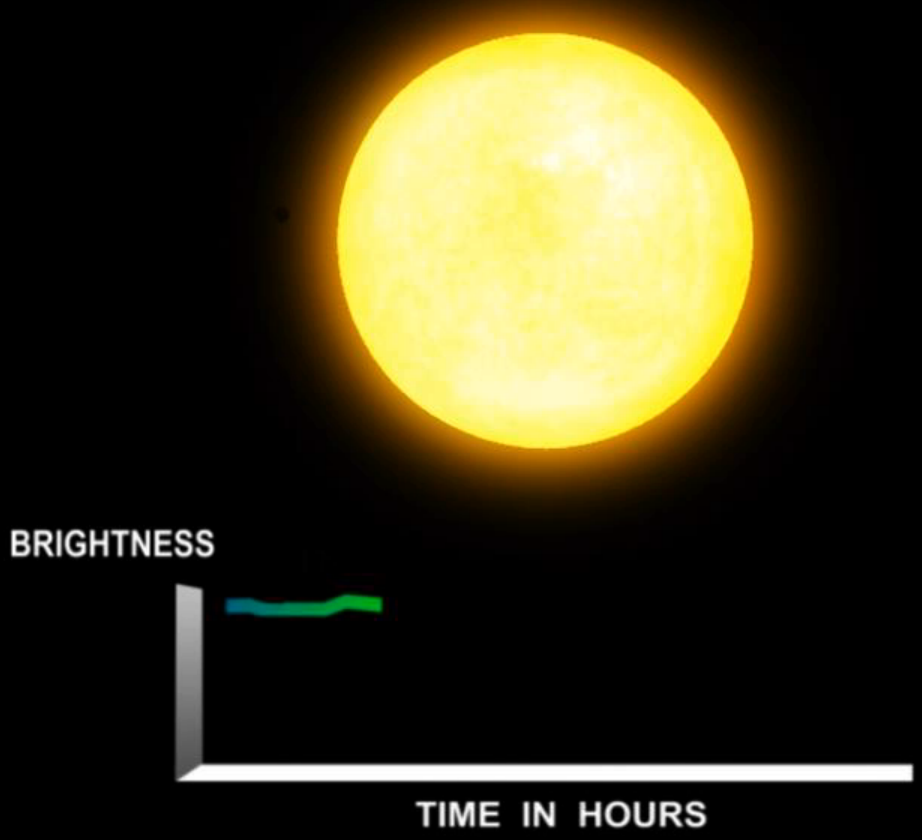
Kolby Weisenburger
With Prof. Suzanne Hawley

