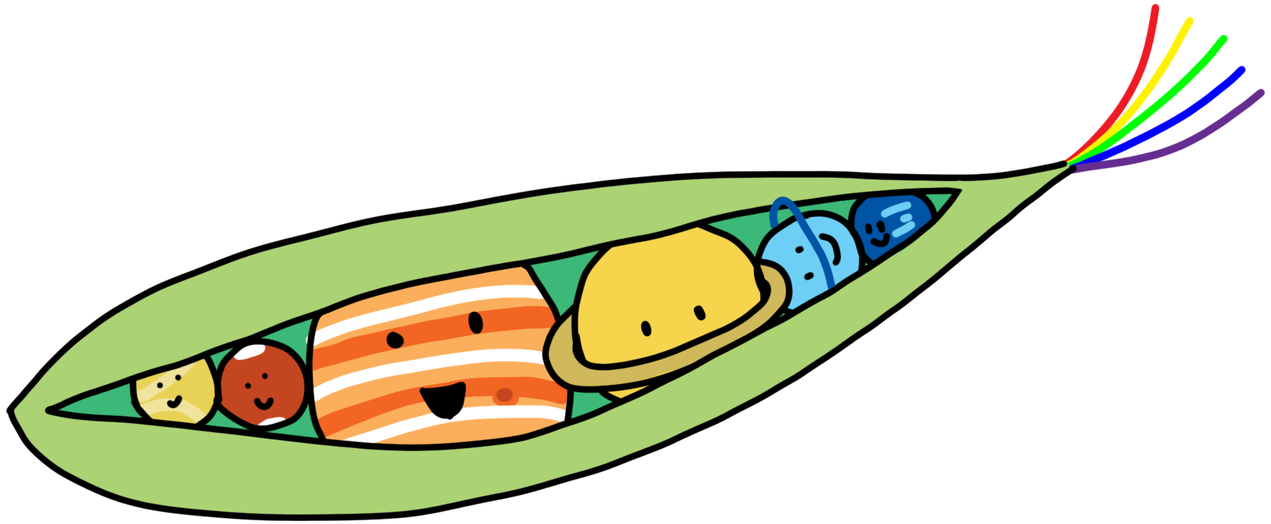

PEAS

Planet as Exoplanet Analog Spectrograph

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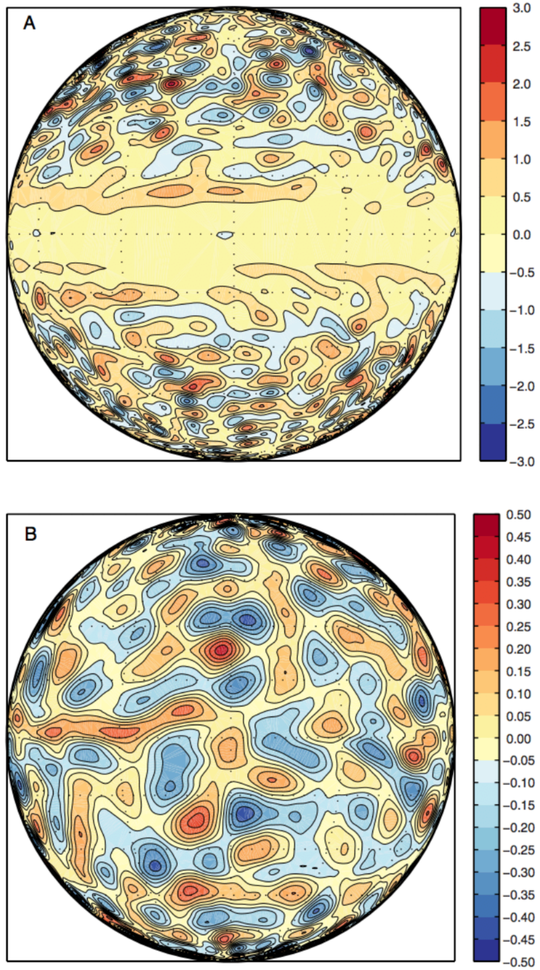
NSF Postdoctoral Fellow
UC Chancellor's Fellow

ExoPAG
June 18, 2020

Collaborators: Evan Morris (UCSC), Andy Skemer (UCSC), Matt Radovan (UCO), Jonathan Fortney (UCSC), Jason Wang (Caltech)

