Ariel 2020 Community Meeting

Mark Swain, Principal Investigator

Featuring LCHS Advanced Art II

The Landscape for CASE

- Partner mission contribution to ARIEL (ESA M4)
- Conditionally selected July 2017
- Selected for implementation November 2019
- Studies atmospheres of planets found by Kepler and TESS
- Addresses NASA Science Plan (2014) objective: "Discover and study planets around other stars, and explore whether they could harbor life."
- Outline
  - CASE science requirements
  - CASE hardware delivery
  - ARIEL science scope

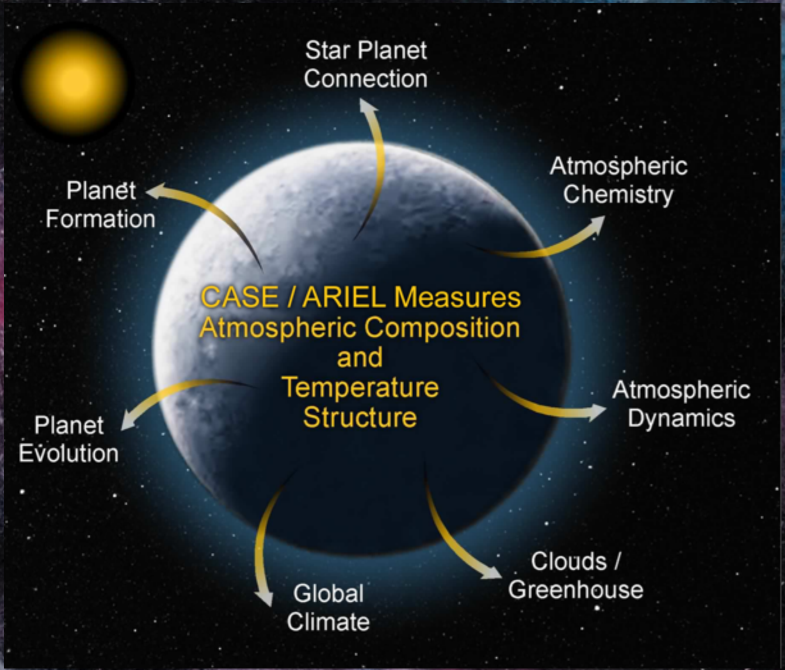
ARIEL Survey

What are planets made of?

How do planets form?

How do planets and their atmospheres evolve?

CASE/ARIEL Survey Synergistic with JWST and Planetary Community



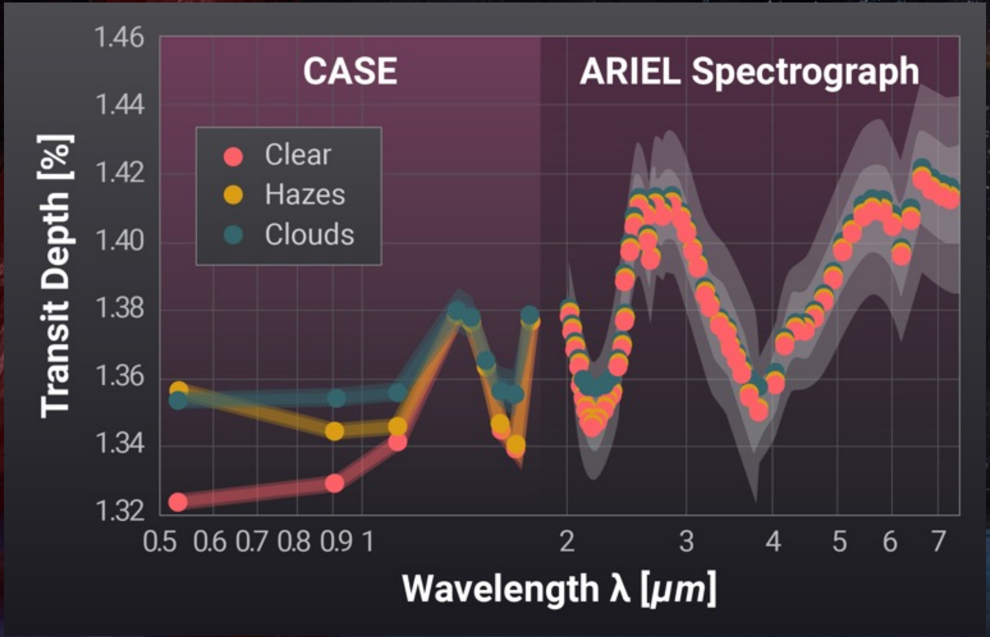
- Connects: Astrophysics and planetary fields
- Reveals how JWST exoplanet observations fit into the larger exoplanet family