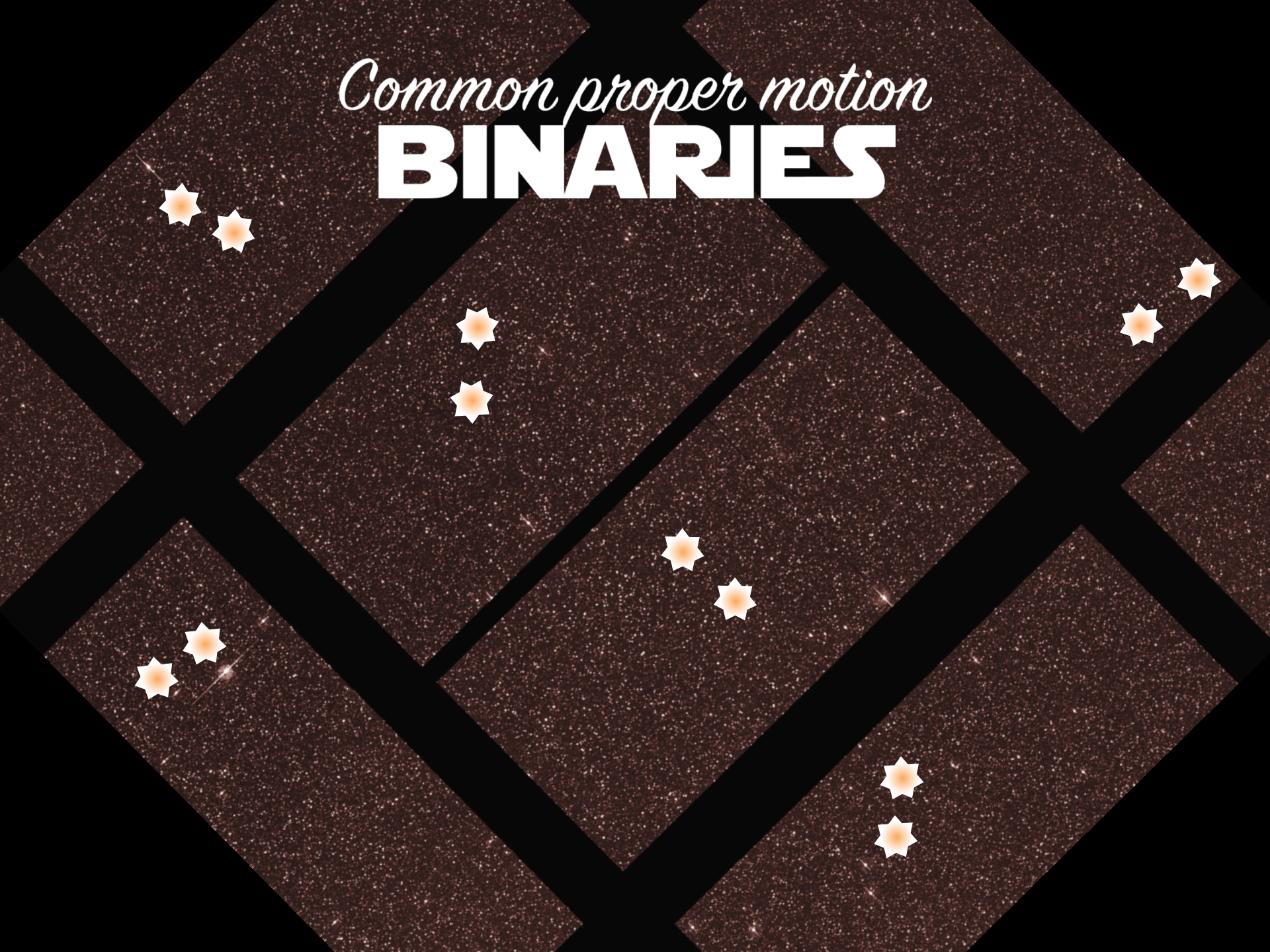
20 November 2015

KEPLER

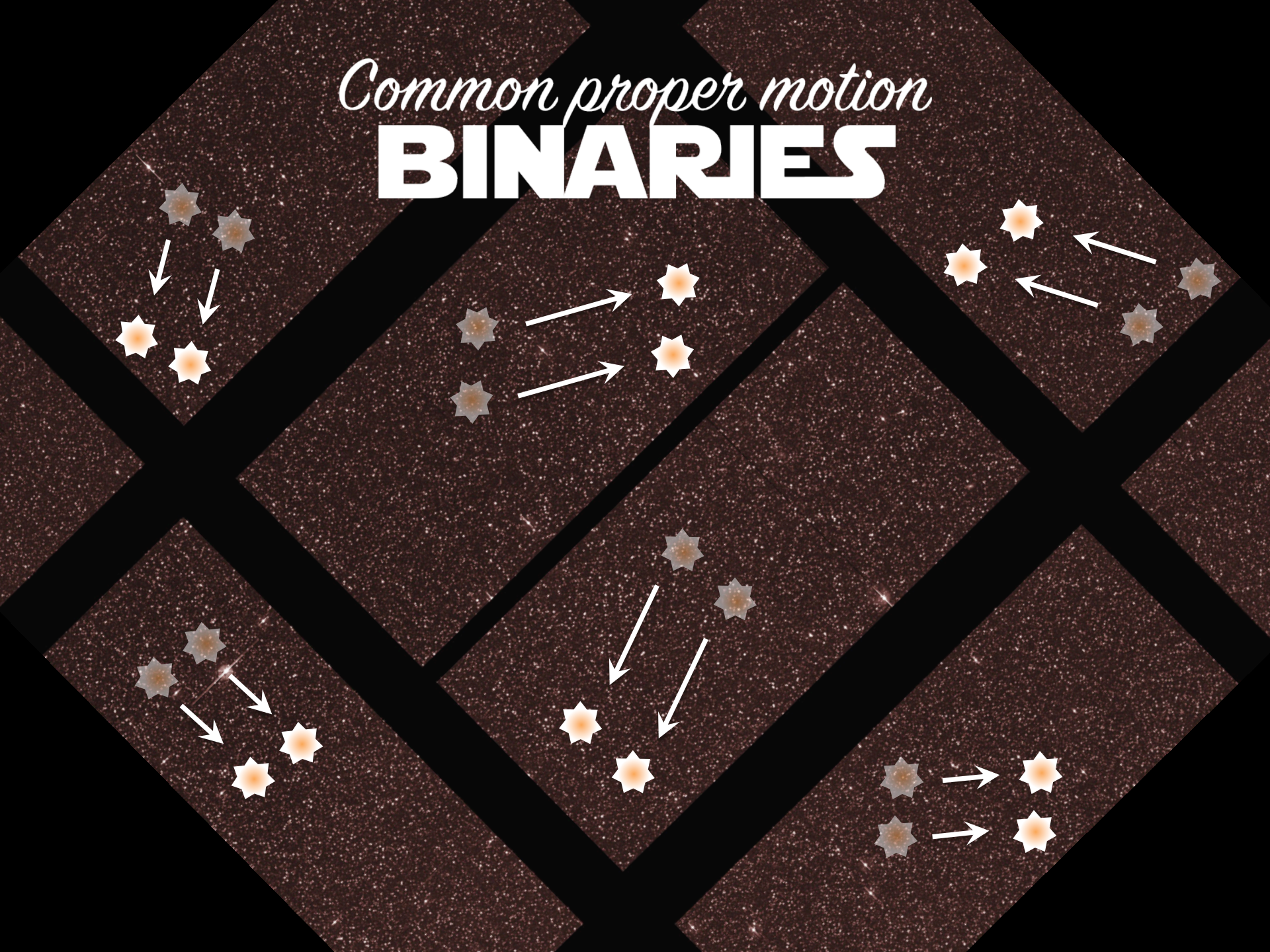


KEPLER

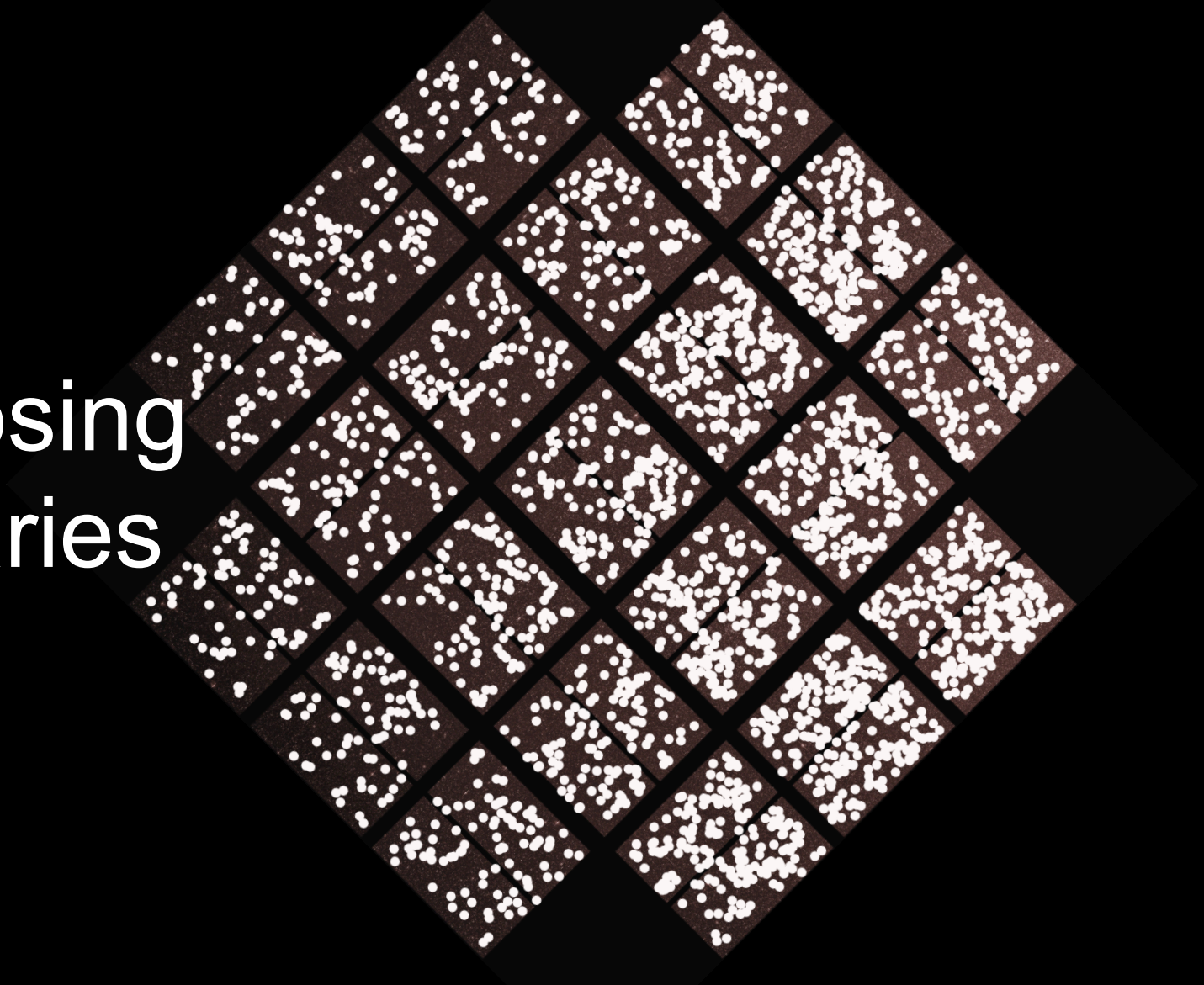



Common proper motion
BINARIES

Common proper motion
BINARIES

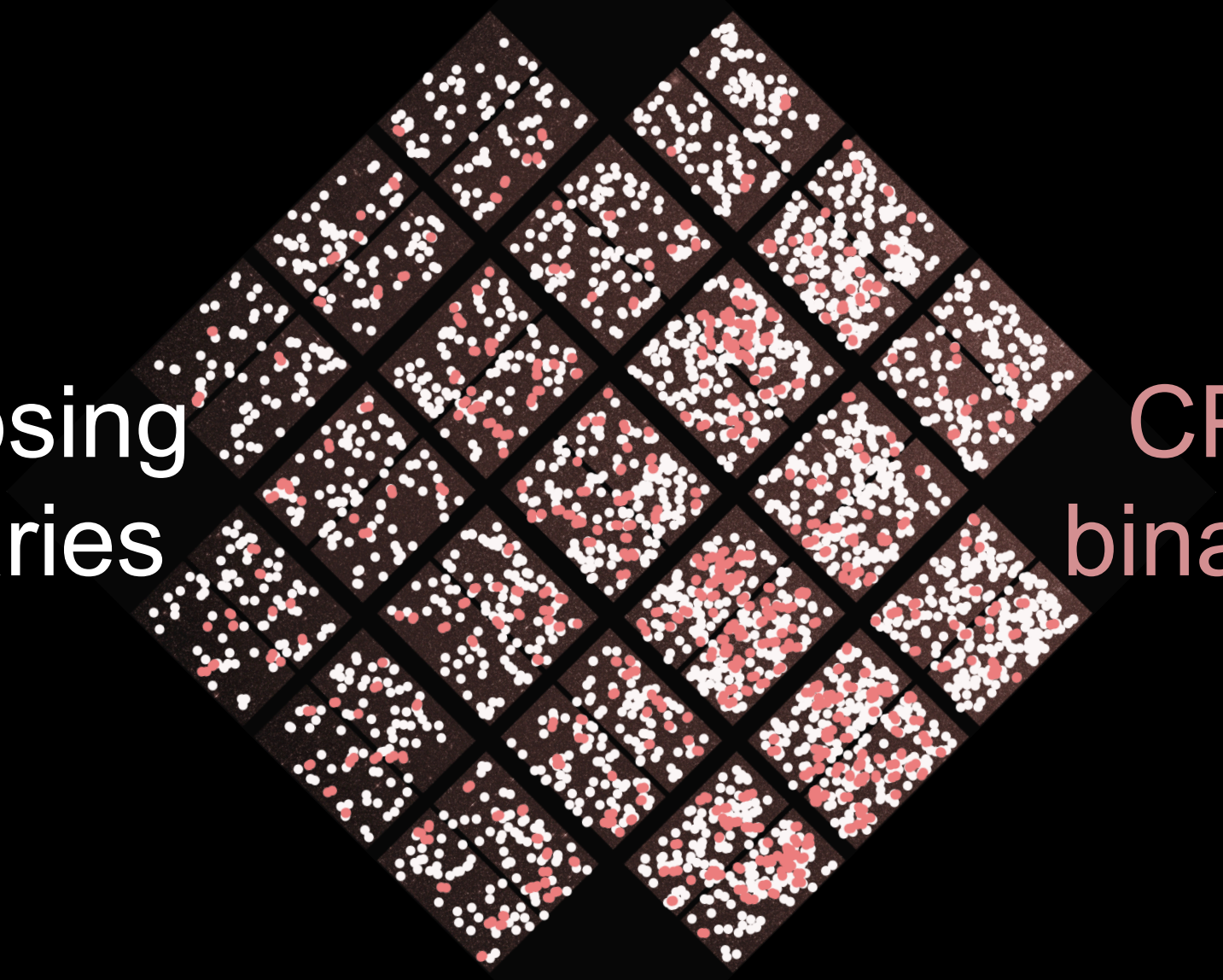


KEPLER



Eclipsing binaries

KEPLER

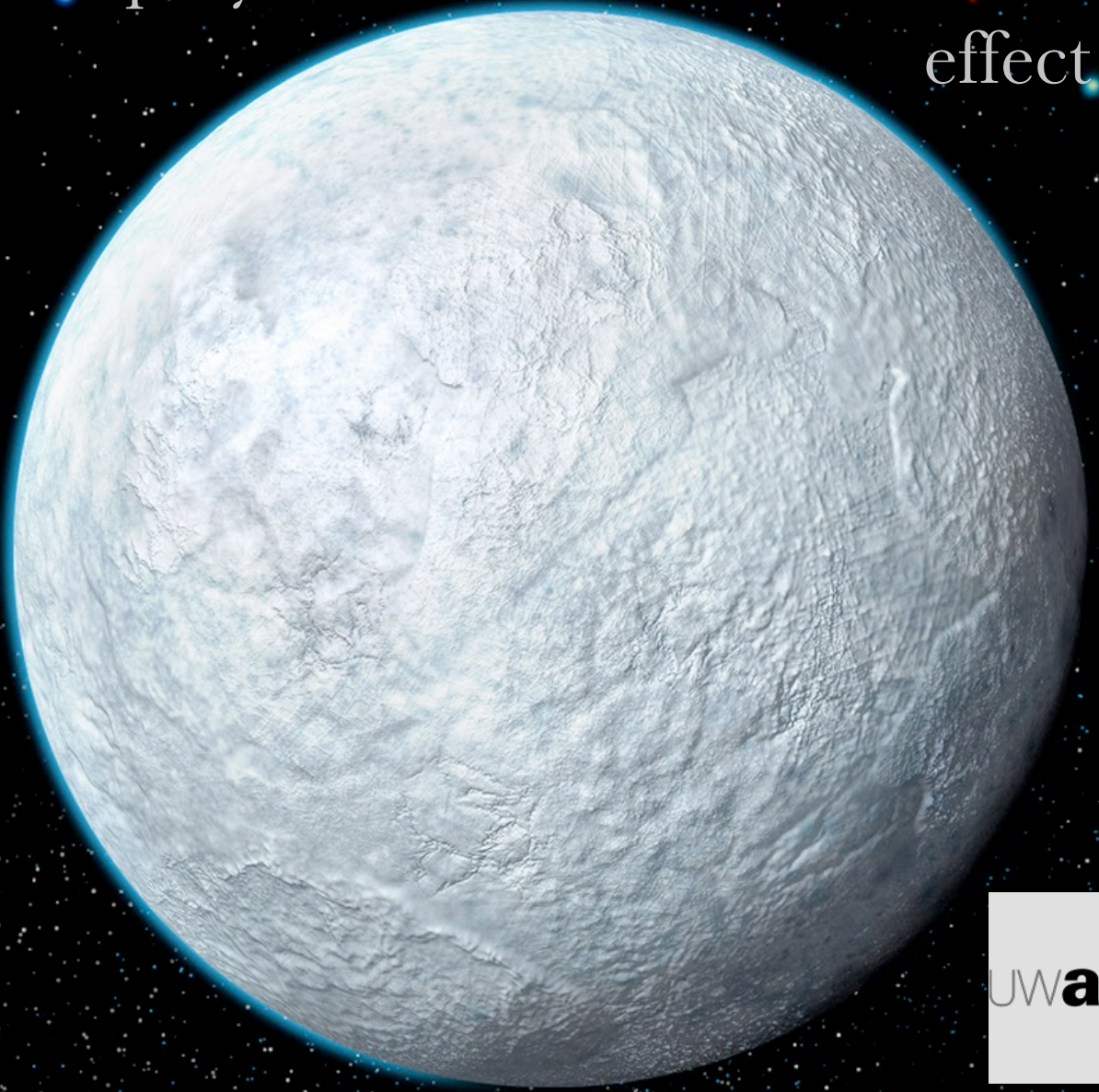


Eclipsing binaries

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

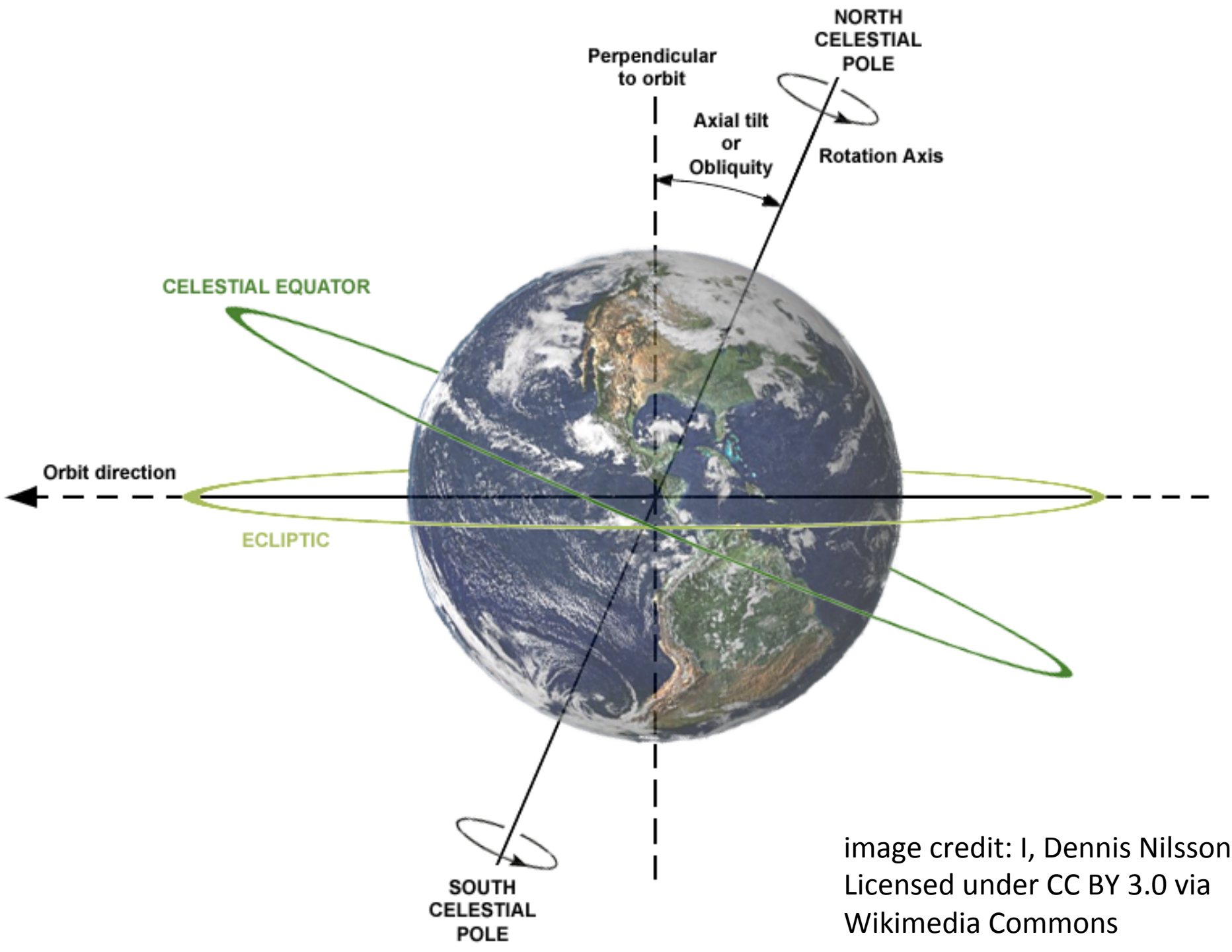
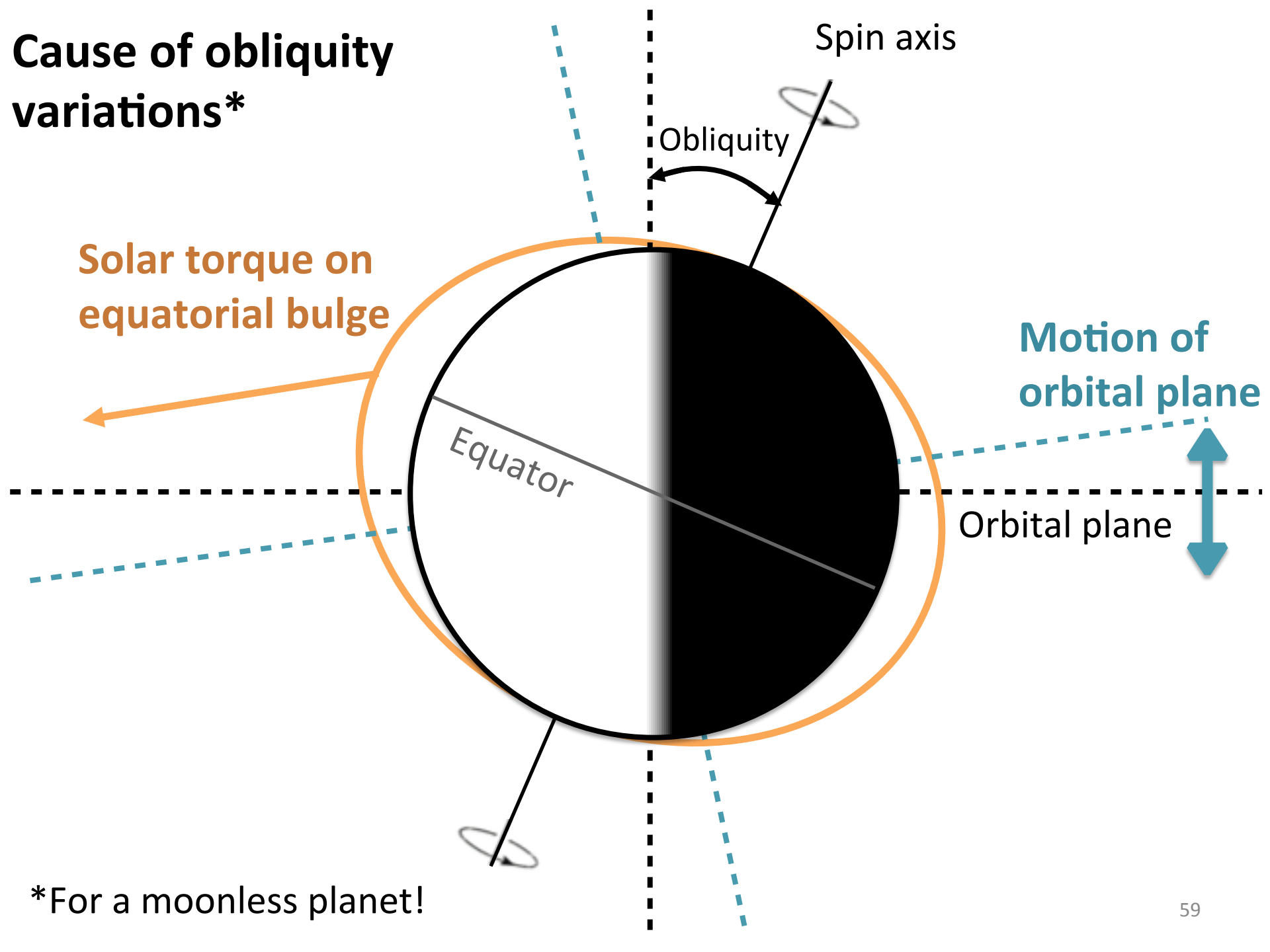


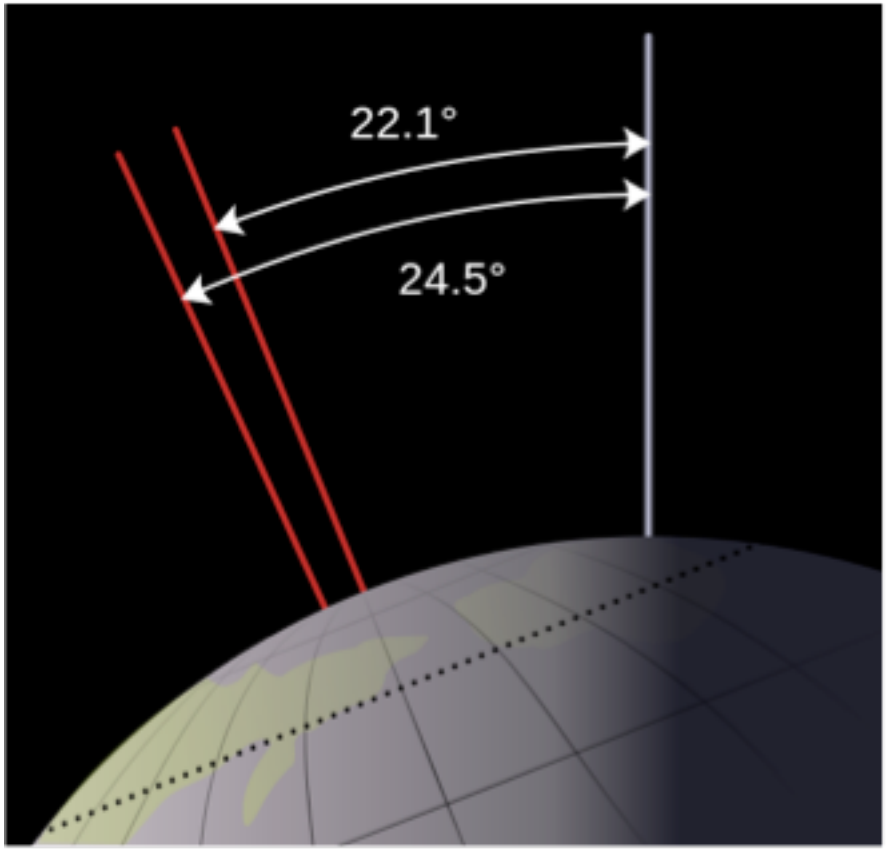
image credit: I, Dennis Nilsson. Licensed under CC BY 3.0 via Wikimedia Commons

Cause of obliquity variations*

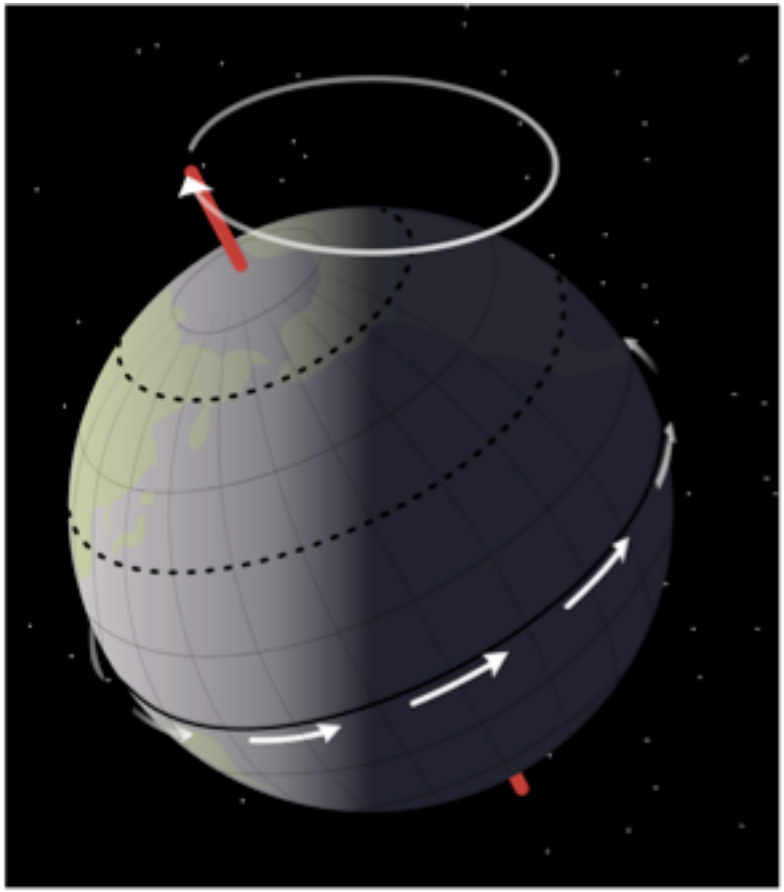


*For a moonless planet!

Obliquity variations



Nutation aka “Wobble”