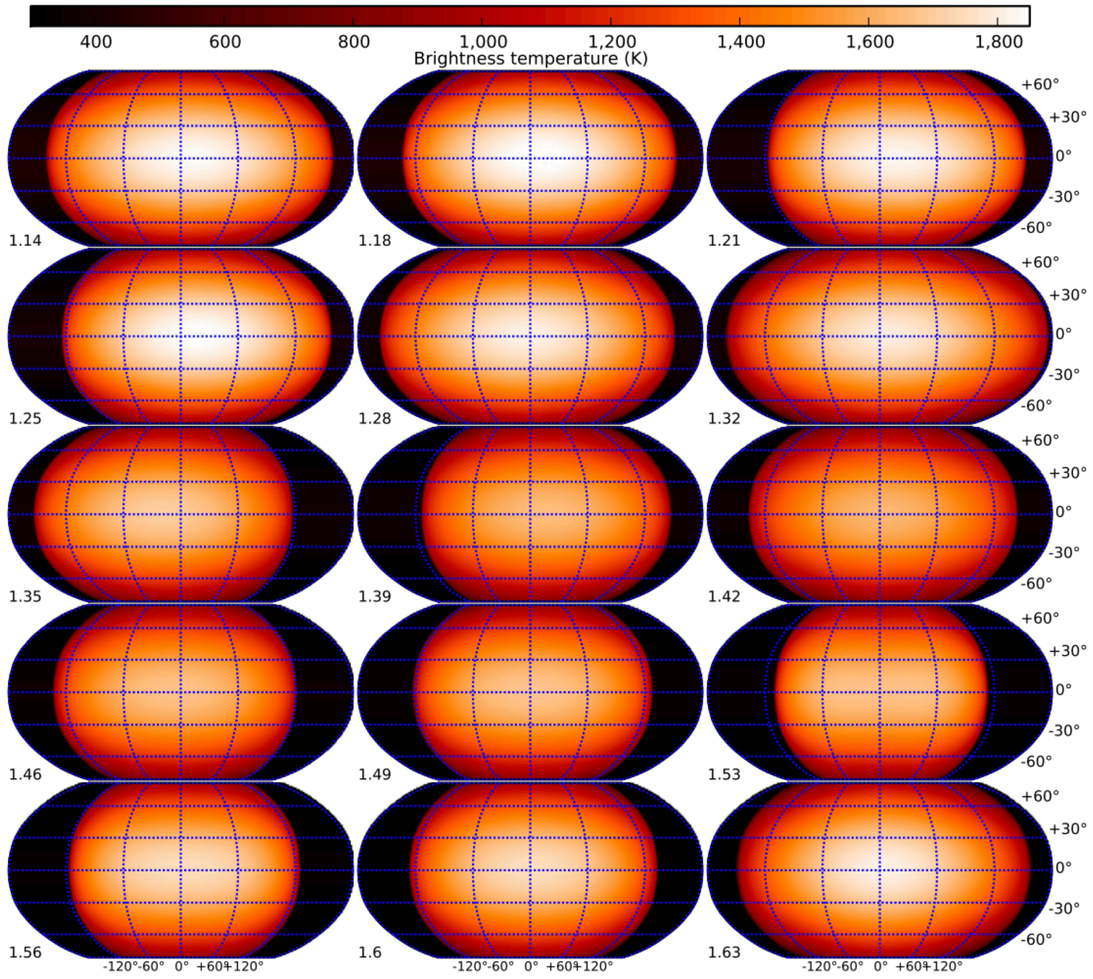
We want to observe atmospheric dynamics (weather) on exoplanets.



Zhang & Showman2014

HabEx and LUVOIR will have the capability,

but will we really understand the observations?