CASE and ARIEL revolutionize the field of exoplanet atmospheres

Probing Atmospheres on Kepler and TESS Planets

CASE Science Objectives

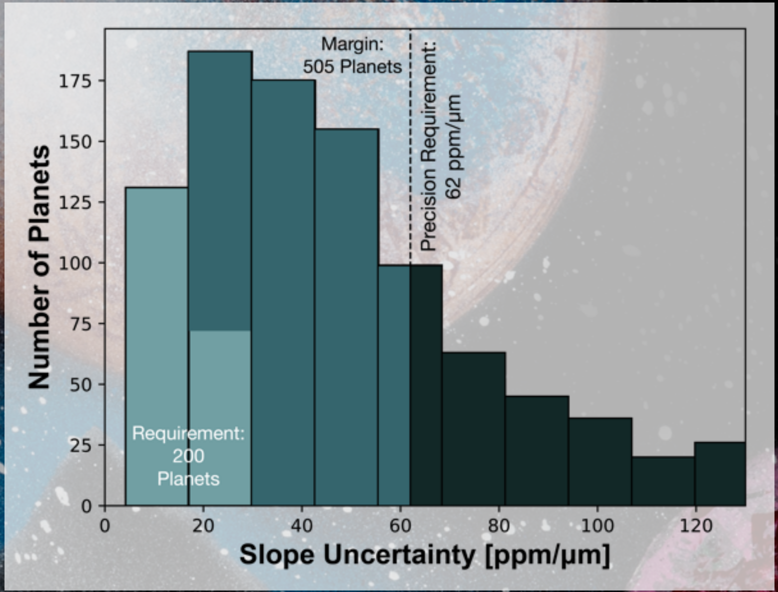
- Determine the occurrence rate of aerosols (clouds and hazes)
- Measure the geometric albedo of exoplanet atmospheres to constrain aerosol composition

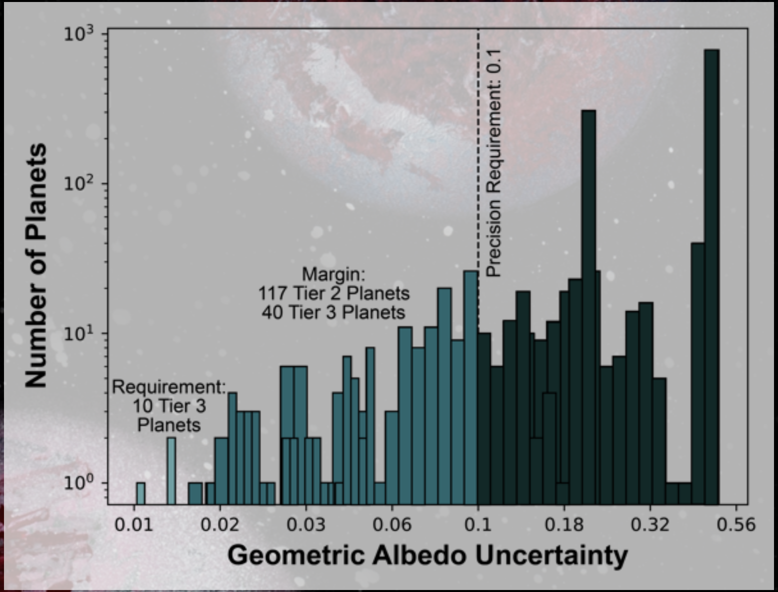


CASE provides aerosol and albedo data products

Large Science Margins

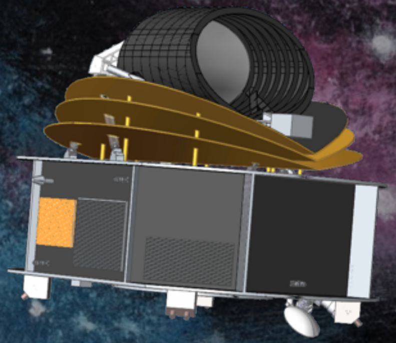
- Aerosol slope precision requirement 310 % margin
- Albedo precision requirement 400 % margin