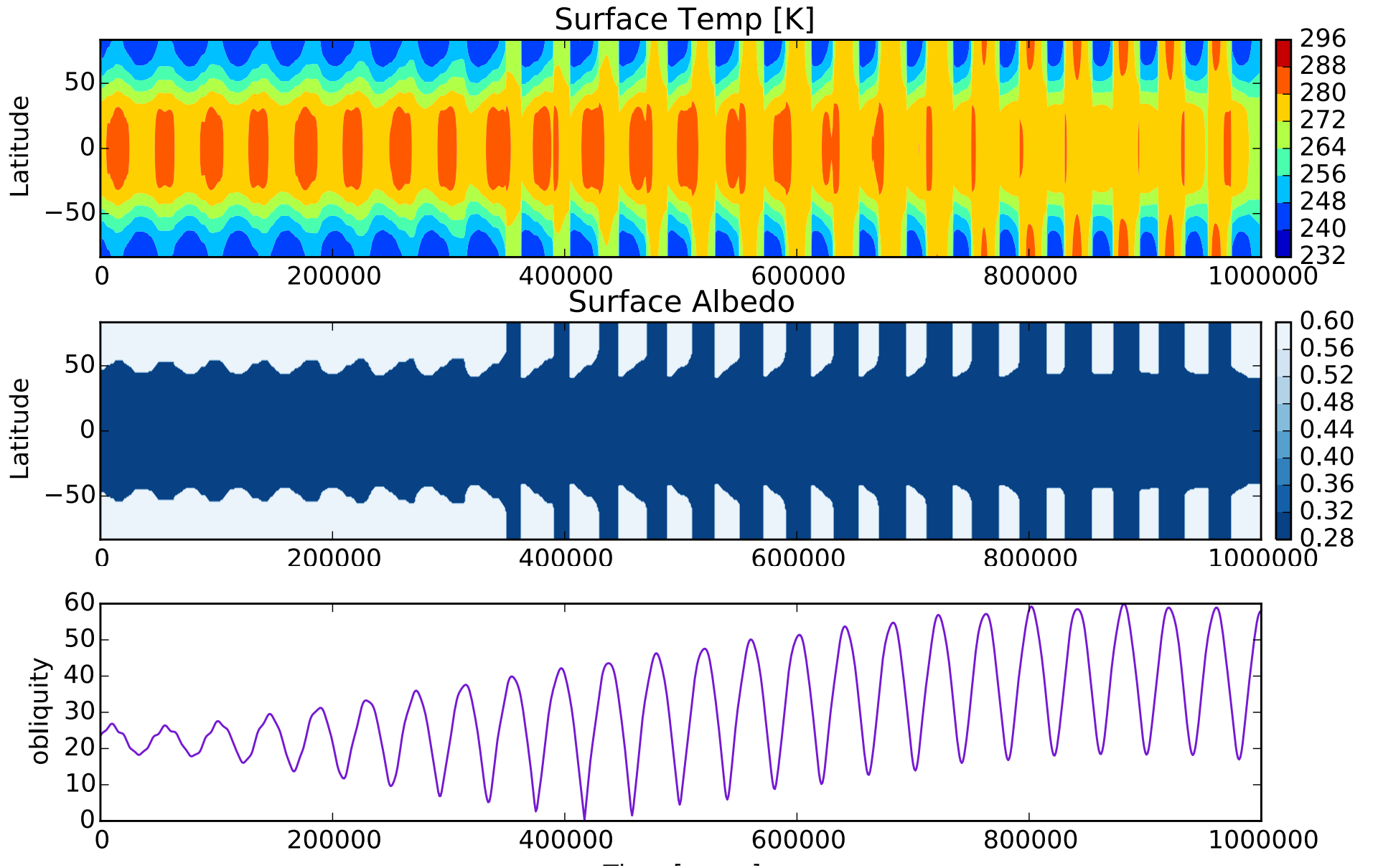


Precession

Image credit: NASA

Small for Earth, because of the Moon

Climate impact



FINDING AND CHARACTERIZING EXOPLANETS WITH KEPLER

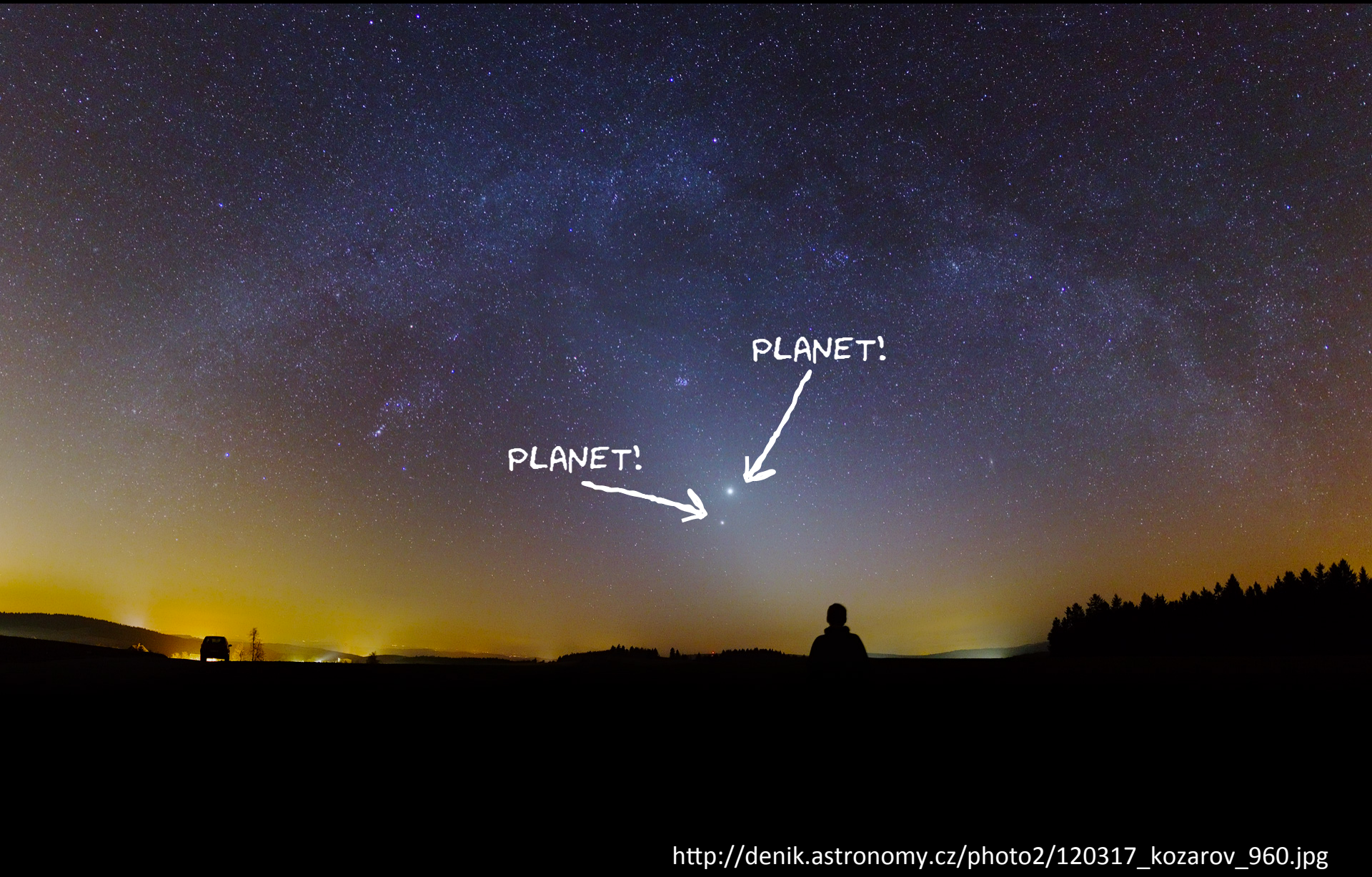
RODRIGO LUGER

GRADUATE STUDENT

UNIVERSITY *of* WASHINGTON

DEPARTMENT OF ASTRONOMY

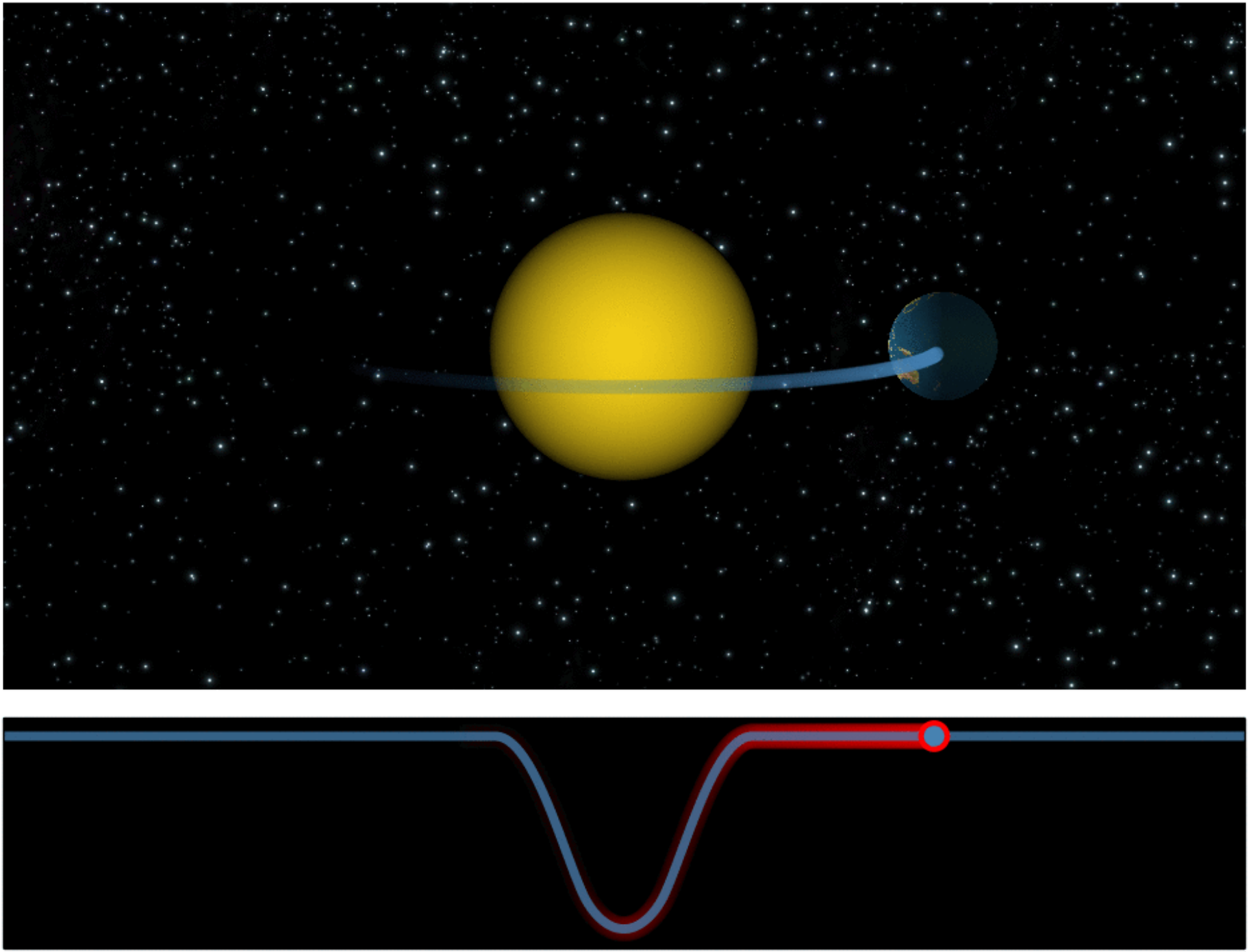
DETECTING PLANETS IN OUR SOLAR SYSTEM (EASY)



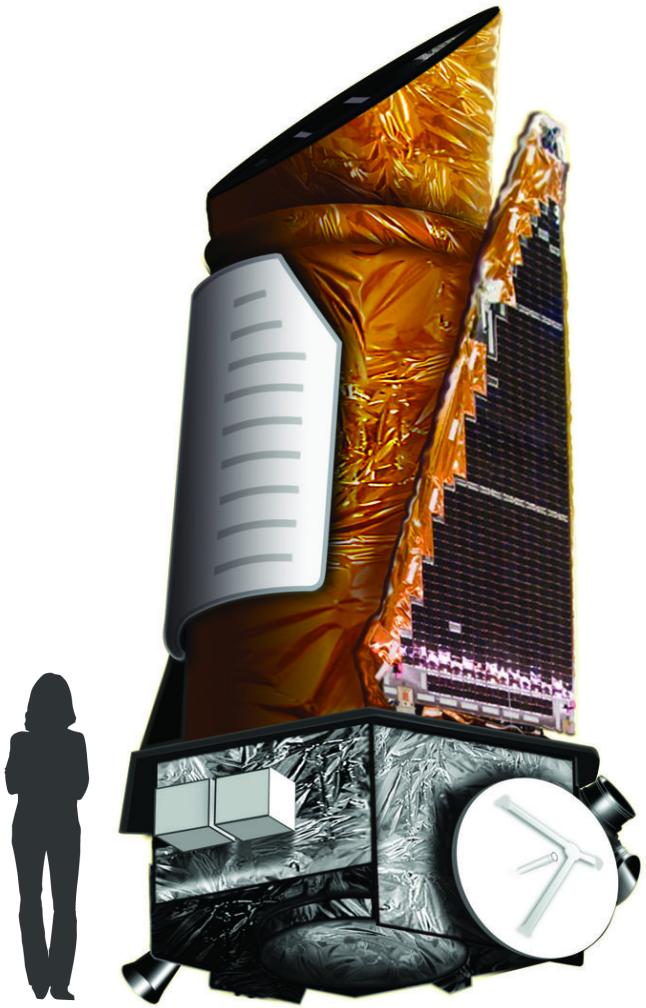
http://denik.astronomy.cz/photo2/120317_kozarov_960.jpg


DETECTING EXTRASOLAR PLANETS
STAR (NO PLANET)

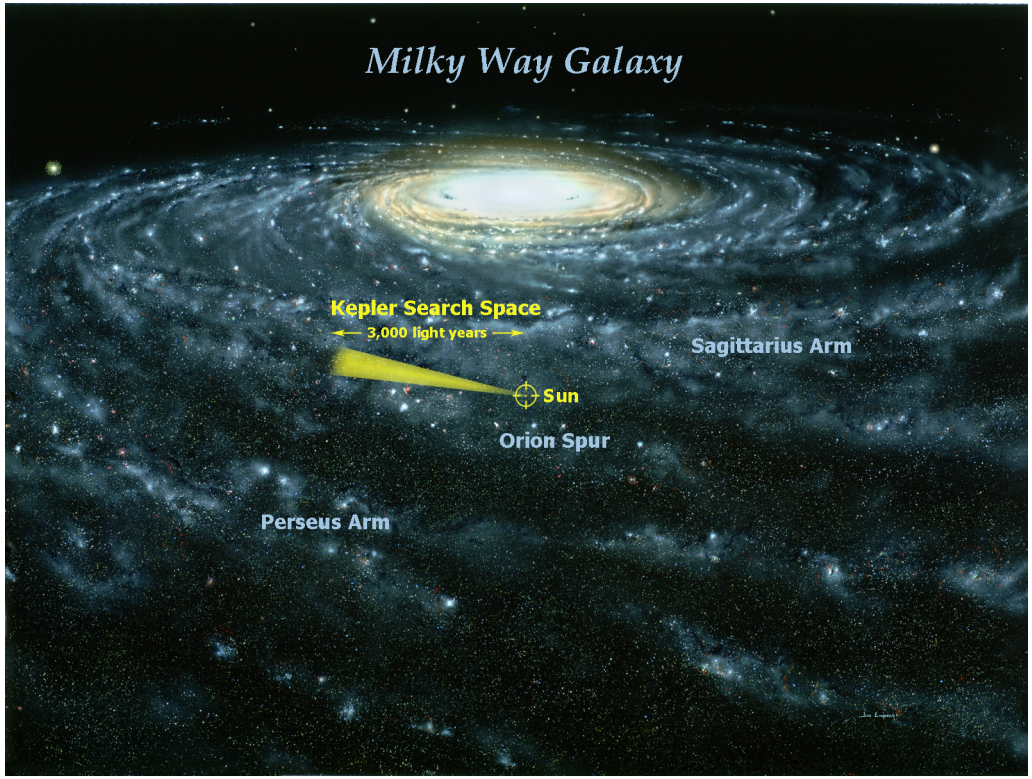

DETECTING EXTRASOLAR PLANETS
(HARD)
STAR (WITH PLANET)



THE KEPLER SPACECRAFT

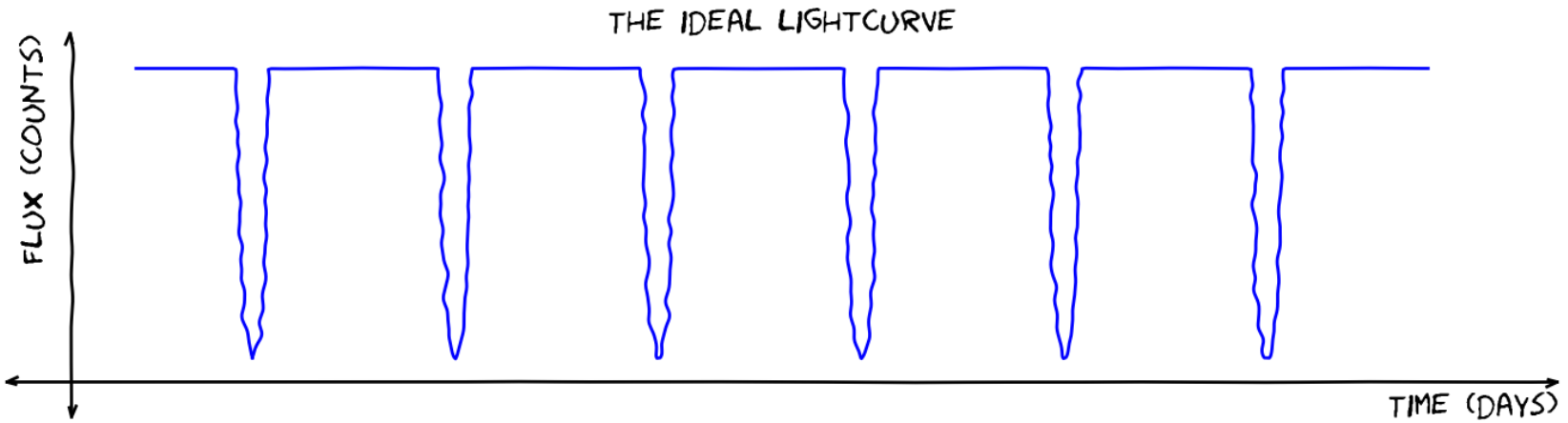


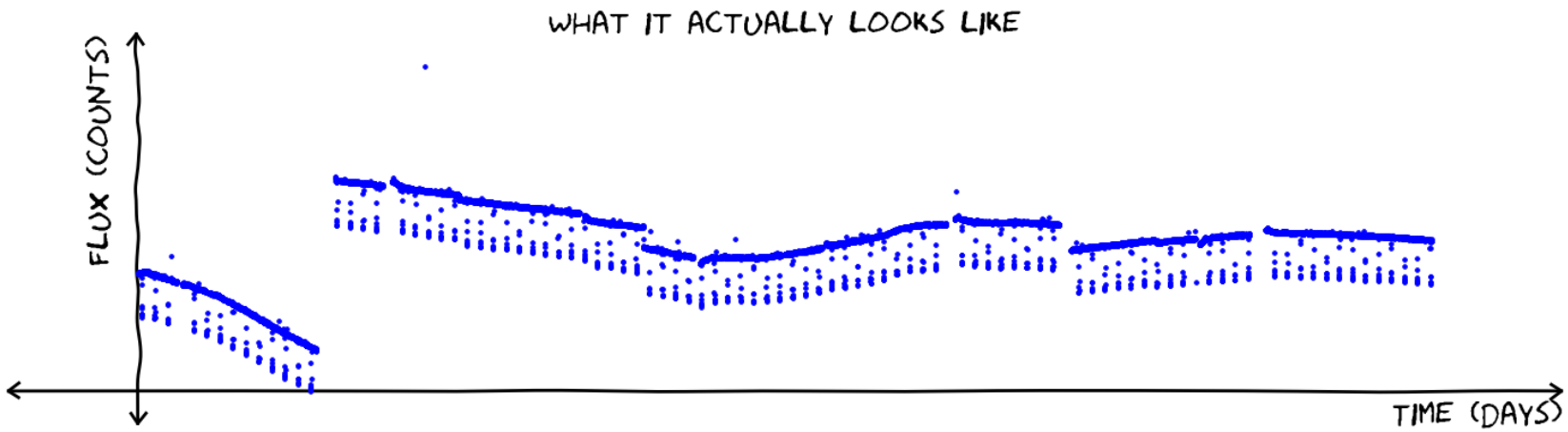
Credit: NASA

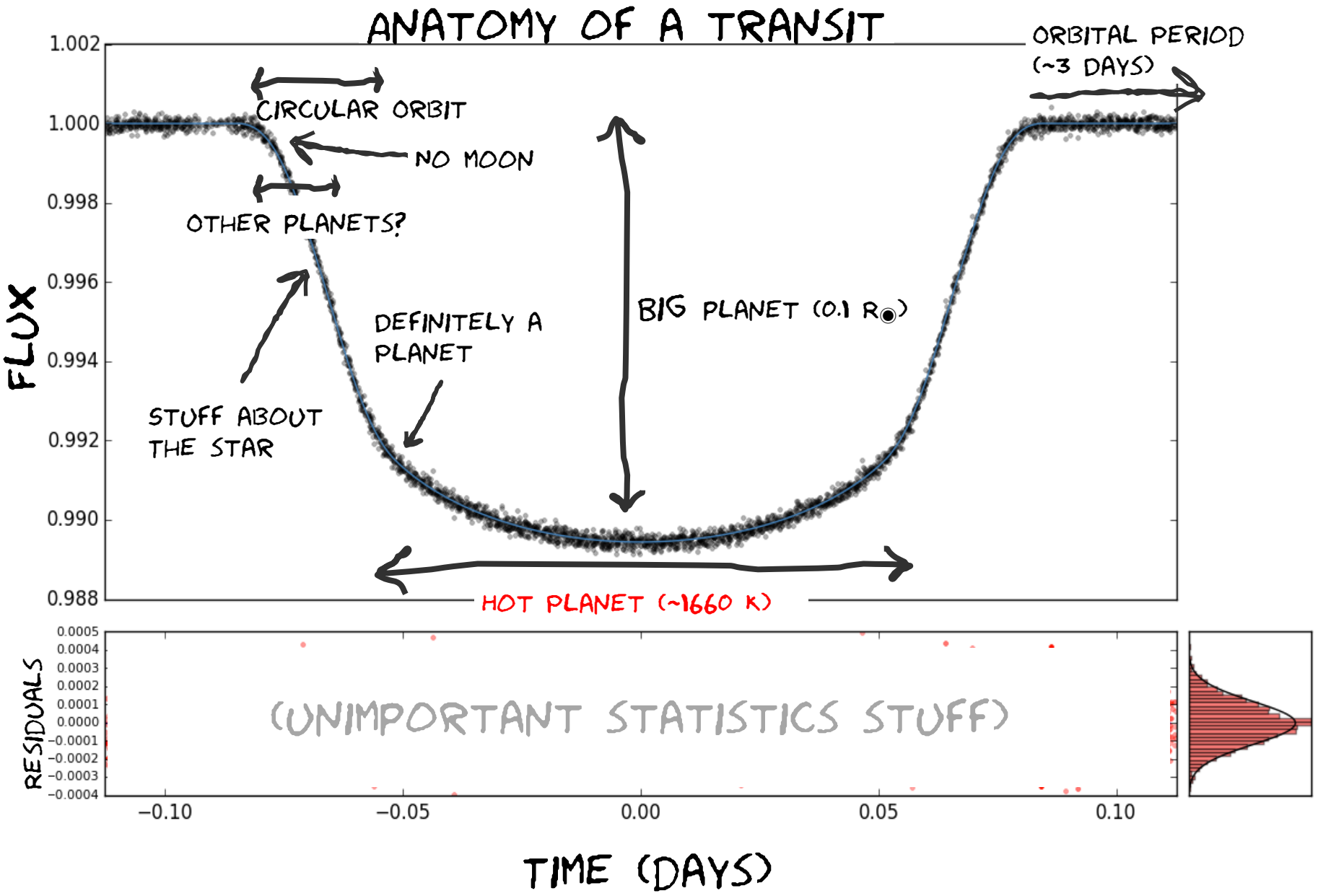


https://en.wikipedia.org/wiki/Kepler_(spacecraft)