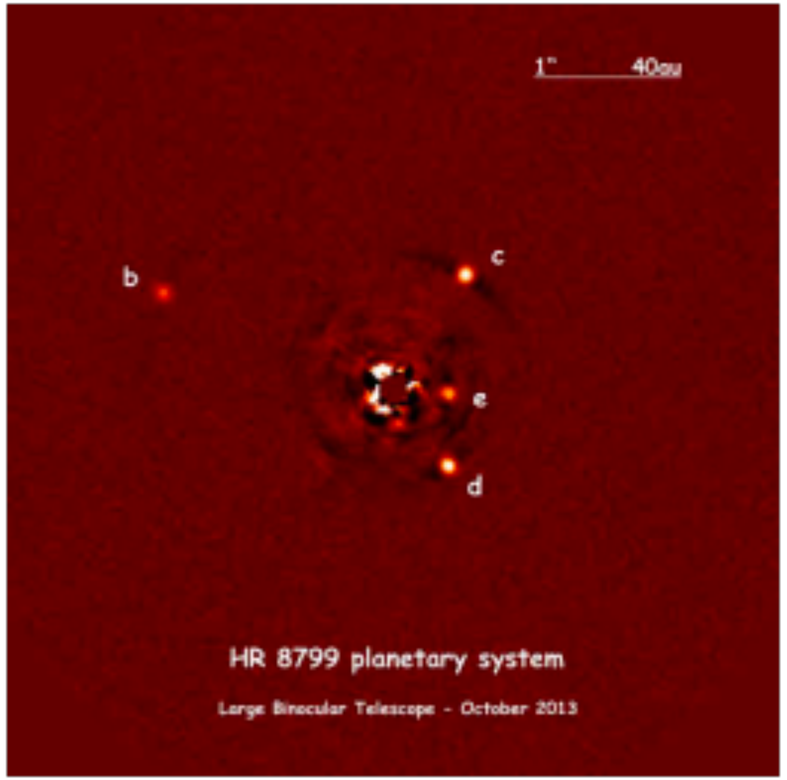


Stevenson+ 2014

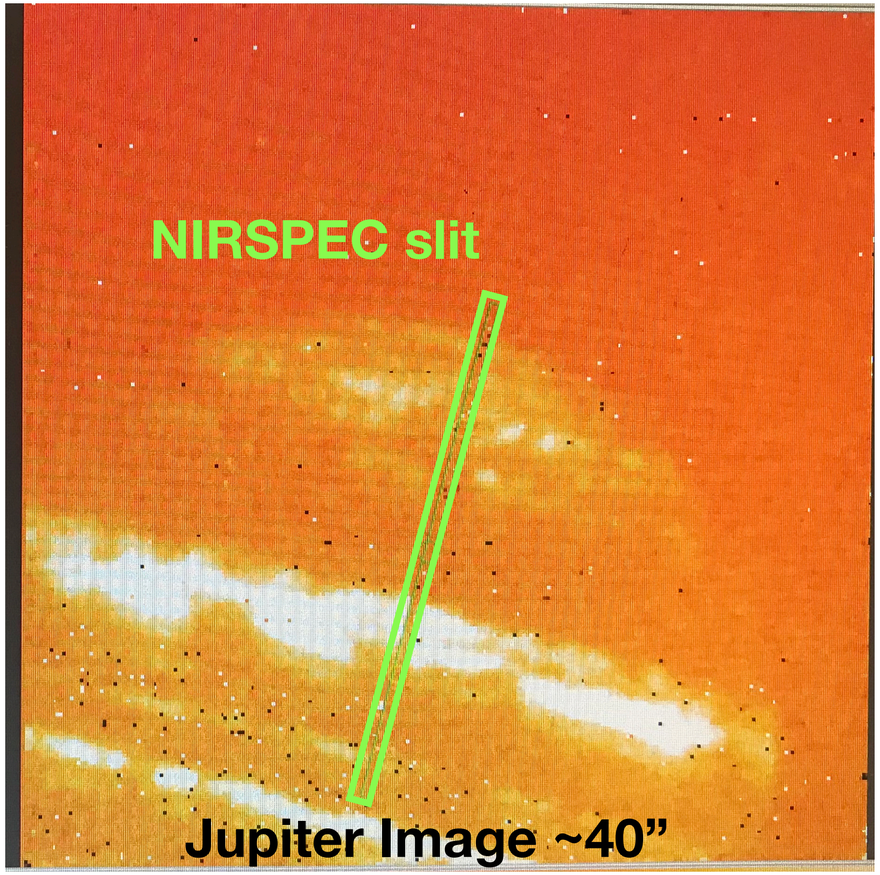
Current observations of Solar System planets do not exist in a comparable form to what we observe with exoplanets

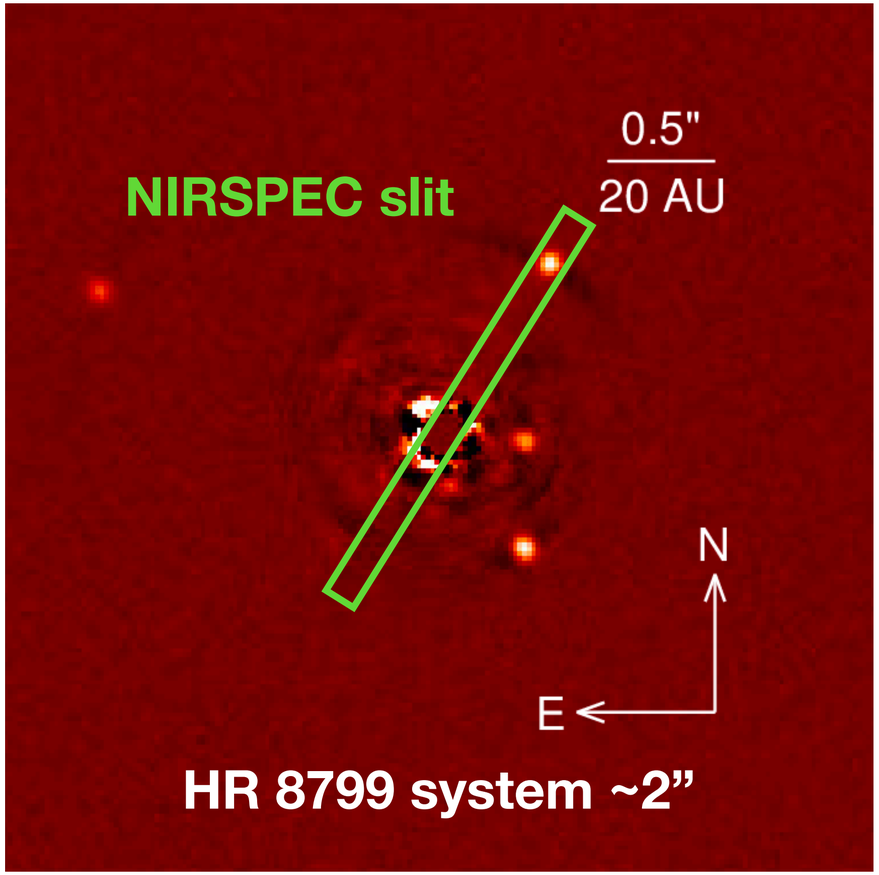
~40”

~2”