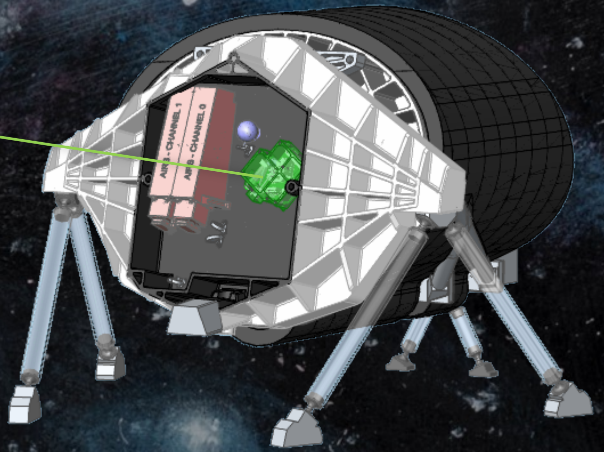




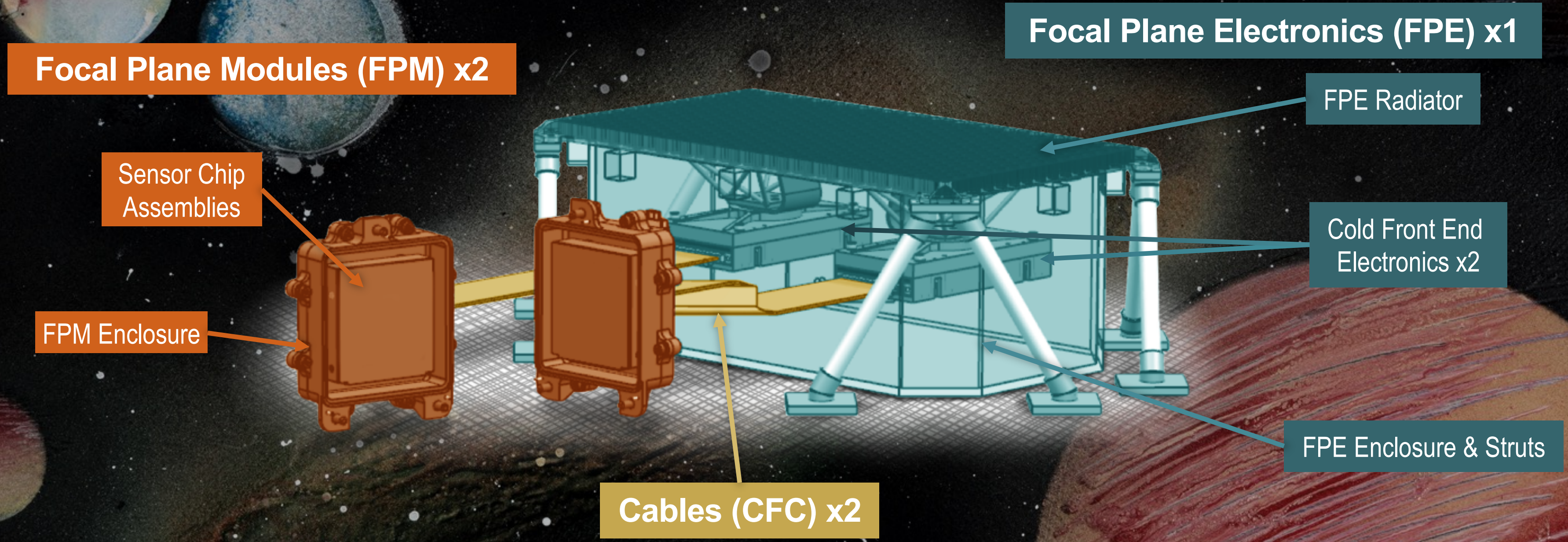
CASE and the ARIEL Payload

- Off-axis 1.1 m × 0.7 m elliptical telescope
- ARIEL Infrared Spectrometer (AIRS): Resolution λ/Δλ=30-200), 1.95 – 7.8 μm
- Fine Guidance System (FGS)
  - Vis-Phot: 0.50μm – 0.55μm
  - FGS1: 0.8μm – 1.0μm
  - FGS2: 1.0μm – 1.2μm
  - NIR-Spec: 1.25μm – 1.95 μm (λ/Δλ=10)



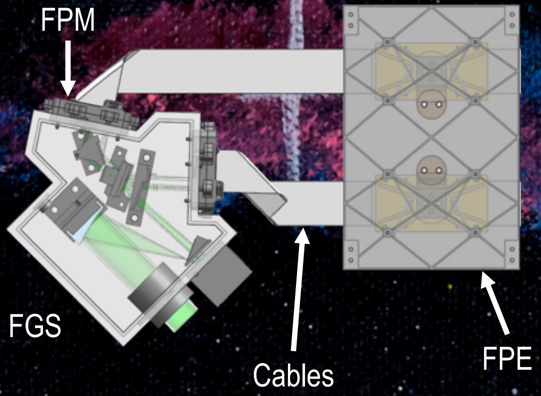


CASE Delivers Simple, Well-Defined Hardware