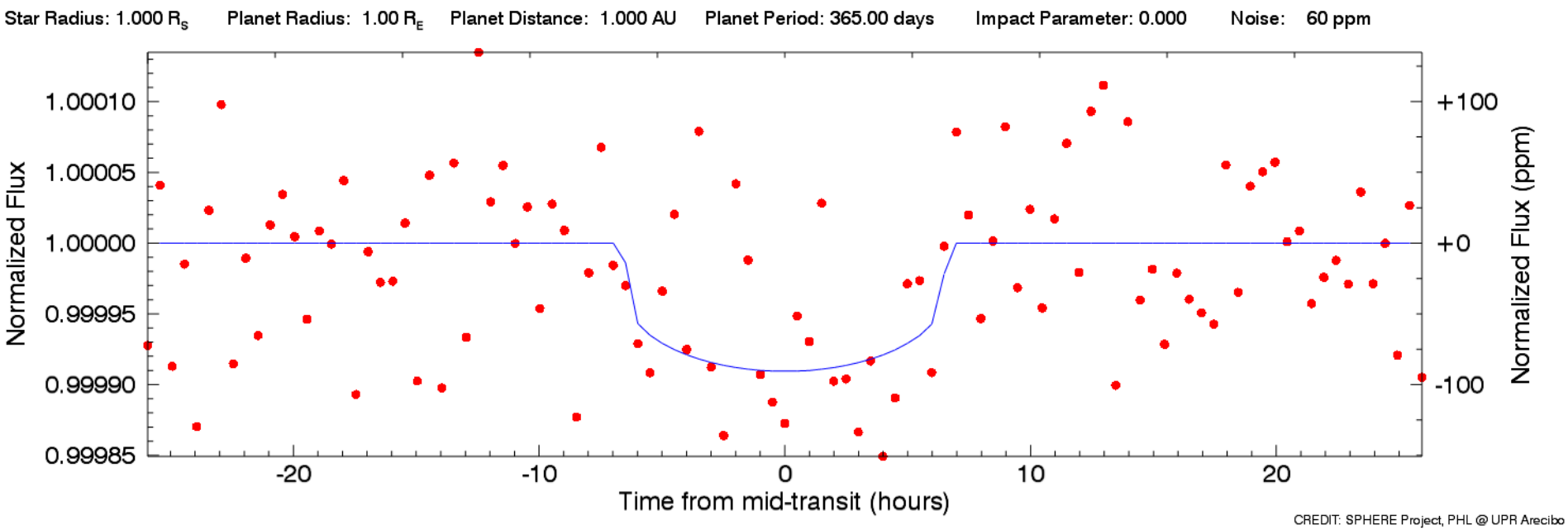
TRANSIT LIGHTCURVES






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

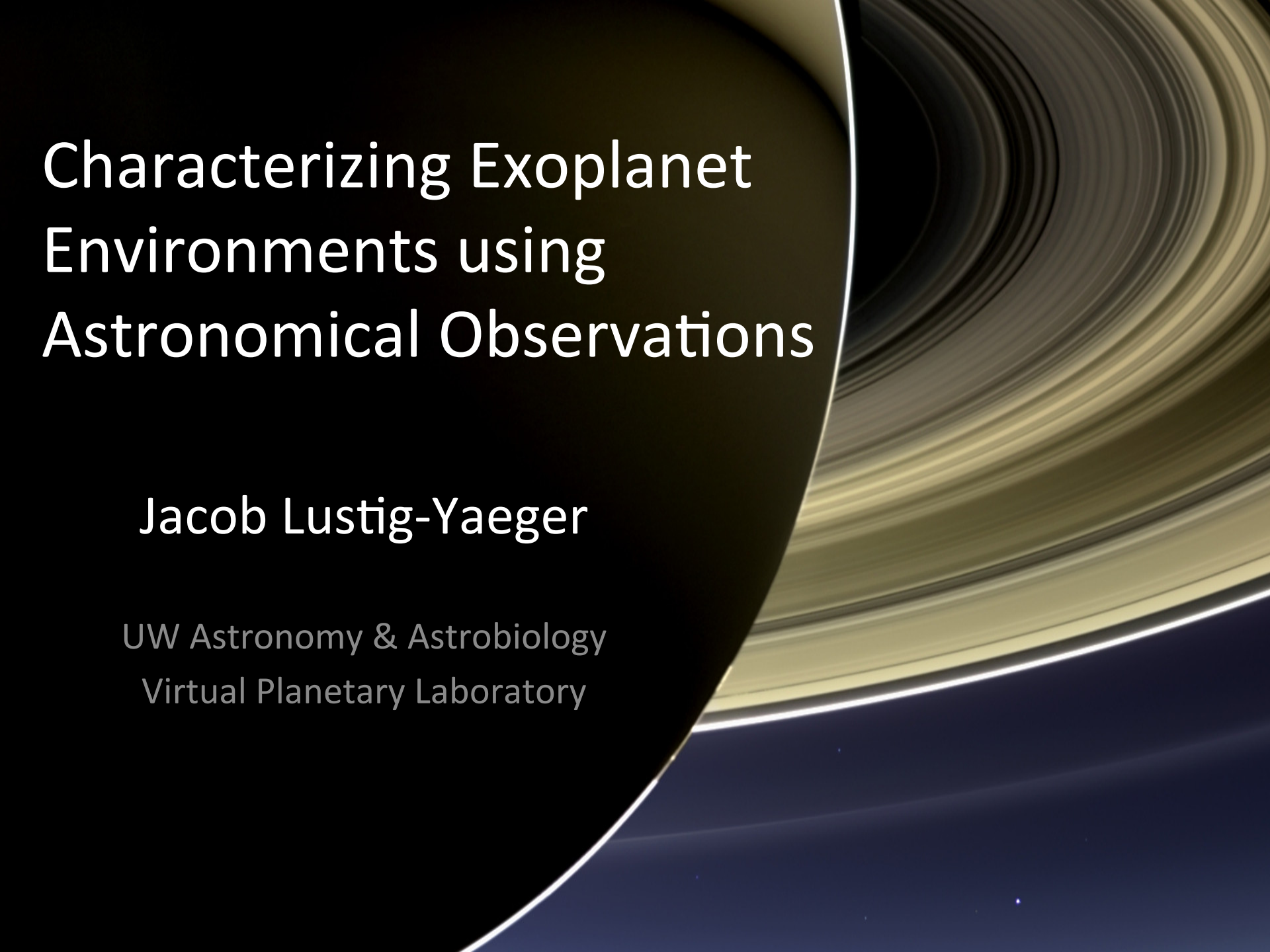


CREDIT: SPHERE Project, PHL @ UPR Arecibo

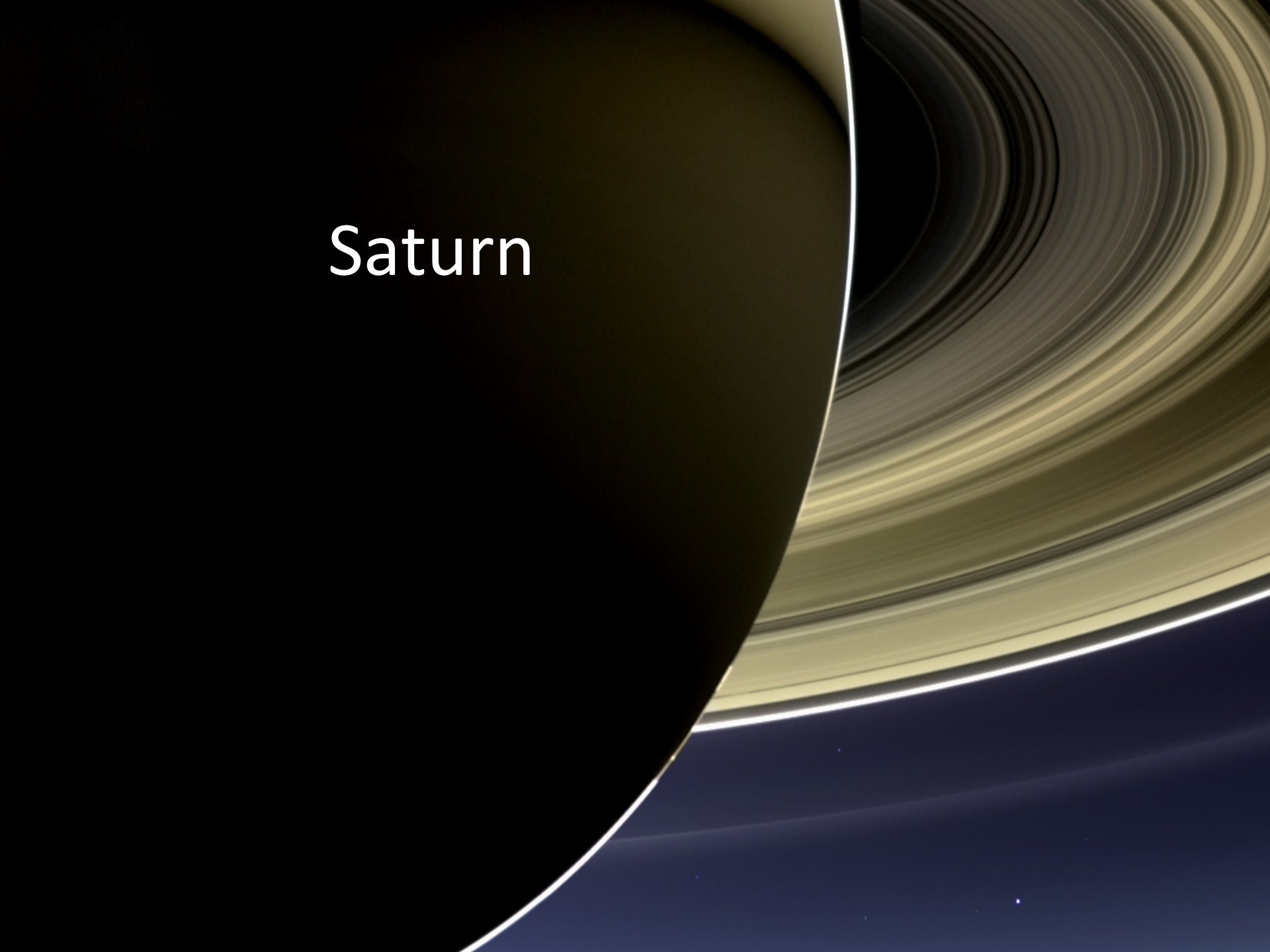
Characterizing Exoplanet Environments using Astronomical Observations

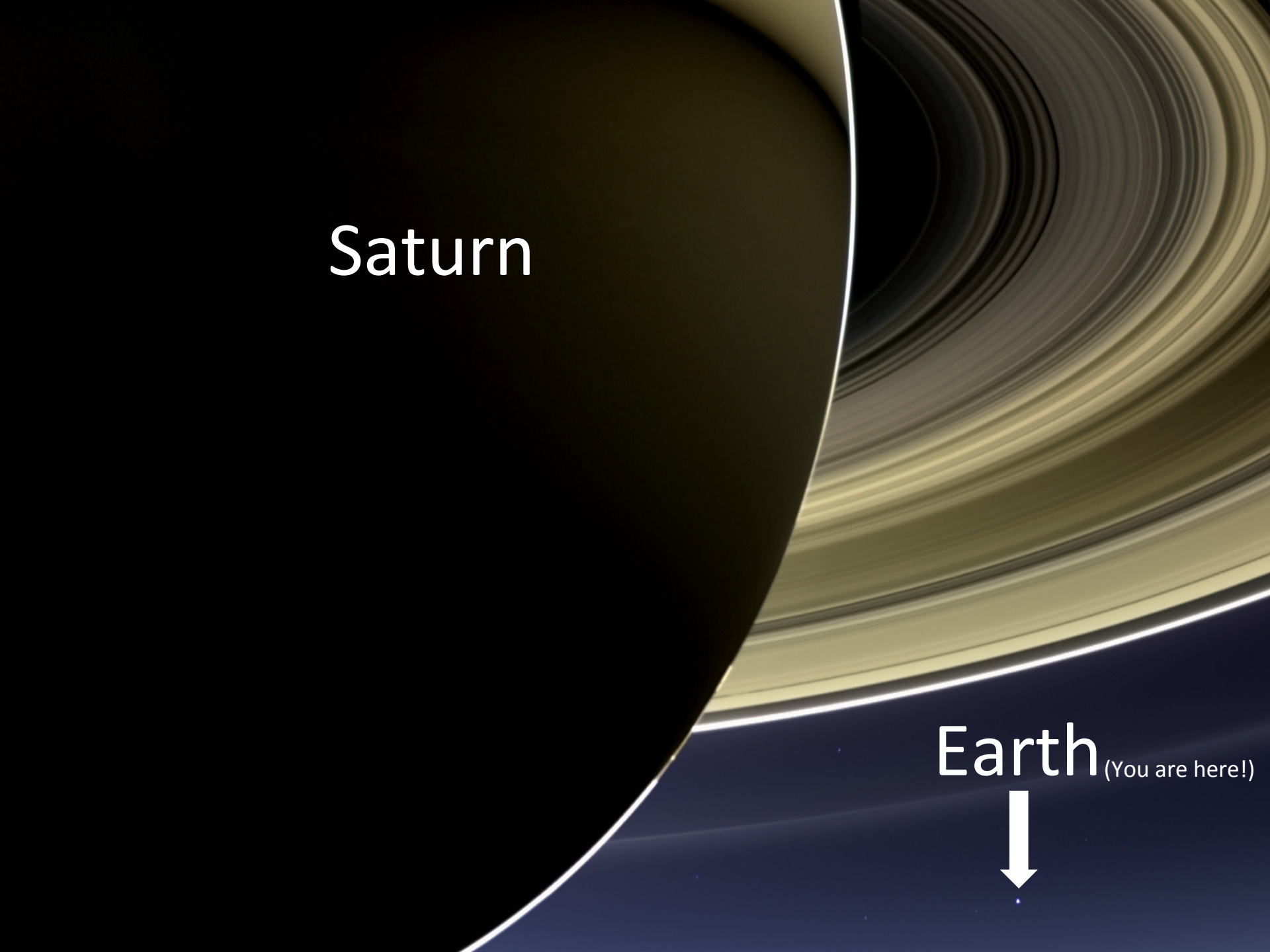
Jacob Lustig-Yaeger

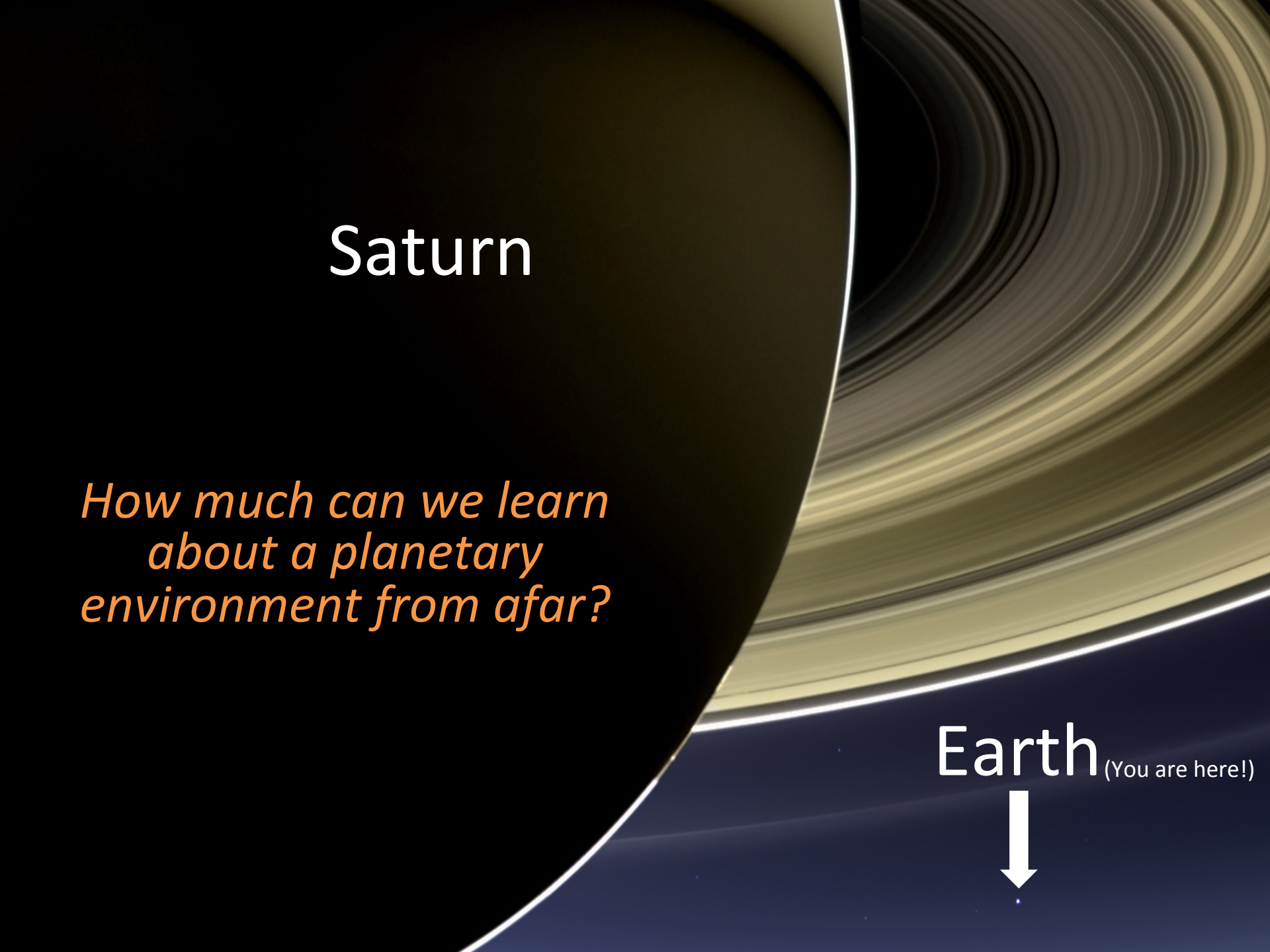
UW Astronomy & Astrobiology
Virtual Planetary Laboratory