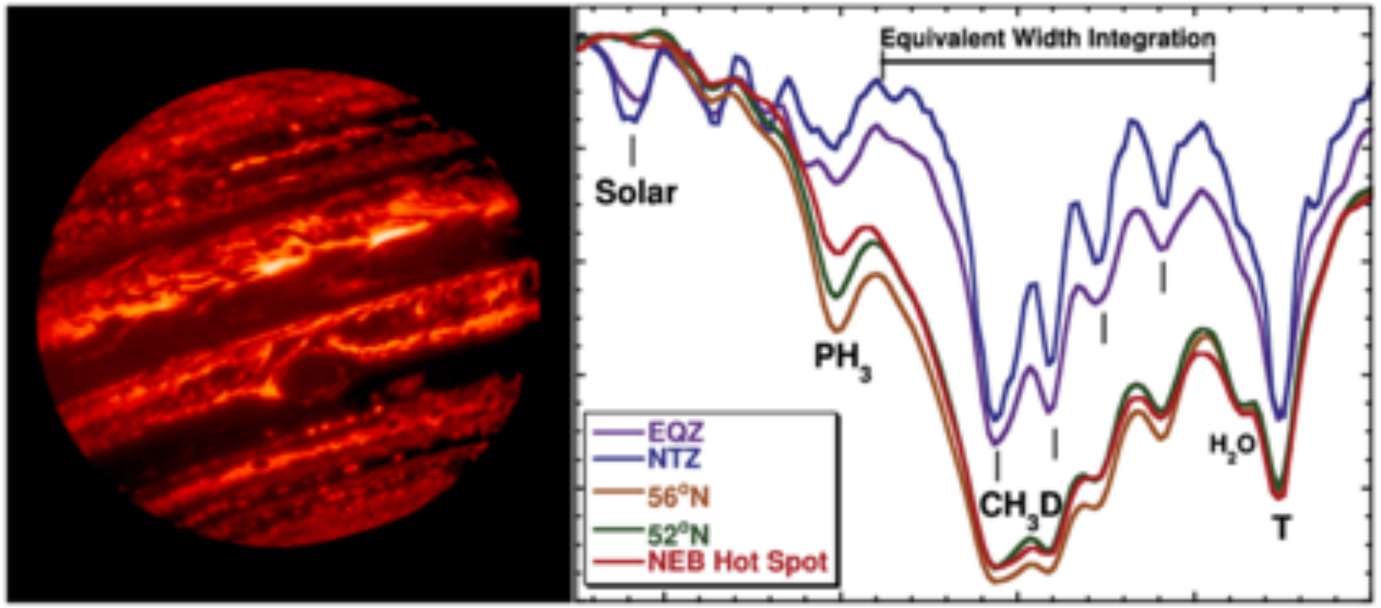


Jupiter vs. Exo-Jupiter with Keck/NIRSPEC

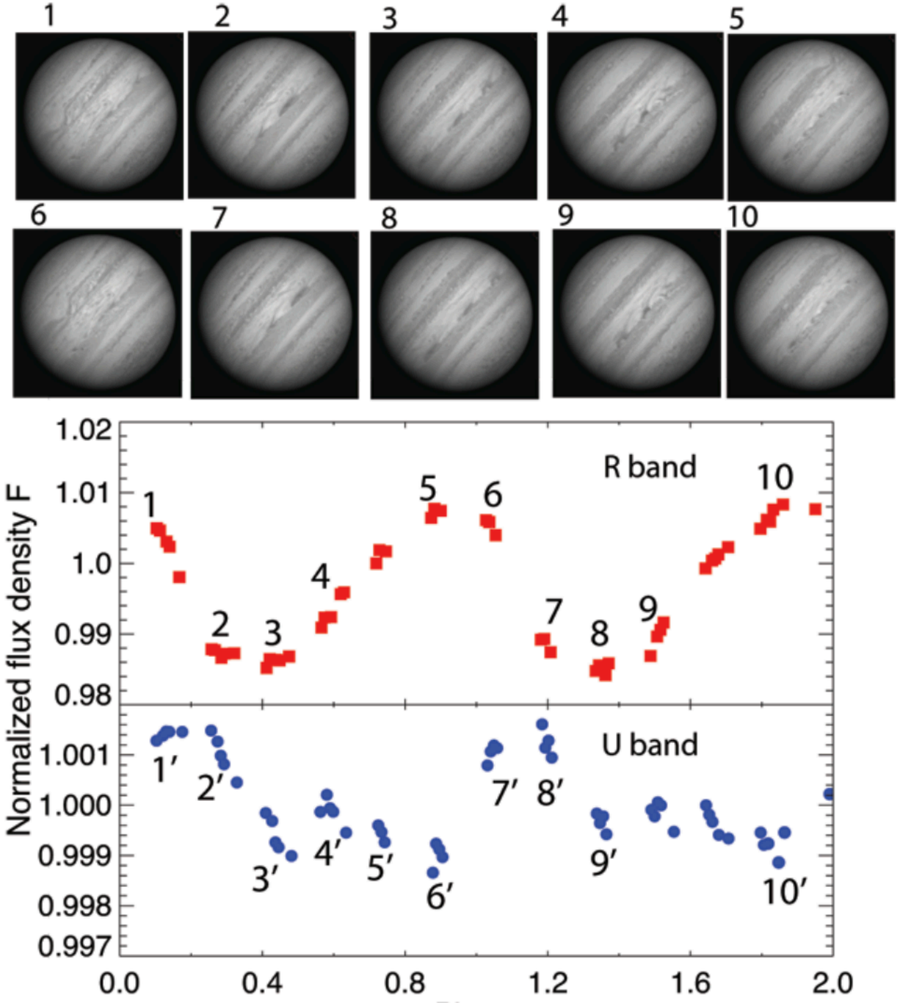




Spatially resolved spectra and imaging show the heterogenous, time-varying structure of Jupiter