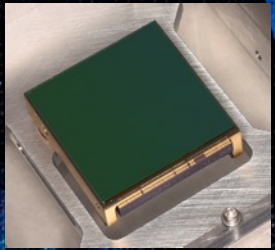


CASE Approach Ensures Successful Implementation

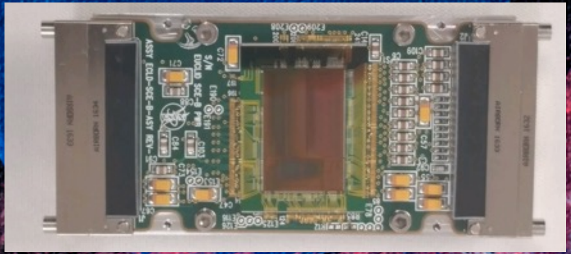
CASE is a subsystem of the ARIEL FGS



CASE reuses Euclid hardware designs



SWIR Detector from Euclid



SIDECAR SCE electronics from Euclid

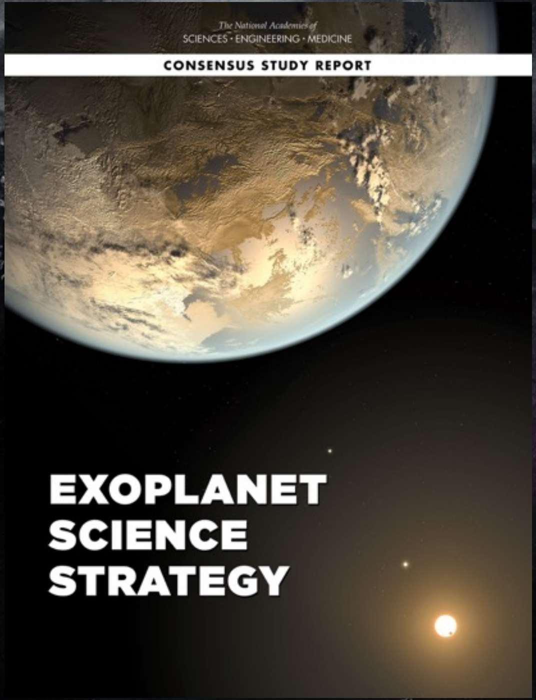
The CASE team is well-integrated with the ARIEL payload team

National Academy of Science

Consensus Study Report:

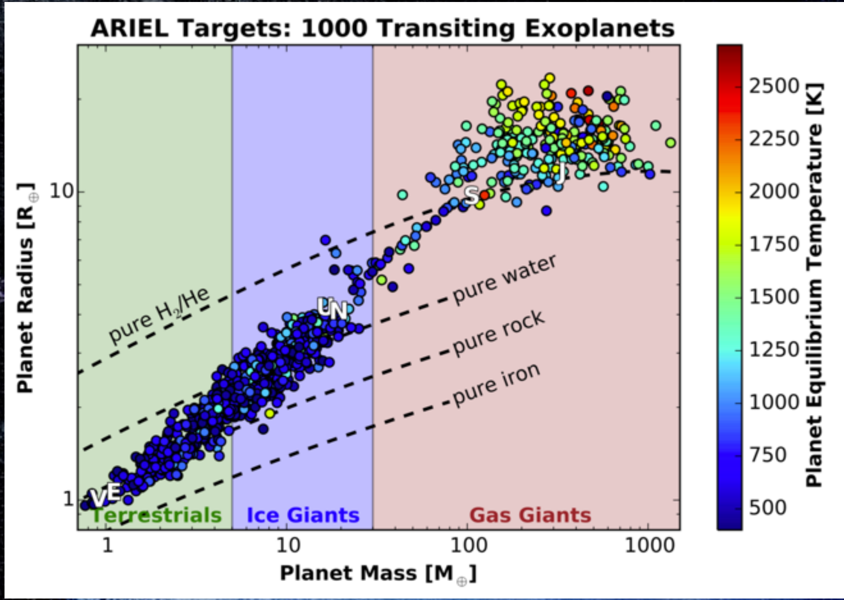
Exoplanet Science Strategy

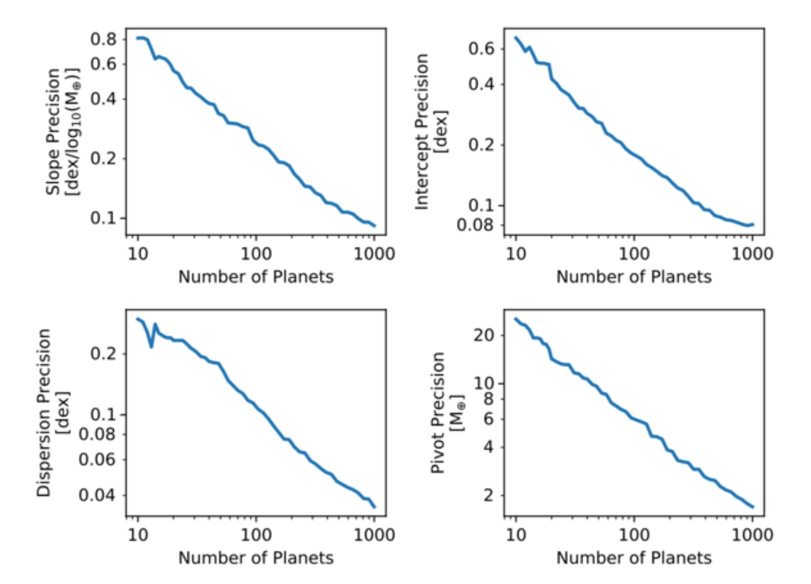
- “The U.S. exoplanet community would benefit from participation in ARIEL.”
- “U.S. scientists would benefit from the CASE mission by participating in the planning, execution, and exploitation of the ARIEL survey.”