Saturn

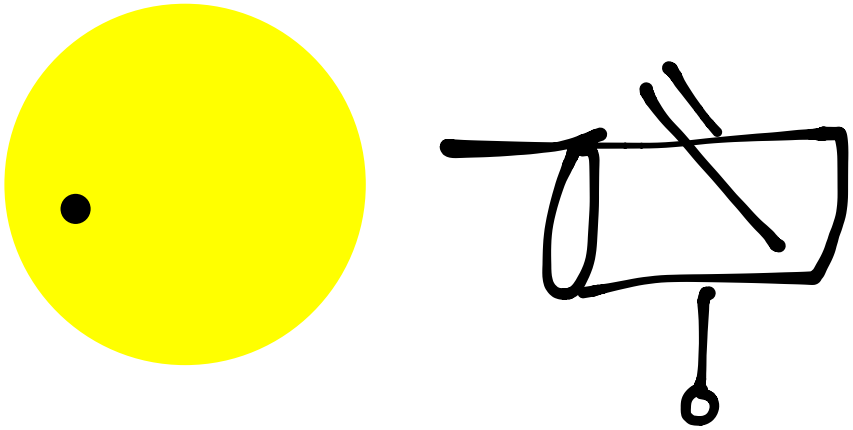



Saturn
Earth (You are here!)

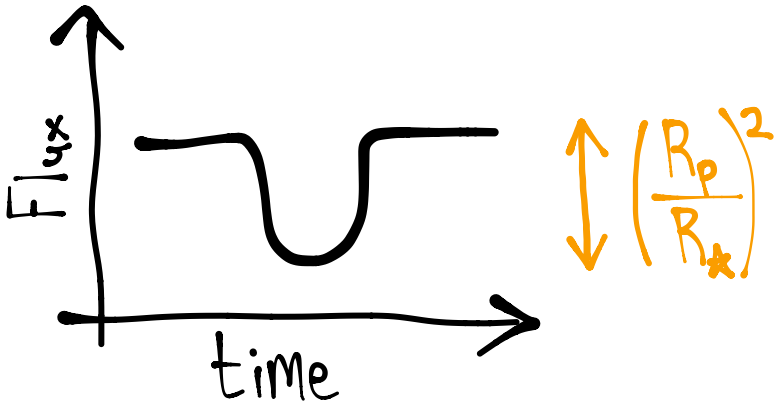

Saturn
How much can we learn about a planetary environment from afar?
Earth (You are here!)

Transiting Exoplanets

Observation:

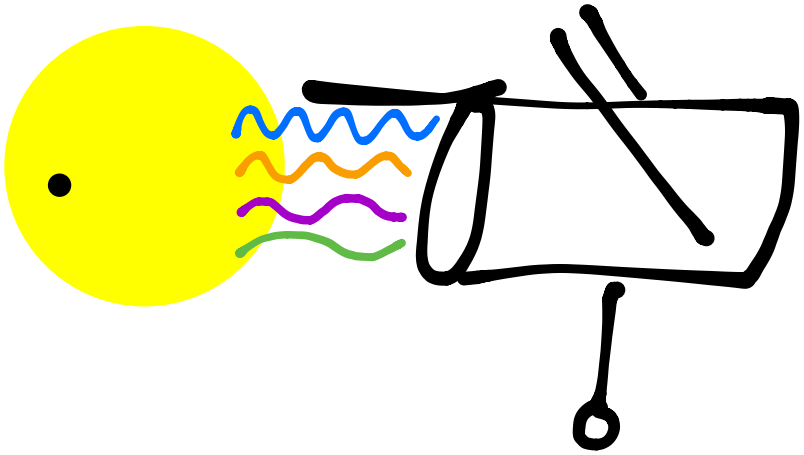


Measurement:

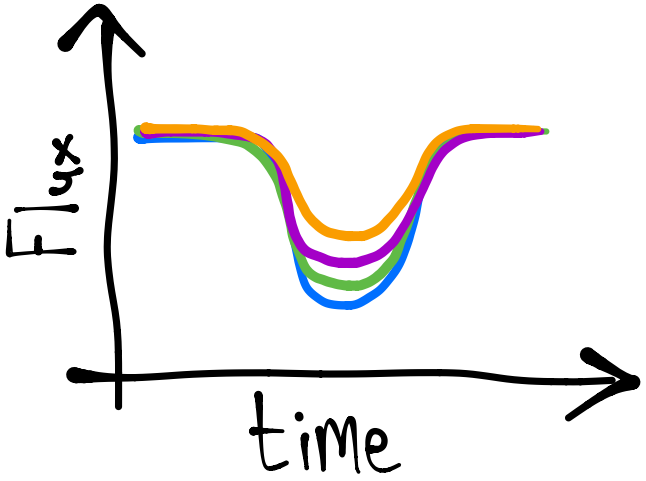


Transiting Exoplanets

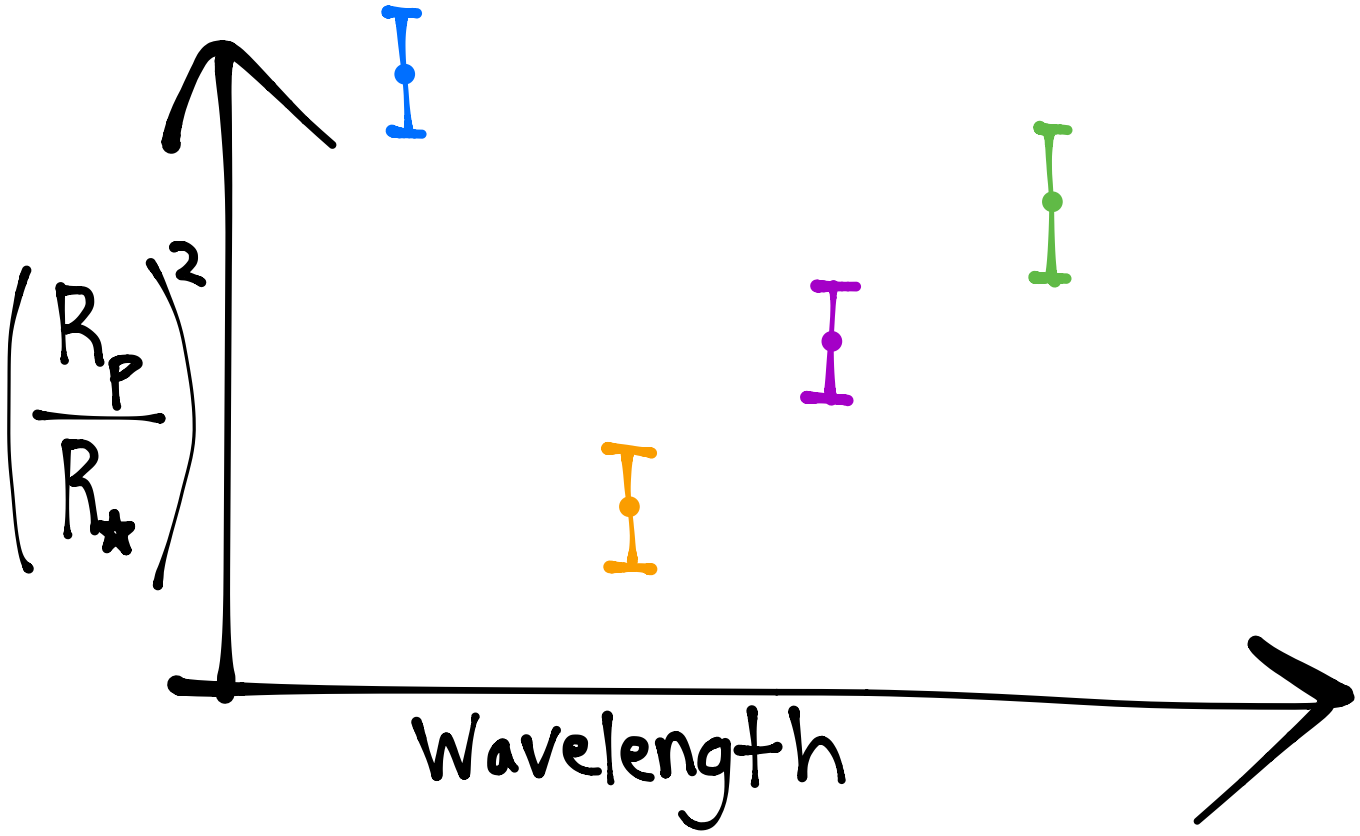
Observation:



Measurement:

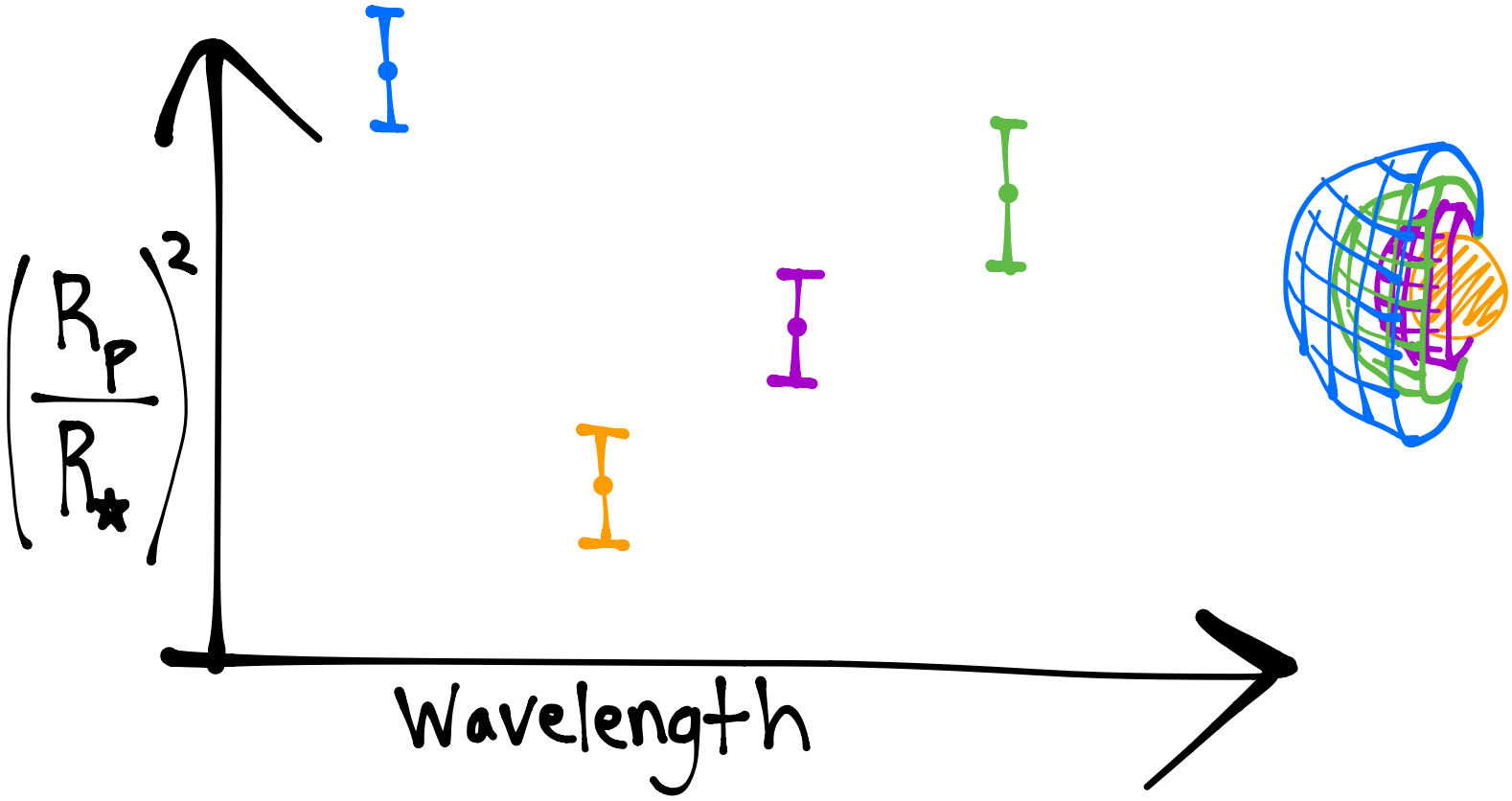


Transiting Exoplanets



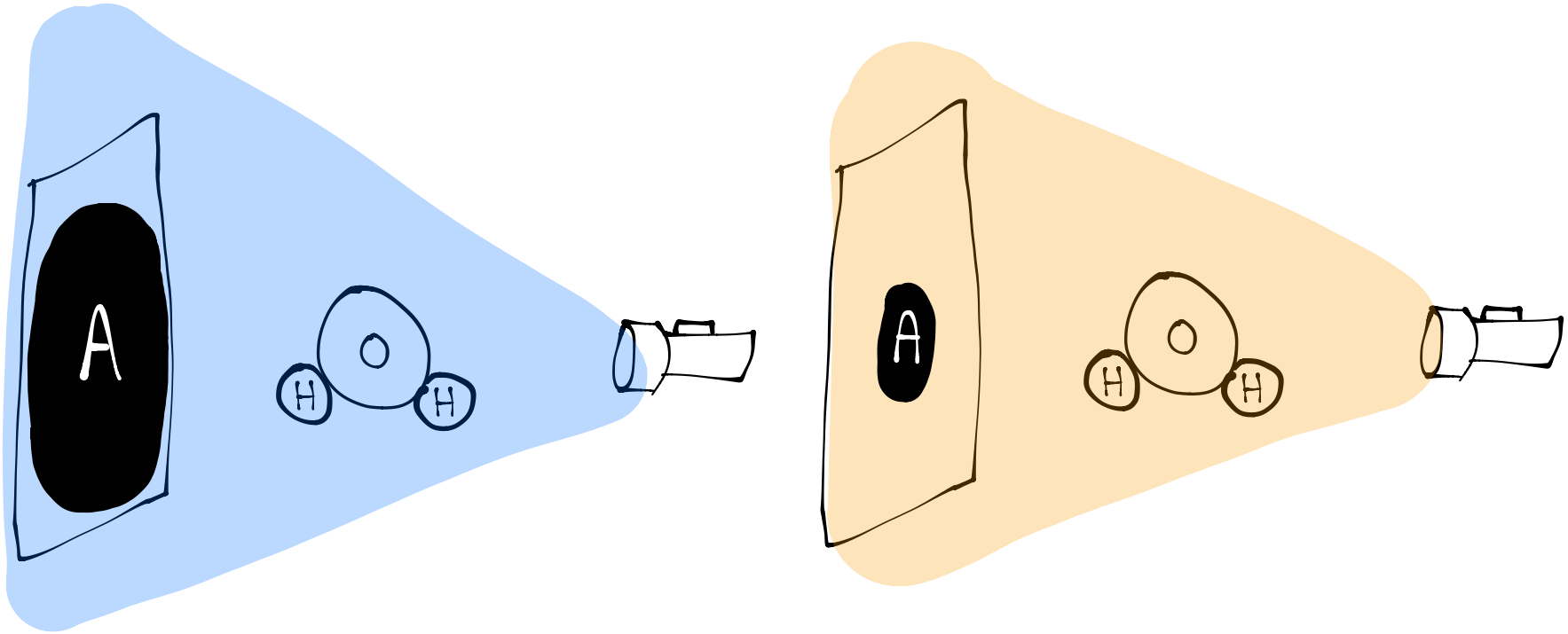
Transiting Exoplanets

Transmission Spectroscopy

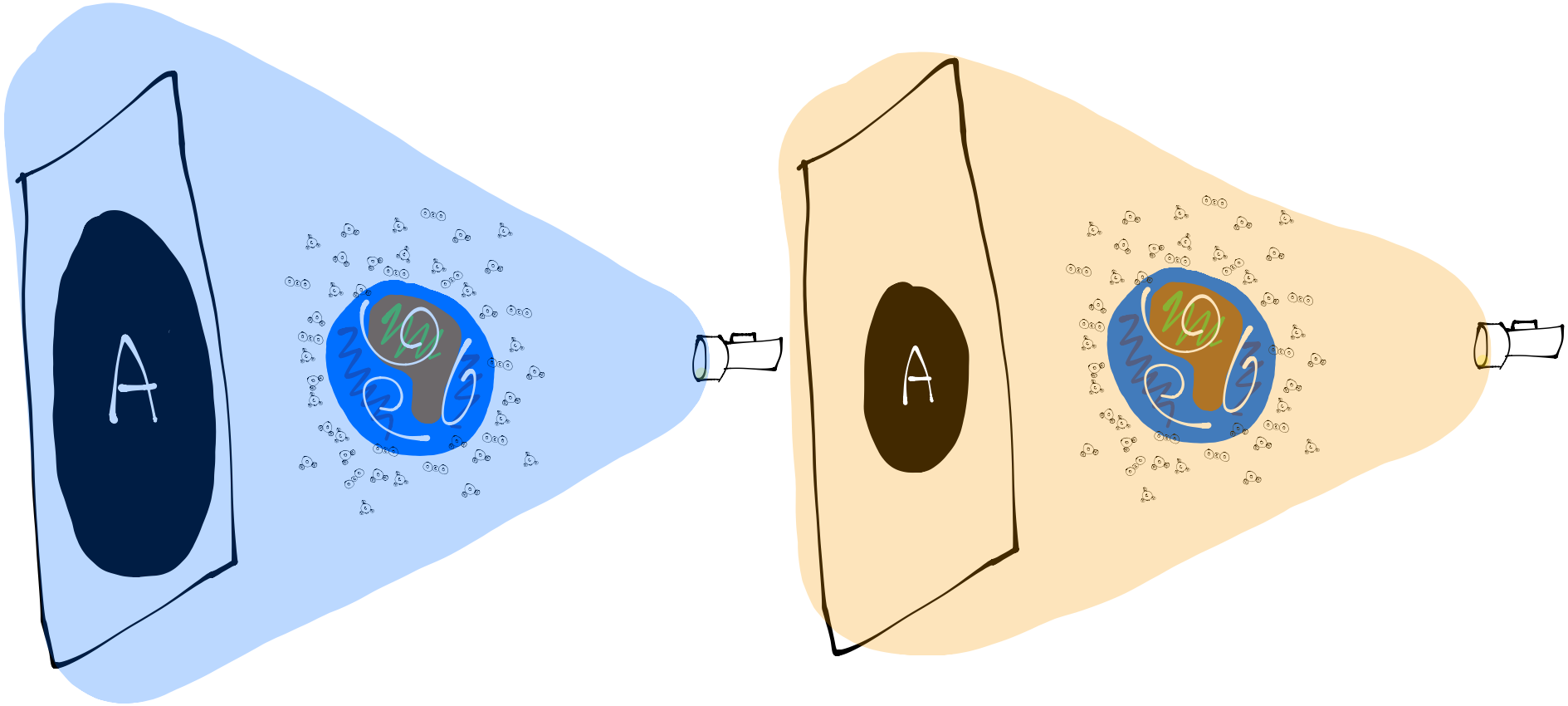


*What causes the **radius** of a planet to change as a function of the **wavelength** of light observed?*