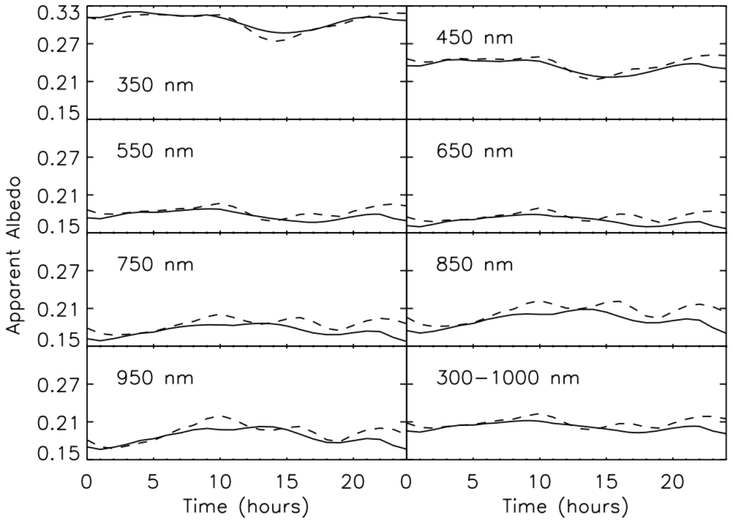


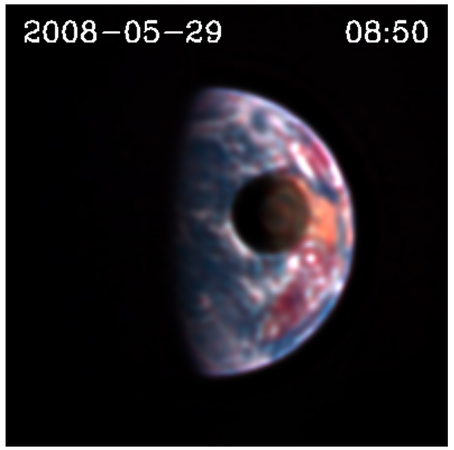
Bjoraker+ 2015



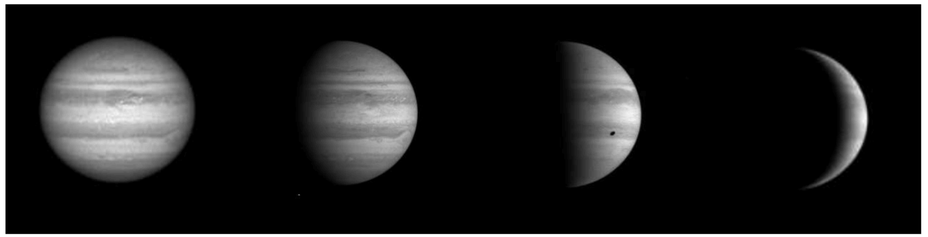
Karalidi+ 2015

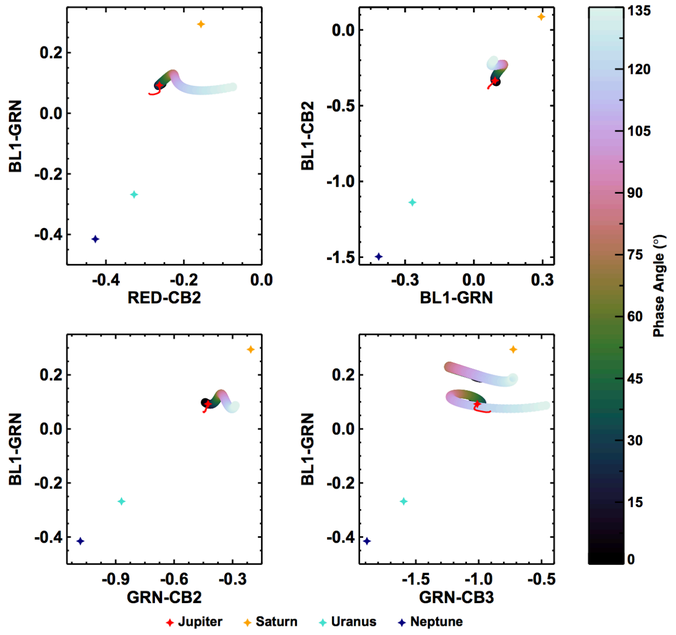
Several missions have used disk-integrated photometry of Solar System planets to study them as “exoplanets”, for example:



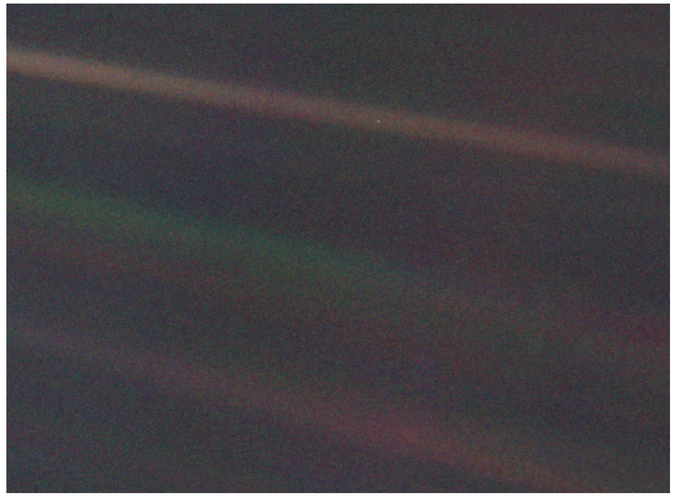


Cowan + 2009 NASA EPOXI mission





Mayorga + 2016 Cassini phase curves of Jupiter

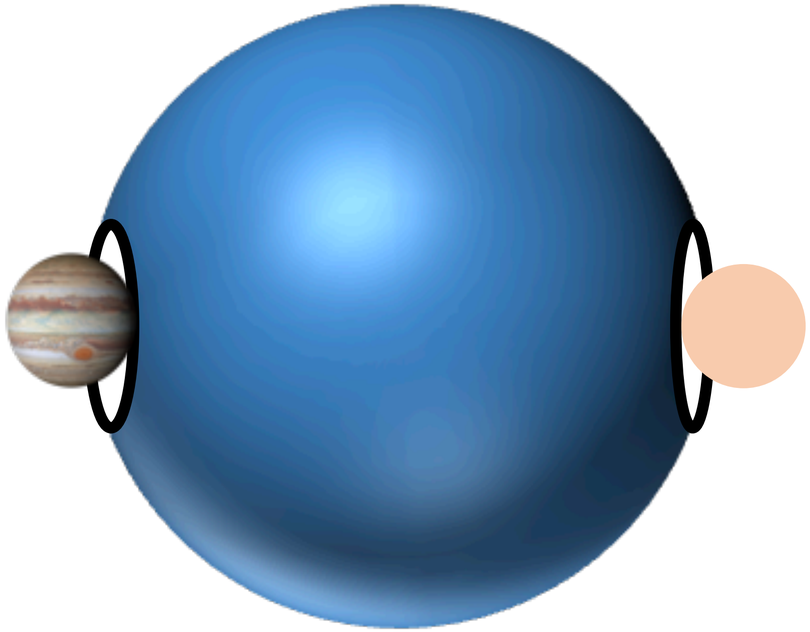


Sagan + 1993
Galileo and the Pale Blue Dot

Enter PEAS:
The Planet as Exoplanet Analog Spectrograph

PEAS will use an integrating sphere to spatially mix the images of Solar System planets to create a globally averaged light to send to a spectrograph

Jupiter, imaged by telescope

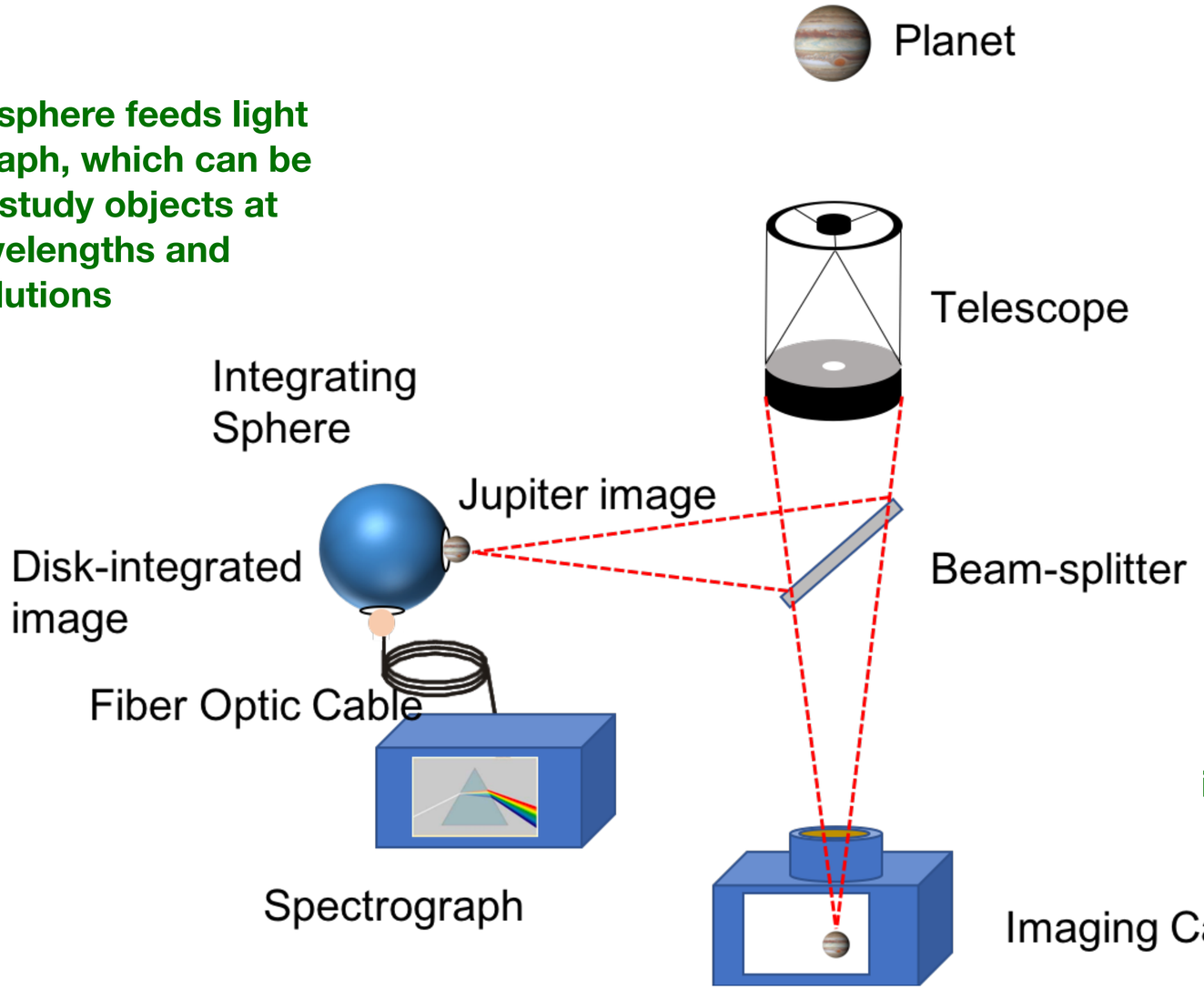


Integrating Sphere

Disk-integrated Jupiter light sent to spectrograph

PEAS Instrument Concept

The integrating sphere feeds light into a spectrograph, which can be exchanged to study objects at varying wavelengths and resolutions