Extraordinary Value

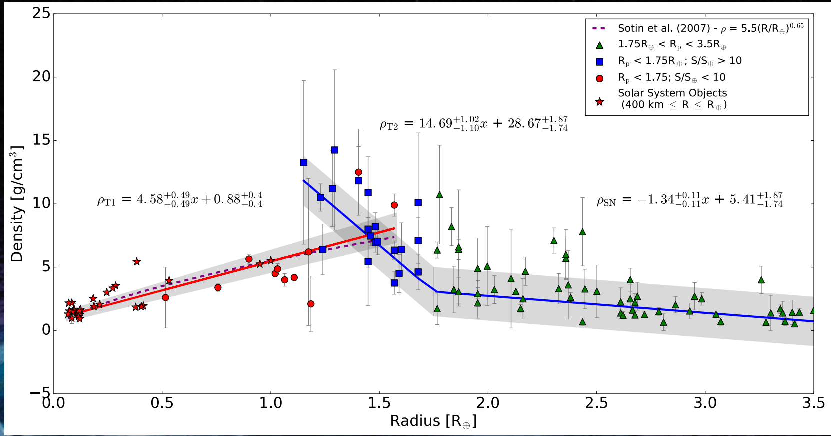
CASE team simulation finds ARIEL Tier 1 survey sample provides excellent constraints on the mass-metallicity relation



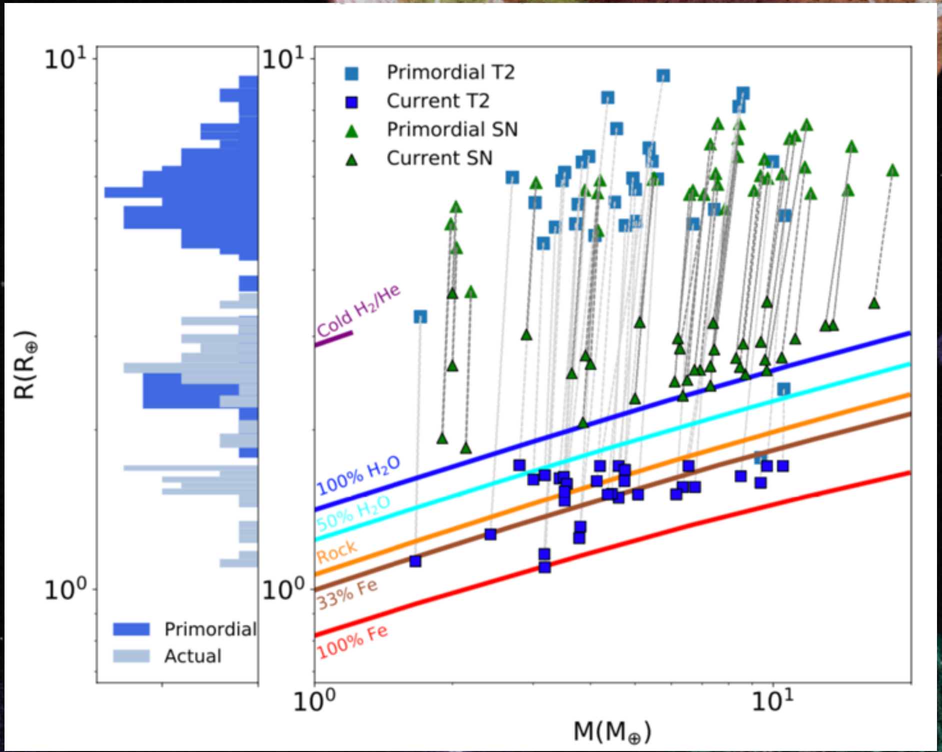


Zellem et al. 2019

ARIEL: provides access to new science opportunities



Swain et al. 2019



Atmospheric evolution: close orbiting sub-Neptunes < 3.5 Rearth have lost ~70% of their primordial H/He envelope. Estrela et al. 2020 submitted.

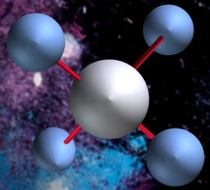
What are Exoplanets Really Like?