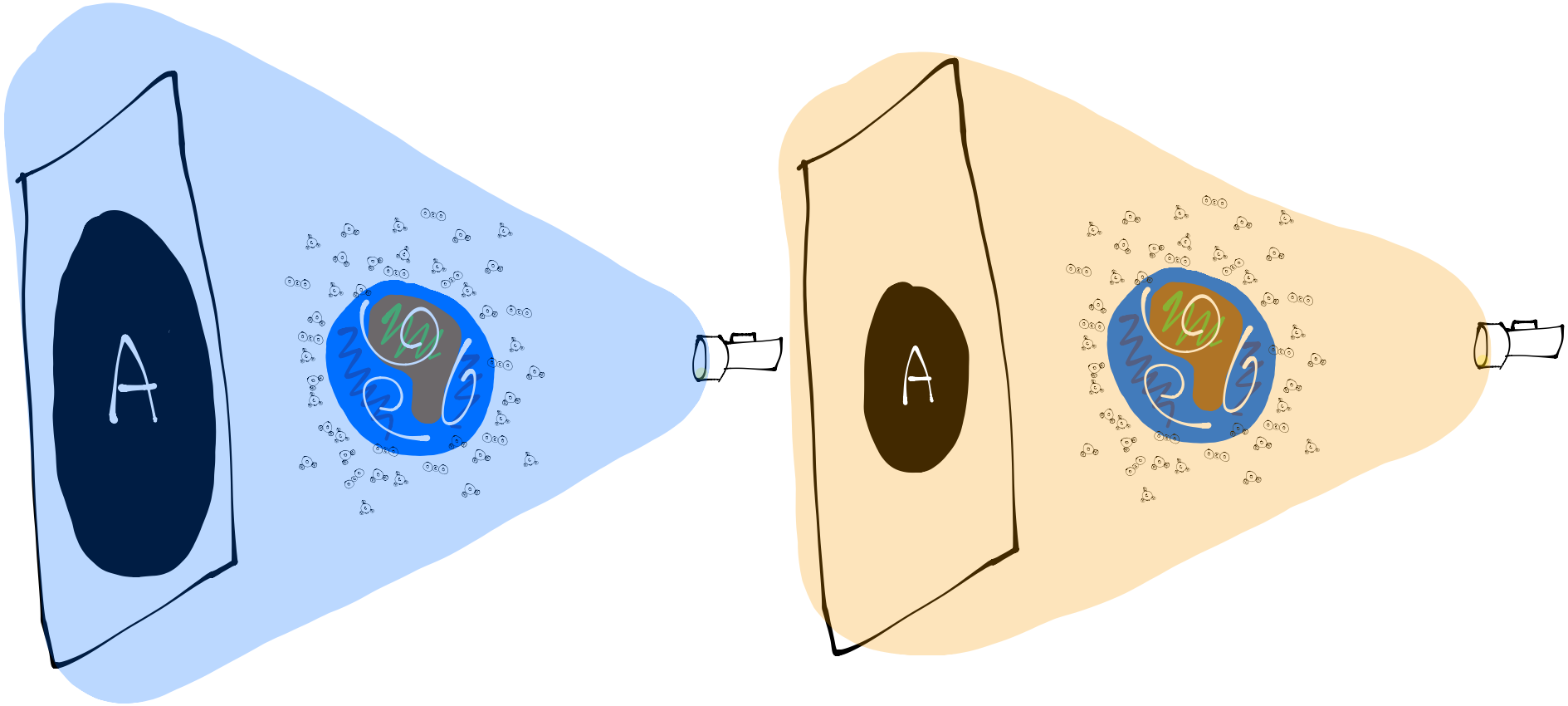
Molecular Absorption



Molecular Absorption



Molecular Absorption

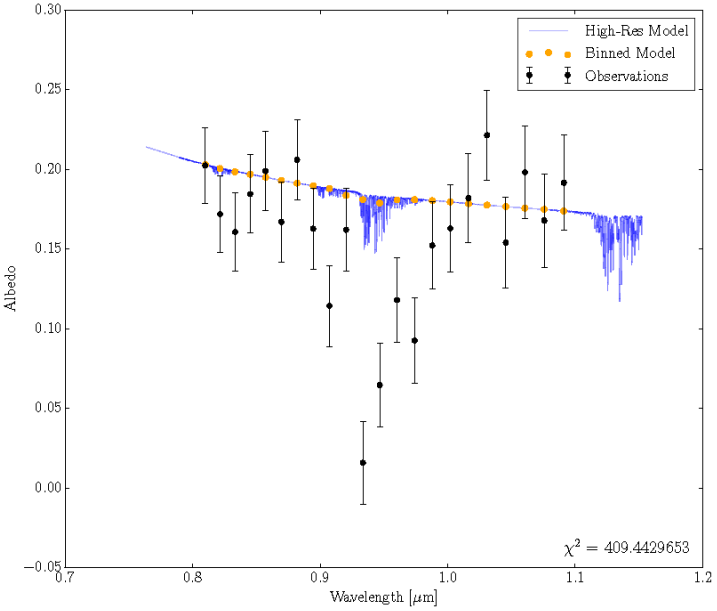


*The **composition** of the planet causes observed changes in radius!*

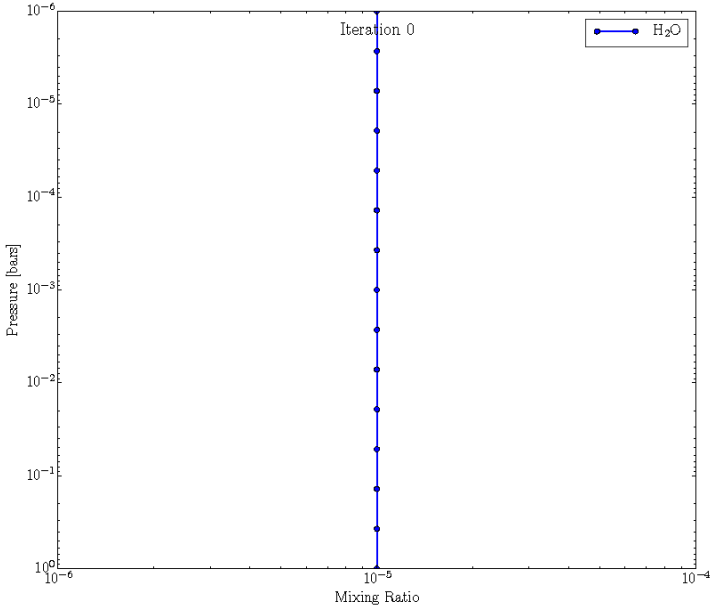
Fitting a model to data

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

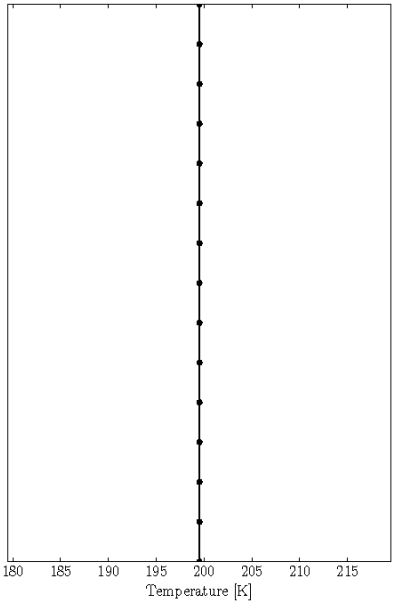
Model vs Data



Amount of water



Temperature

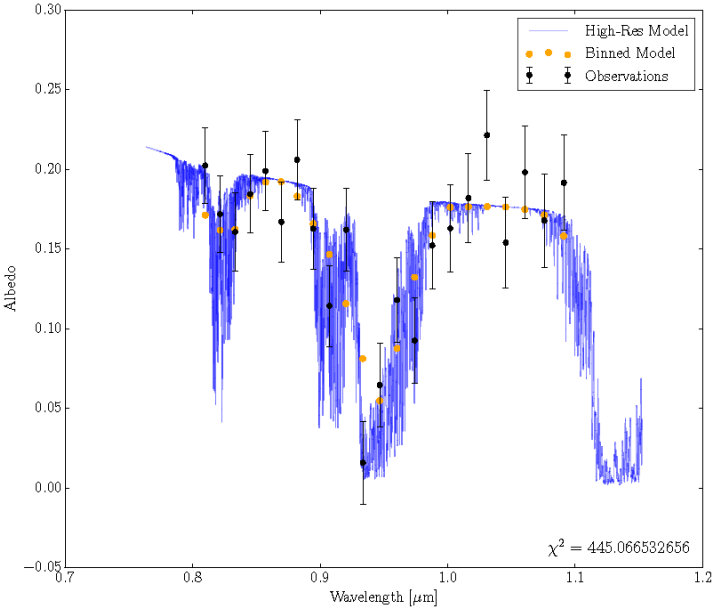


Initial Conditions

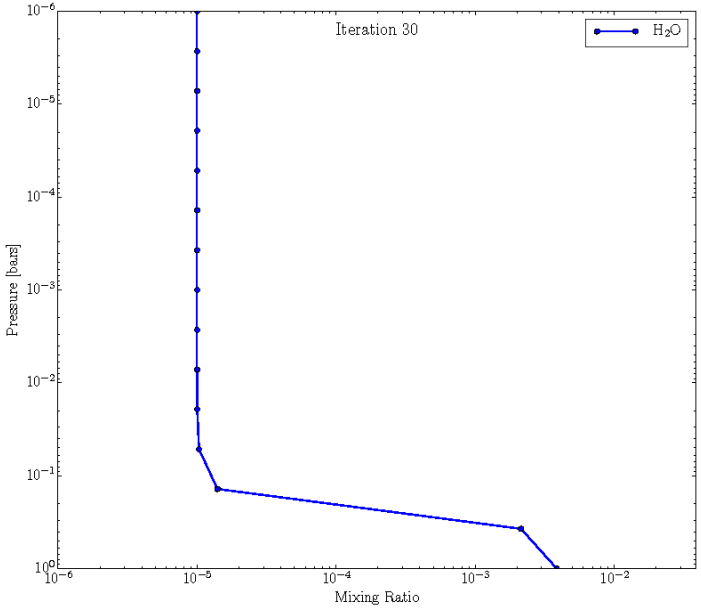
Fitting a model to data

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

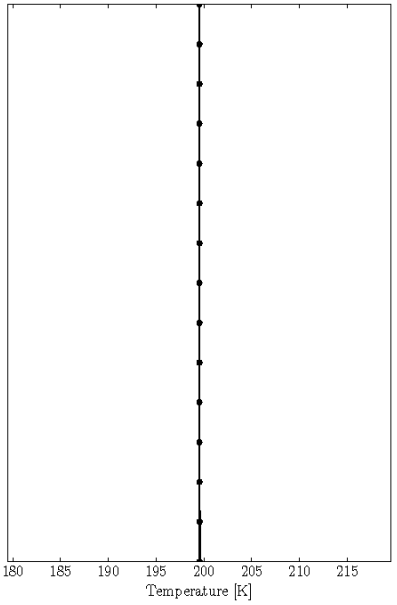
Model vs Data



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

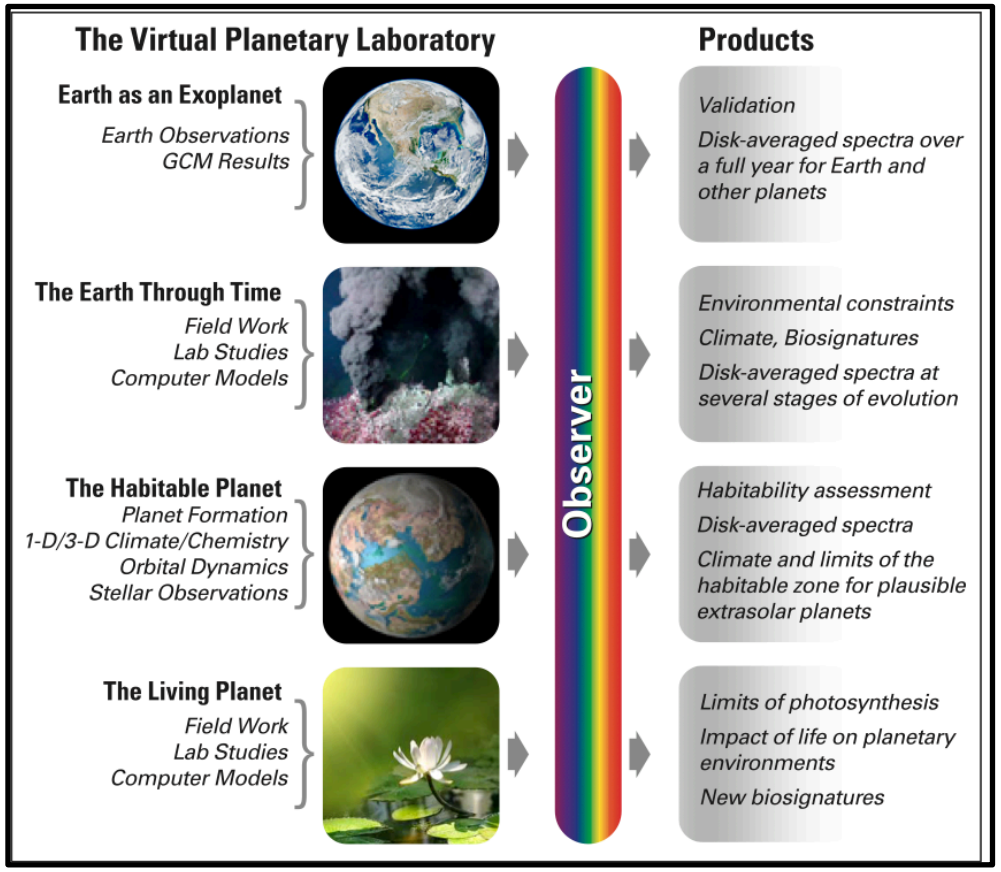
New biosignatures

Eddie's Research: Astronomical Biosignatures & Habitability Markers

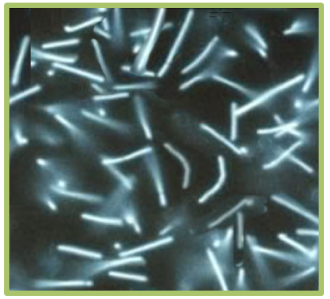
Some of my projects

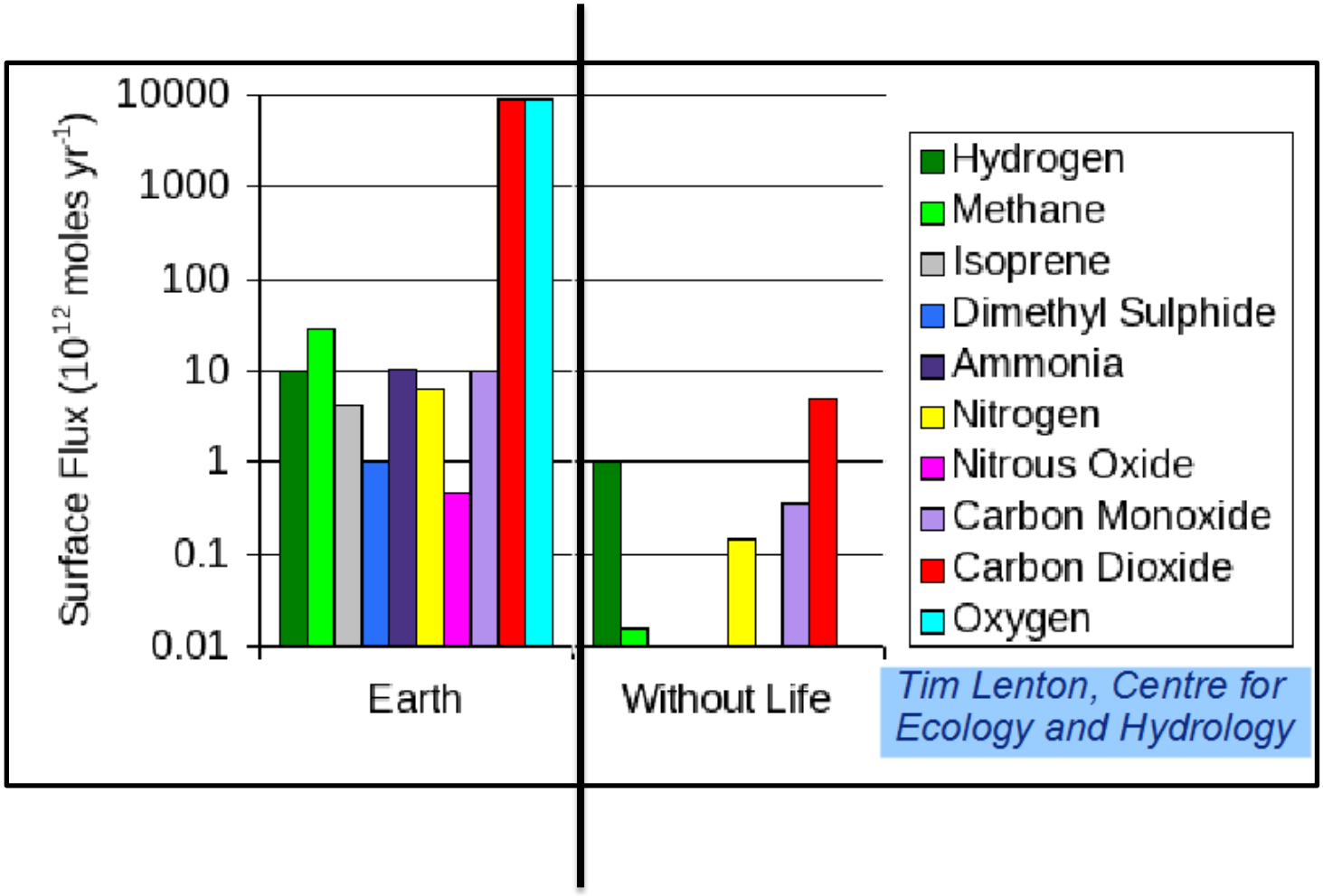
- Detecting N_2 in planetary atmospheres*
- Non-photosynthetic pigments as biosignatures
- Phase-resolved spectral Earth (Earth through a Lunar Month)*
- Spectral modeling of diverse planetary atmospheres*
- **TOOLS:** Radiative transfer model, VPL Earth model, climate model, photochemistry code