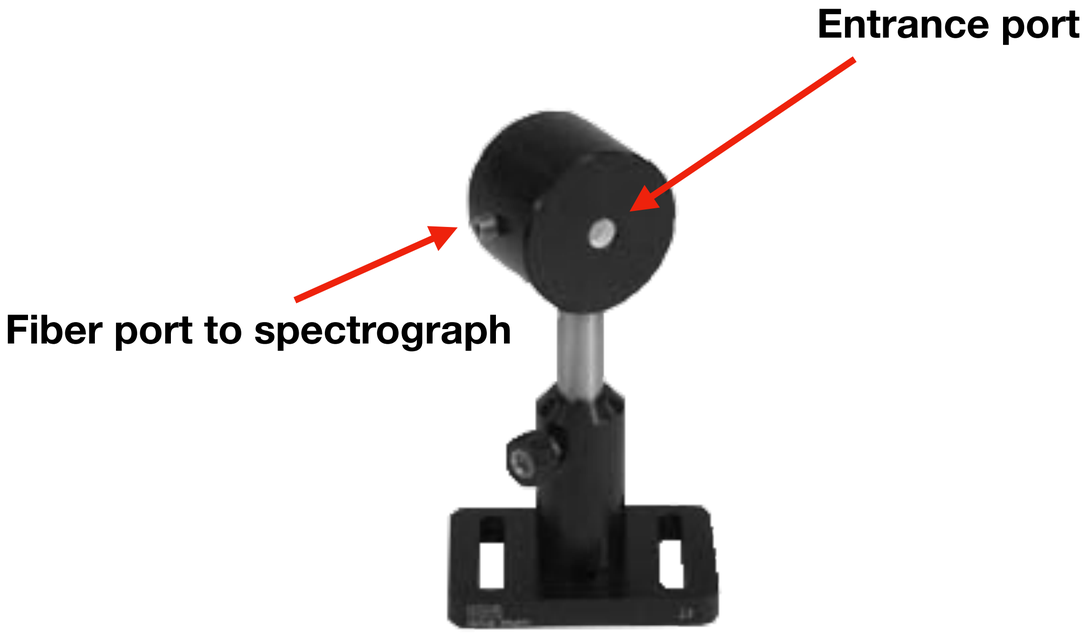
A beam splitter and imaging camera allow for simultaneous imaging (and help with tracking)

Planewave RC-20” (0.51 m) with L500 mount

Hyperbolic primary + secondary
EFL=3544 mm
f/6.98

Pointing Accuracy <10” RMS
Pointing Precision 2”
Tracking Accuracy < .3” error over 5 minute period

Integrating Sphere

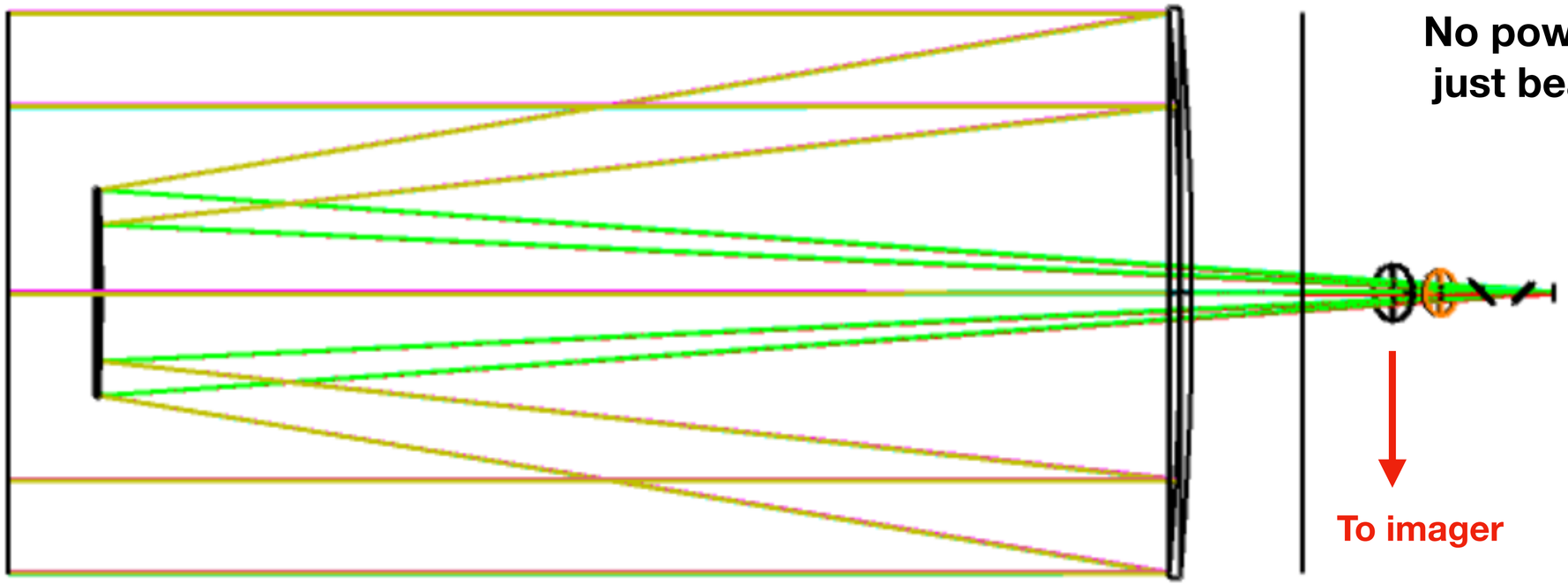


Spectral Products 1” sphere

Integrating Sphere efficiency is a factor of:

- Port fraction (less is better)
- Area of the sphere (smaller is better)
- Fiber coupling (larger NA is better)
- Reflectance (expect ~99%)