Capturing the Public's Imagination

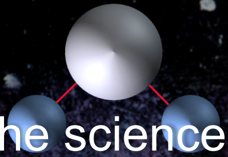
Kennedy Agron, 5th Grade Student at Santa Clarita Elementary School, participating in an outreach event

CASE/ARIEL Benefit to NASA

- CASE/ARIEL data will be used for decades to come, providing a context for future discoveries



- CASE/ARIEL results will be the foundation of the emerging field of exoplanet atmospheres, the field in which the discovery of life outside of our solar system will be made

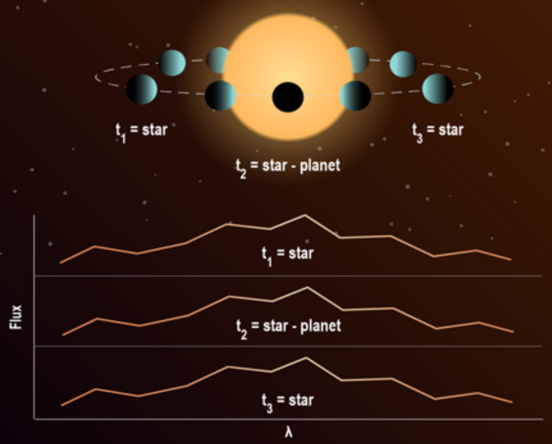


- A legacy that goes beyond the science and shows, for the first time, how our solar system fits into the extended planet family

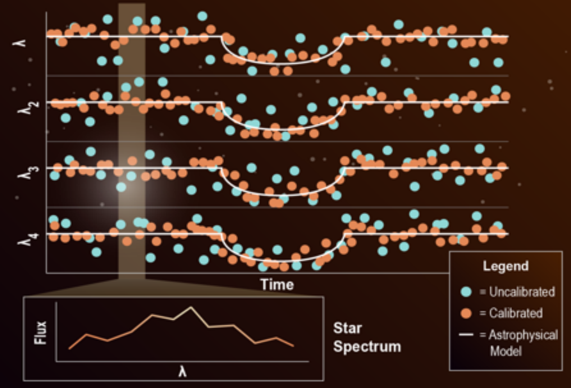
CASE – a historic NASA opportunity

BACK UP

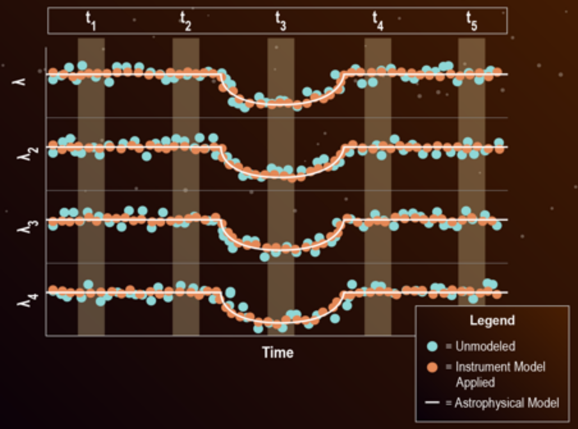
1 CASE records spectra (flux vs wavelength) of the light emitted by the star-planet system as the planet passes in front of the star.



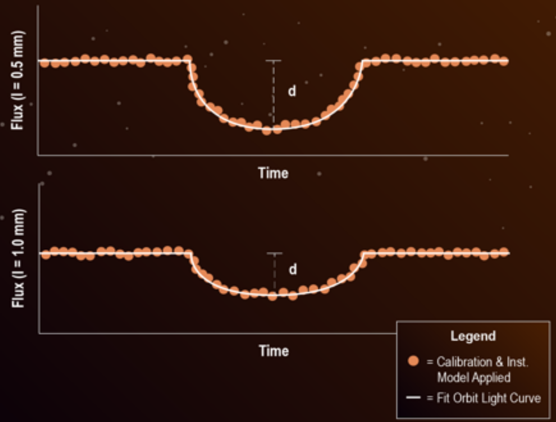
2 The measurements of the passage of the planet in front of the star are recorded at different wavelengths. We can view the star spectrum by taking data from a time either before or after the planet passes in front of the star. The data are calibrated which reduces the scatter around the astrophysical model. But there is still residual measurement scatter even after calibration.