VPL Tasks

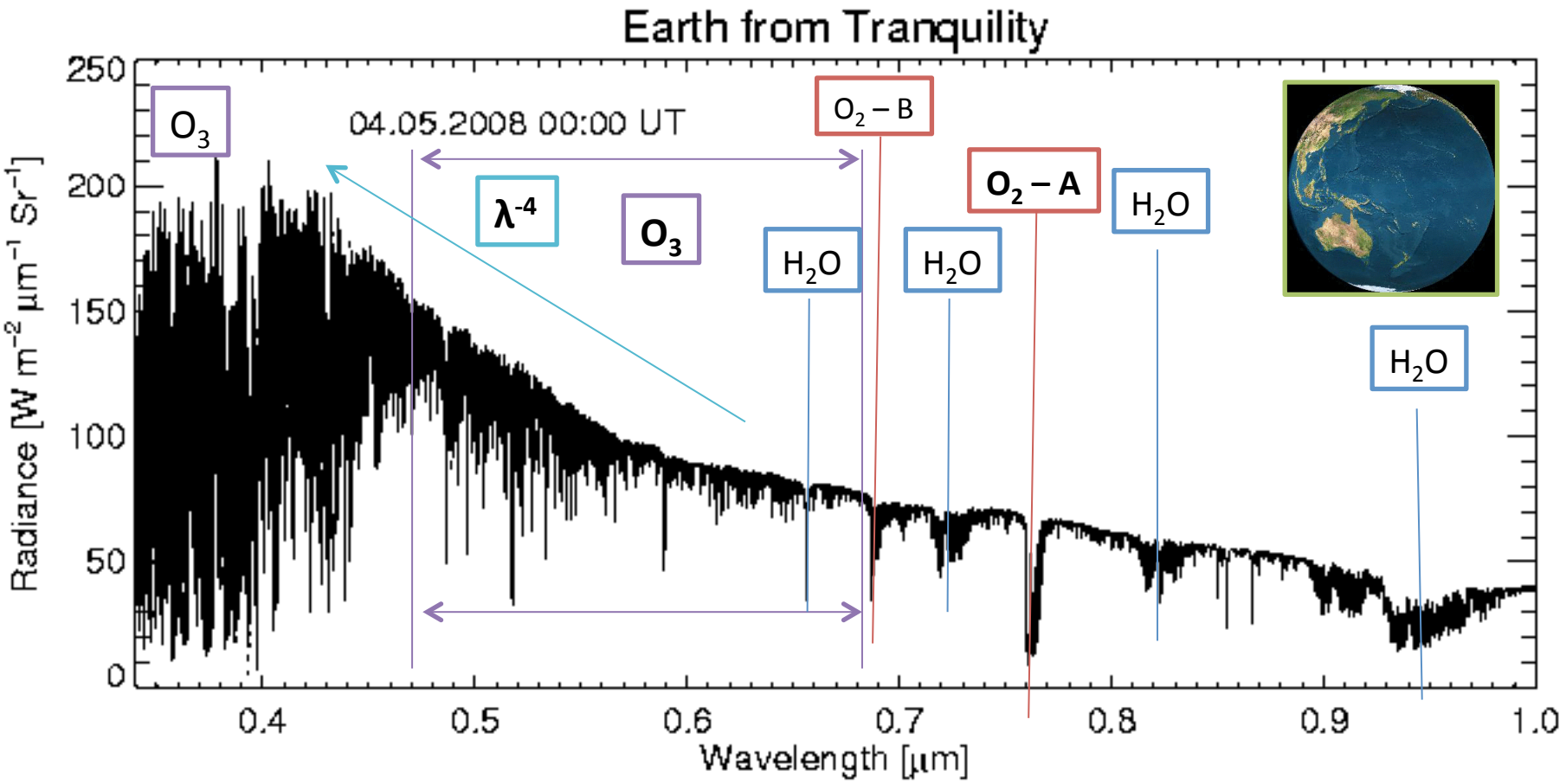


Biology Has Changed Our Atmosphere

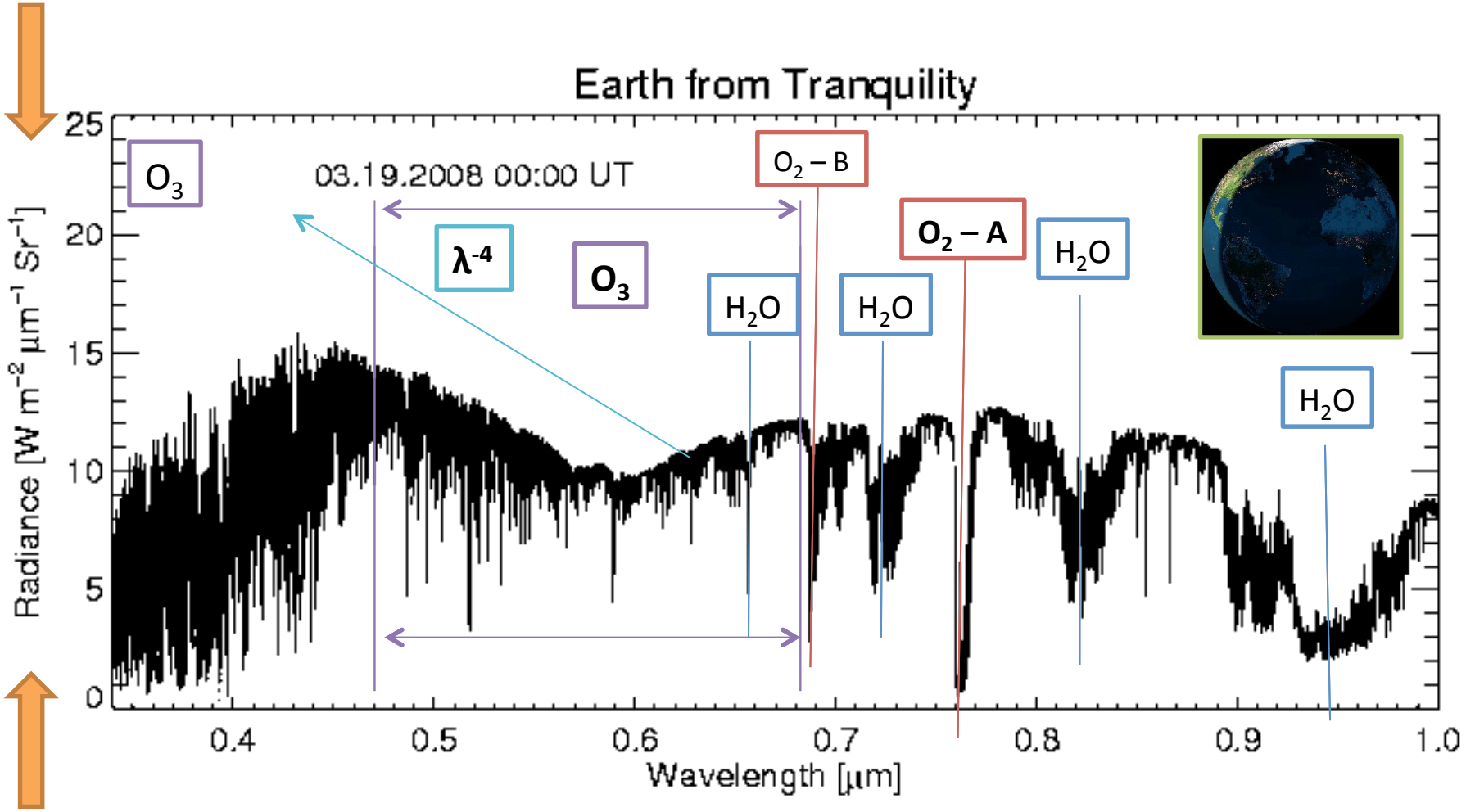




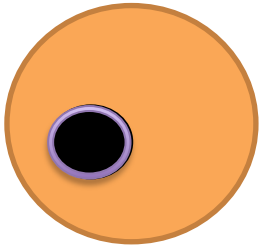
The VPL Earth Model

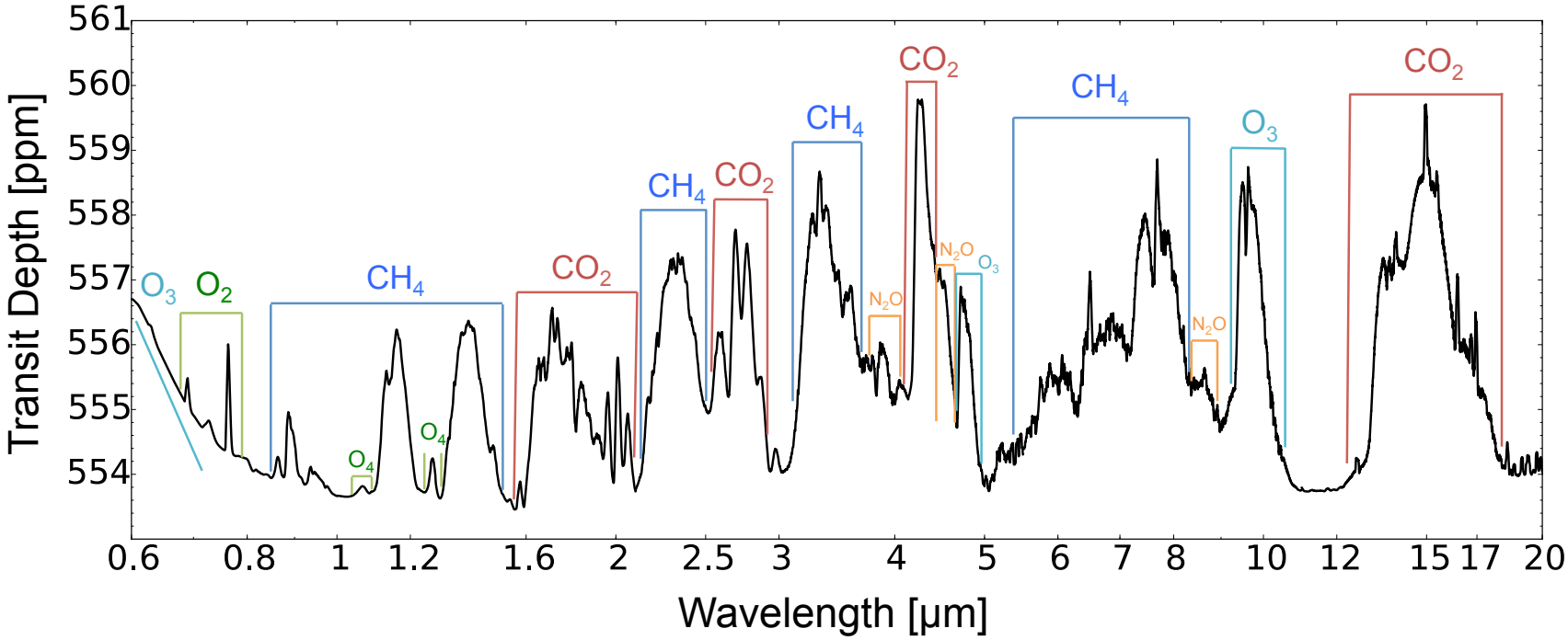


The VPL Earth Model



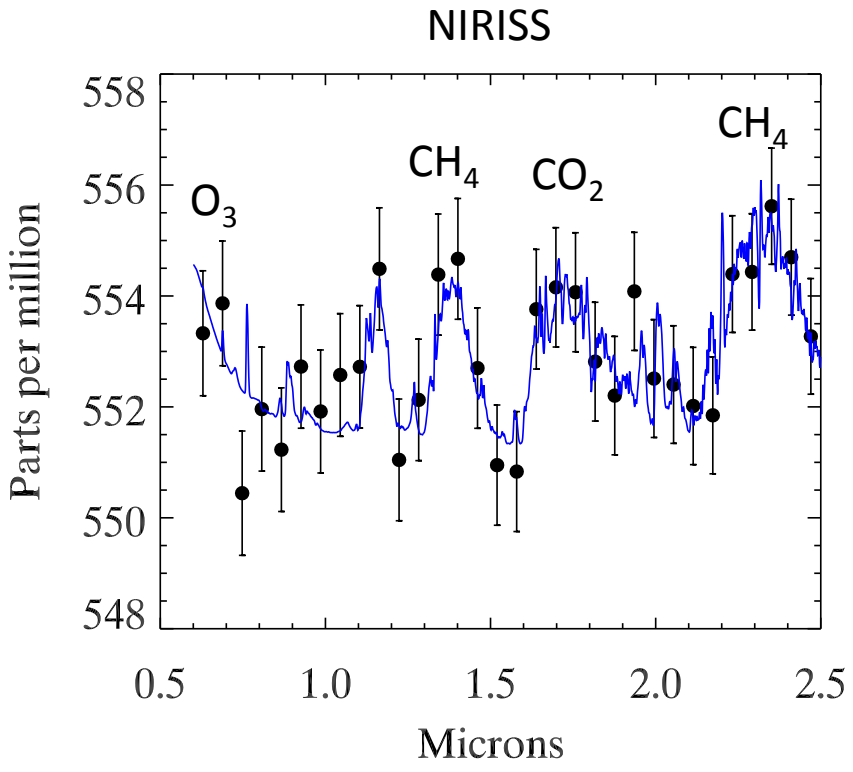
Transmission Spectrum of an Earth around an M dwarf

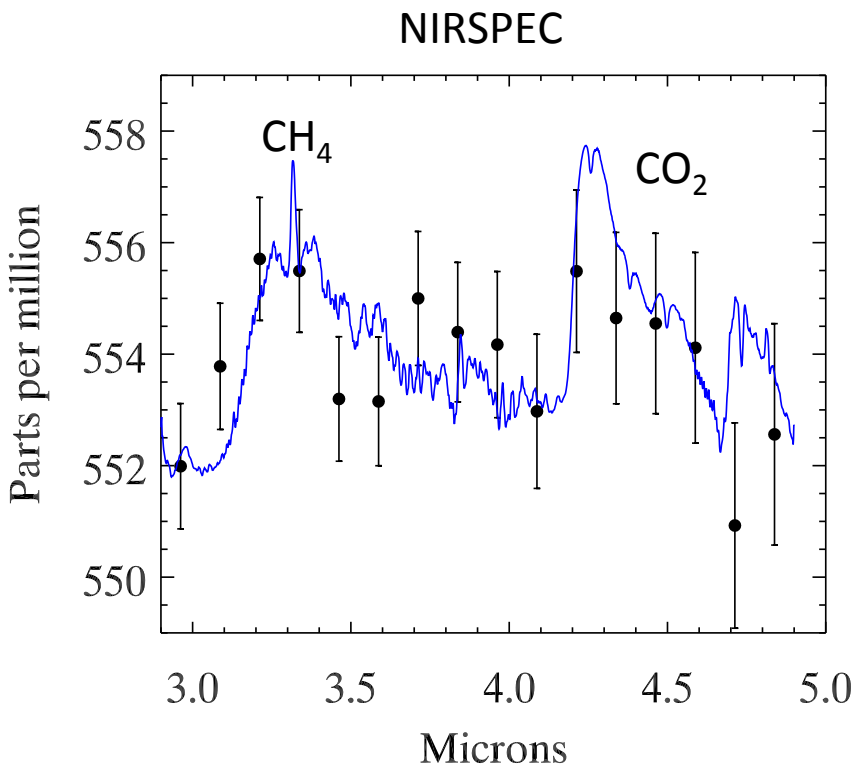




Atmosphere chemical profile from Segura et al. 2005

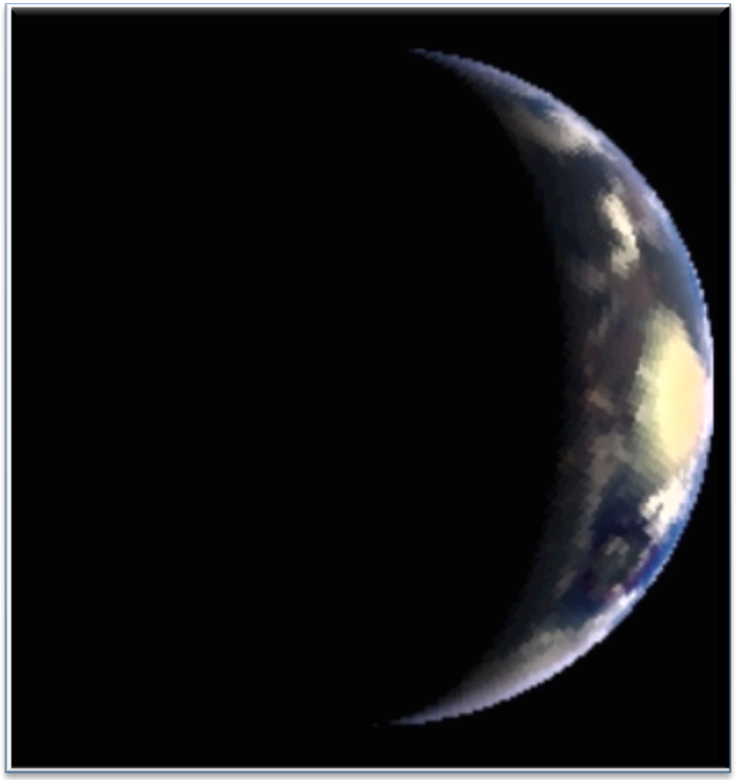
Earth around an M dwarf: Simulated JWST Observation