Simple Optical Design



No powered optics,
just beam splitters

Integrating
sphere

To imager

X
Z

500 mm

Off-the-shelf spectrograph and camera

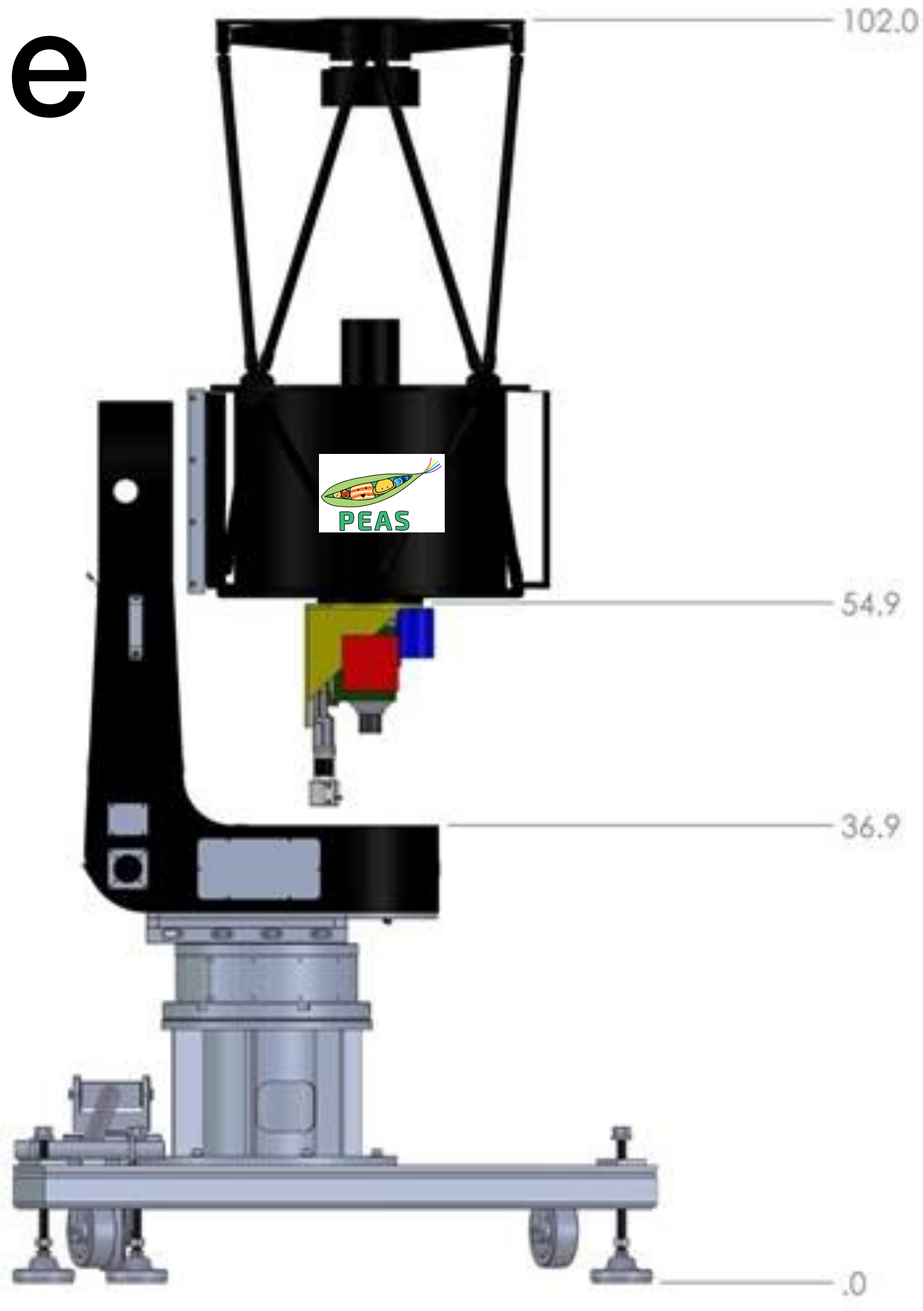
ANDOR Kymera 328-i

Optical spectrograph with 4 grating options
Protected silver coating on all optics
Adjustable slit
iDUS 420 imager

SBIG STF-8300 Imager

3326x2504, 5.4 micron pixels
Optical alignment and simultaneous imaging
350-900 nm

PEAS, to scale



Computer cart:

- Laptop to run telescope, imager, and spectrograph
- Spectrograph

PEAS will live inside the dome of the 120-in at Lick Observatory and will observe from the parking lot to the East

PEAS science mission

Measure atmospheric compositions and trace elemental abundances, compared to in situ or flyby measurements of Solar System planets

Produce 2D surface maps of Venus, Mars, Jupiter, Saturn, Uranus, Neptune

Produce fiducial measurements that will be used to plan instructments for future exoplanet missions, such as HabEx/LUVOIR and TMT/GMT/ELT.

Time-series observations of Solar System planets to explore variability and weather patterns on planets

Study planetary seismology (oscillation modes) of Solar System planets

Produce an atlas of Solar System planet spectra and images observed by PEAS to serve as comparison to ground-truth observations from space missions and to compare to historical data

PEAS instrument timeline

Project Activities	01/20	04/20	07/20	10/20	01/21	04/21	07/21	10/21	01/22	04/22	07/22	10/22
Design Finalized												
All hardware in hand												
Hardware assembled and tested at UCSC	COVID-19 :(											
Commissioning at Lick												
Observe initial Solar System Atlas												
Time-Series Observations												
Compare with atmospheric models and ground-truth												

PEAS is a mission for the whole (exo)planetary community

We'd love your help!

- Data analysis: want to do cool science with disk-integrated spectra of Solar System planets?
    - PEAS will be commissioned **this winter** (COVID willing)
- Modular design: reach out if you have ideas for extras to add on or ideas to change!
    - emilymartin@ucsc.edu