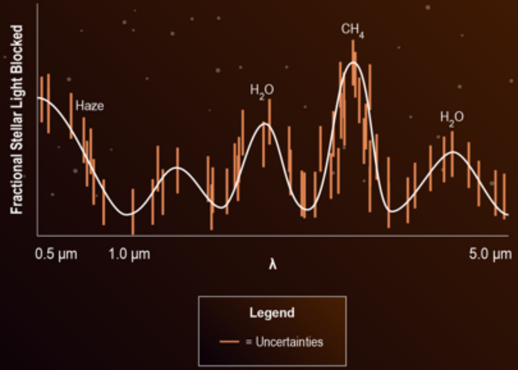
3 Further improvement in the measurement quality is possible by creating an instrument model and applying it to the data. The key science observable is how the spectrum changes during the measurement interval.



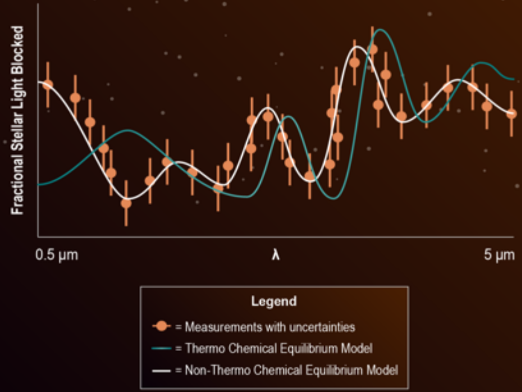
4 A light curve fit is performed at each spectral channel to determine the transit depth "d". The transit depth is a measure of the opacity in each spectral channel.



5 A planet without an atmosphere would have a uniform response. In a channel where the atmosphere has strong absorption, the exoplanet appears larger (more light blocked). Thus, change in fractional light in a spectral channel corresponds to a particular chemical constituent.



6 A retrieval algorithm is used to determine atmospheric composition. Exoplanet model parameters are varied, opacity is predicted and compared to measured and iterated to arrive at a best-fit of exoplanet atmospheric model.



CASE Science Team

Team Member	Role
Mark Swain (JPL)[1]	Principal Investigator
Robert Green (JPL)[1]	Instrument Scientist
Gautam Vasisht (JPL)[1]	Deputy Instrument Scientist
Gael Roudier (JPL)[1]	Data Subsystem Lead
Edward Wright (UCLA)[1]	Statistical processing expertise
Jacob Bean (U. Chicago)[1]	Science Team Lead, calibration
David Ciardi (IPAC)[1,2]	Archiving Lead
Nicolas Cowan (McGill)[3]	Climate and phase curve science
Jonathan Fortney (UCSC)[1]	Theory Lead
Caitlin Griffith (UoA LPL)[1]	Comparison with solar system
Eliza Kempton (U. of Maryland)[1]	Cloud models
David Latham (Harvard/SOA)[1]	TESS target coordination
Michael Line (ASU)[1]	Spectral retrieval
Suvrath Mahadevan (Penn State)[1]	Exoplanet masses
Jorge Melendez (U. São Paulo)[3]	Stellar characterization
Julianne Moses (SSI)[1]	Atmospheric chemistry
Vivien Parmentier (University of Oxford)[3]	Modeling condensable aerosols
Adam Showman (UoA LPL)[1]	Atmospheric dynamics
Andrew Howard (Caltech)	Exoplanet demographics
Laura Kreidberg (Harvard/SAO)[3]	Transit spectroscopy calibration
Evgenya Shkolnik (ASU)[3]	Stellar UV flux and star spots
Kevin Stevenson (STScI)[3]	HST/JWST coordination
Yuk Yung (Caltech)[3]	Atmospheric chemistry

Key

- Mission Development and Operations Co-Is (Mark Swain through Gael Roudier)
- Science Team Co-Is (Edward Wright through Adam Showman)
- Science Team Collaborators (Andrew Howard through Yuk Yung)

CASE Partners

TELEDYNE TECHNOLOGIES Everywhereyoulook™

Detectors and Electronics

Markury SCIENTIFIC

Firmware

Goddard SPACE FLIGHT CENTER

Characterization

ipac

Archive

ARIEL

Mission and Science

ARIEL will Detect Large Numbers of Atmospheric Gases

ARIEL/AIRS spectral range (1.95–7.8 µm; R=30 -100) covers all major atmospheric gases as well as exotic metallic compounds and condensed species.