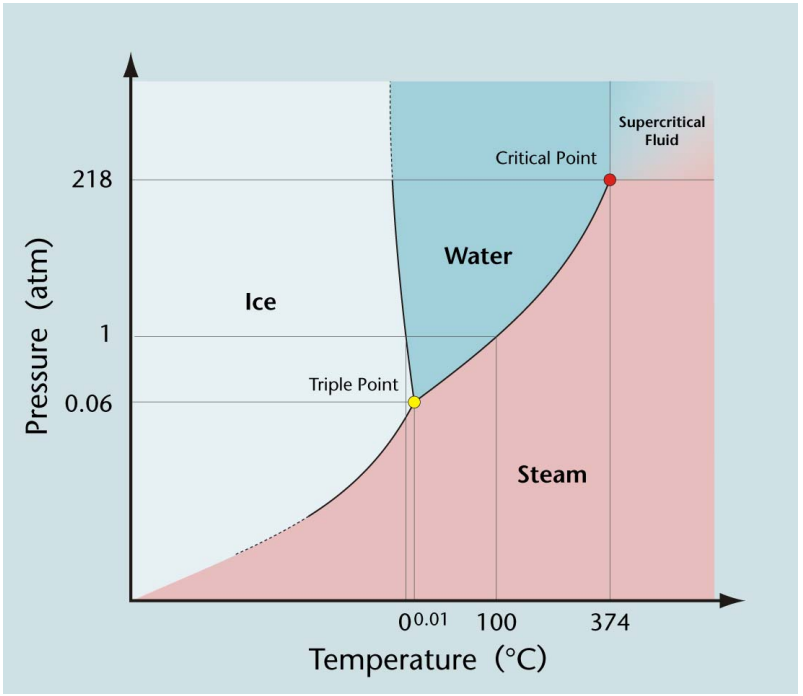


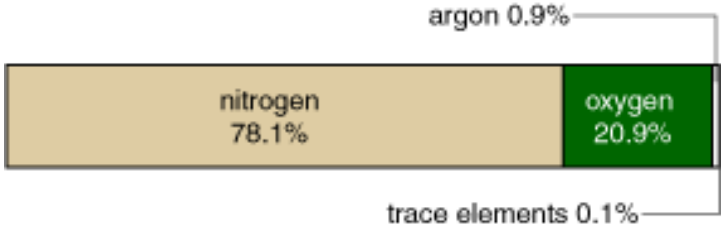
Noise calculation courtesy of Drake Deming, UMD

Detecting Habitability

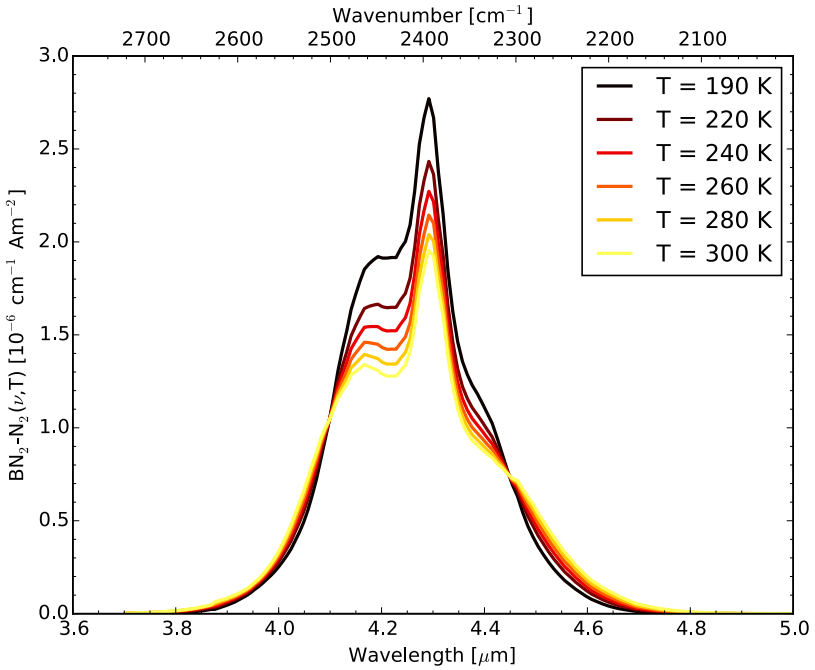


Robinson et al. 2010, 2014





Detecting N_2 and the Bulk Atmosphere



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

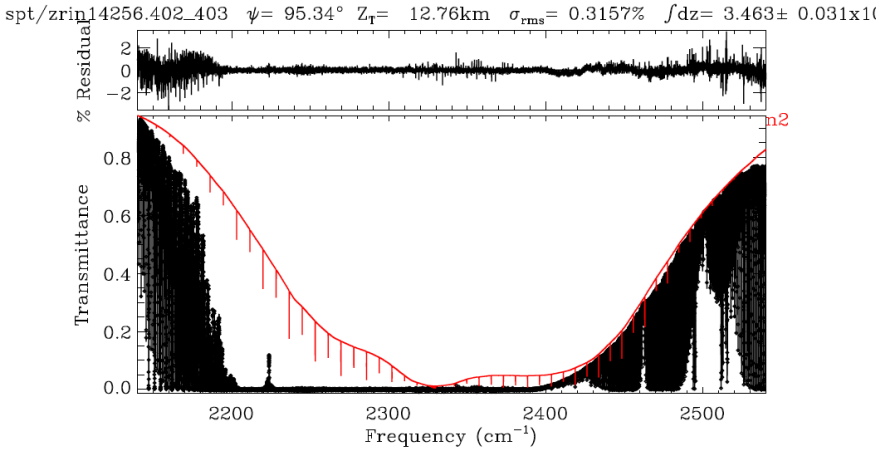
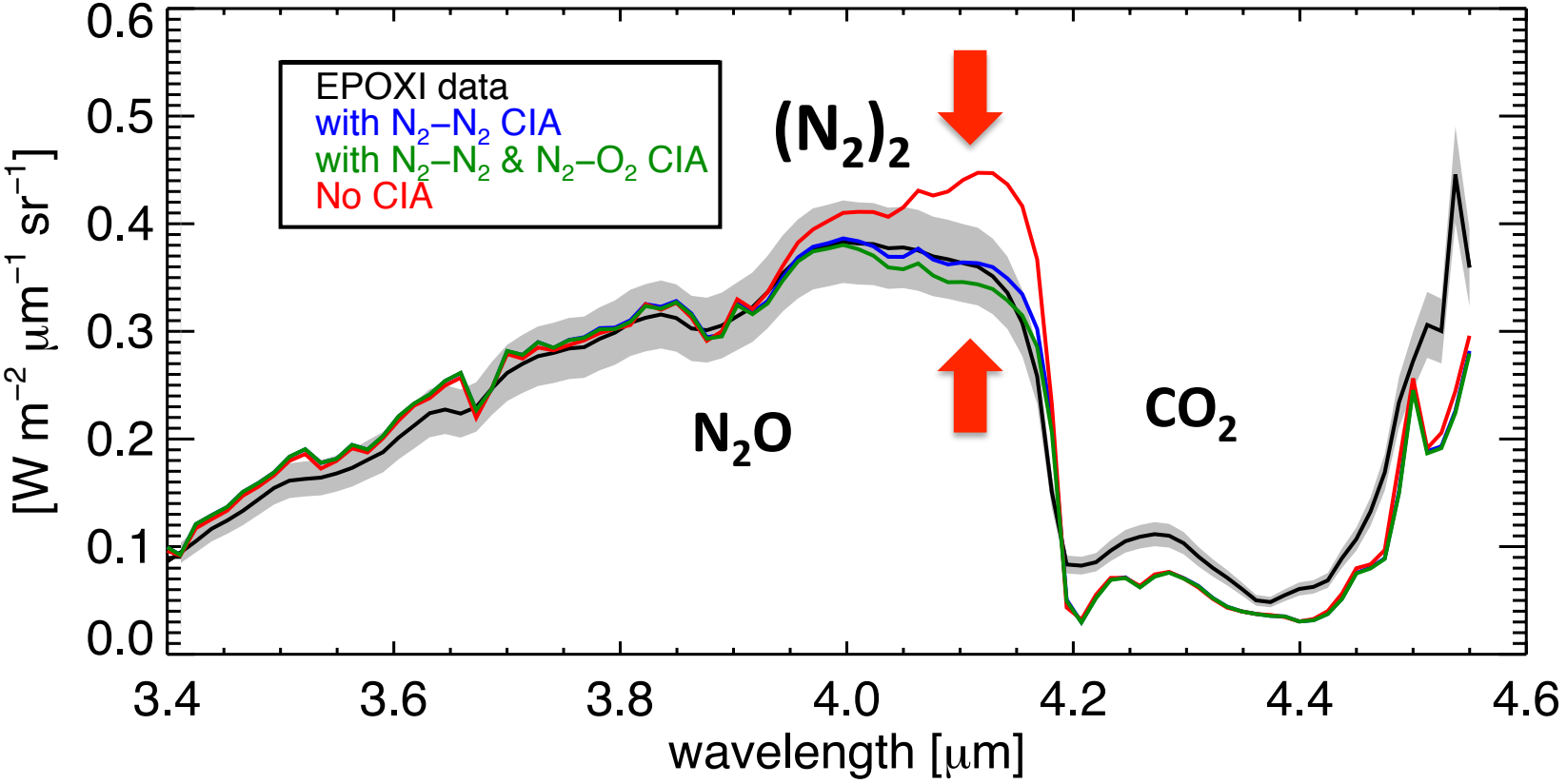


Figure credit:
Geoffrey Toon

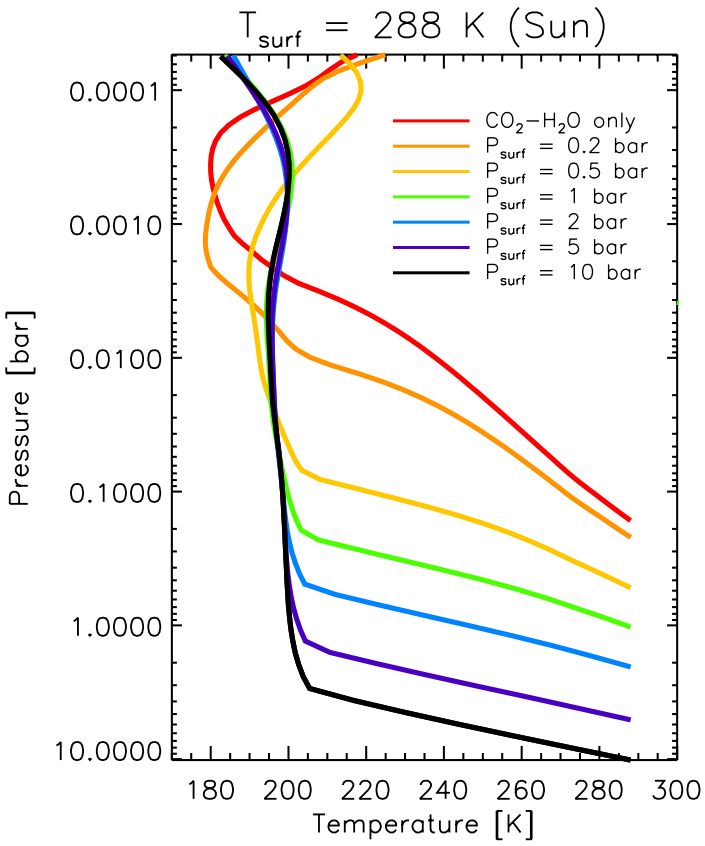
MkIV Sounding balloon with interferometer

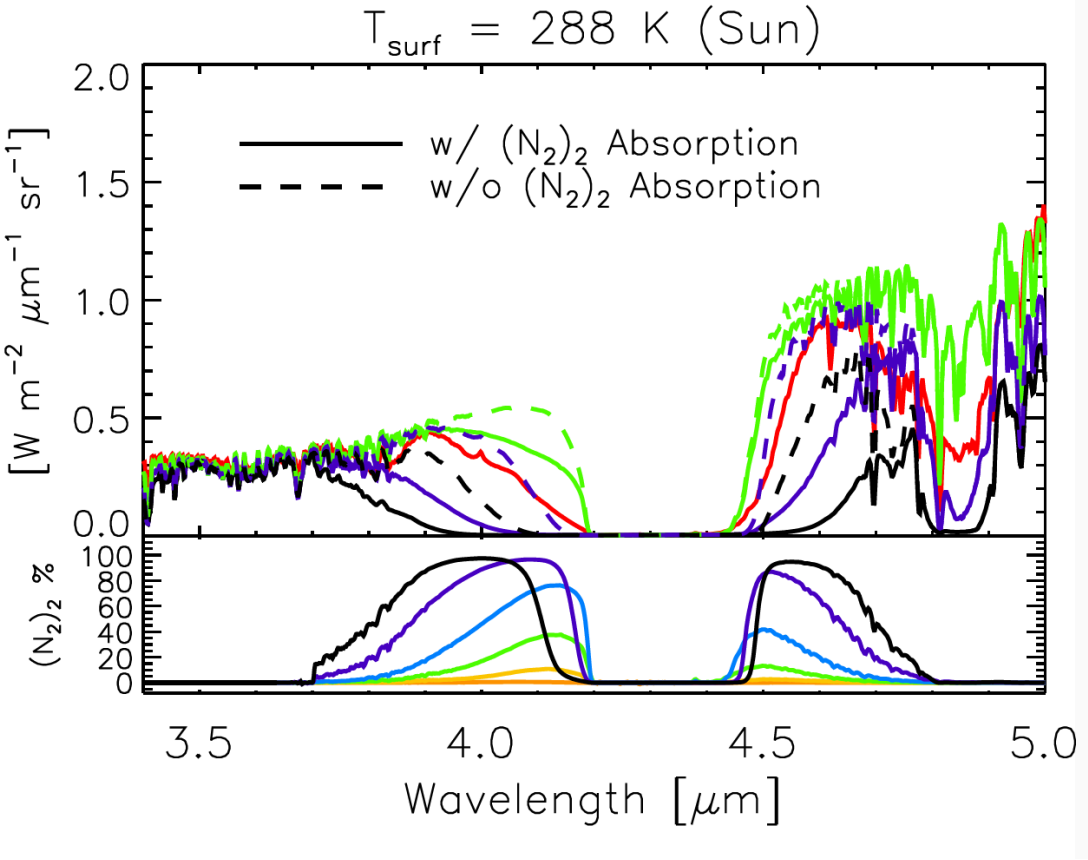
Validation: $(N_2)_2$ directly detected in Earth's disk-integrated spectrum



Schwieterman et al. 2015b, ApJ

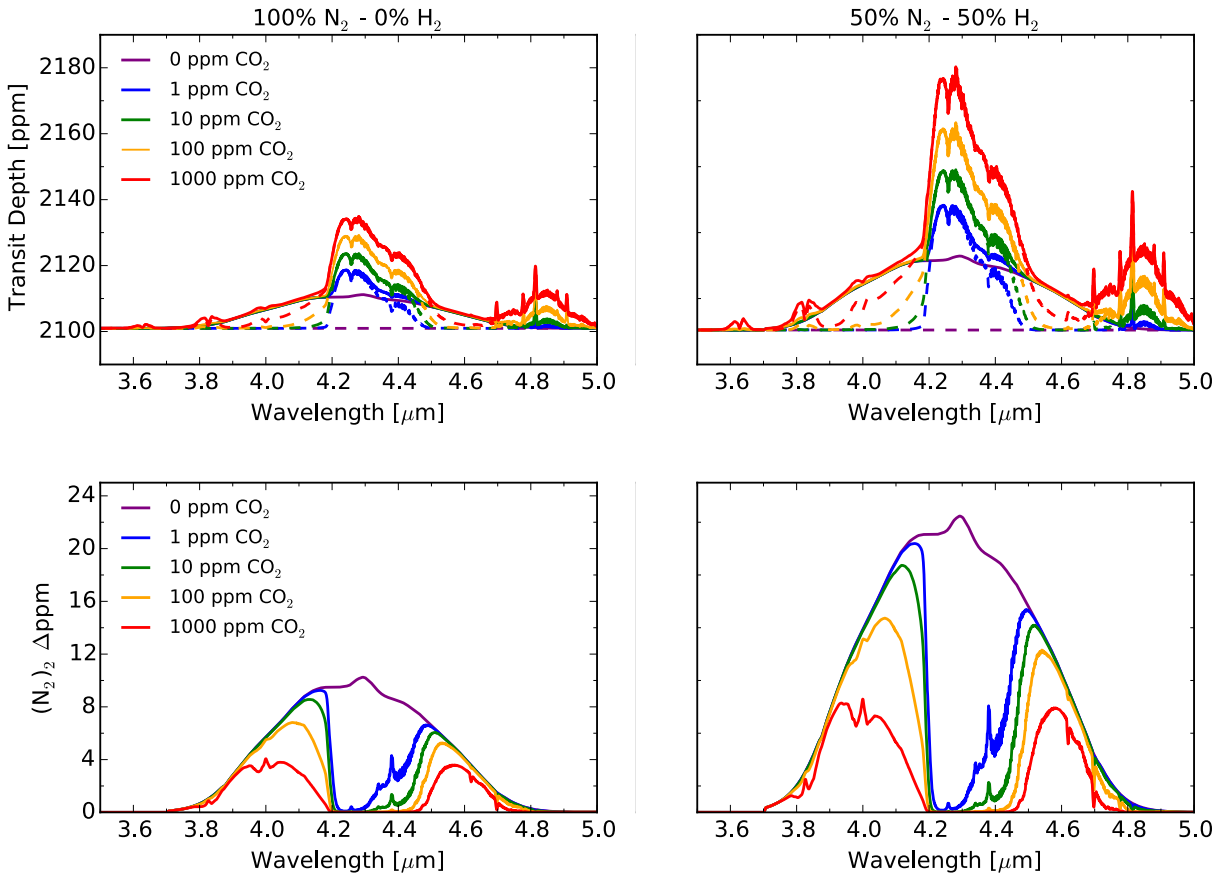
Simulated N_2 Radiance Spectra

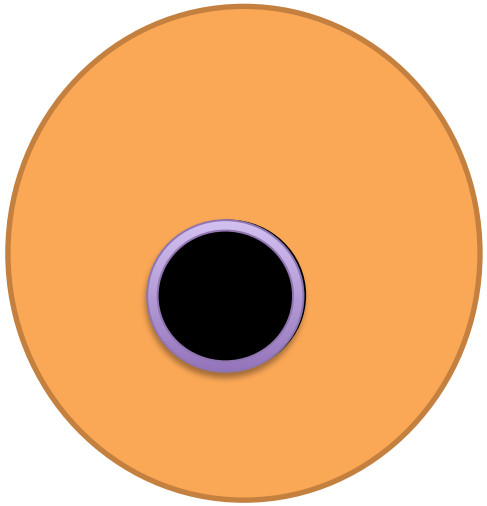




Schwieterman et al. 2015b, ApJ

Simulated N_2 Transmission Spectra





Schwieterman et al. 2015b, ApJ