

Far-infrared Space Astronomy Science Gaps beyond 2030

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Institute of Technology

PRIMA Team

Origins Science & Technology Definition

Team

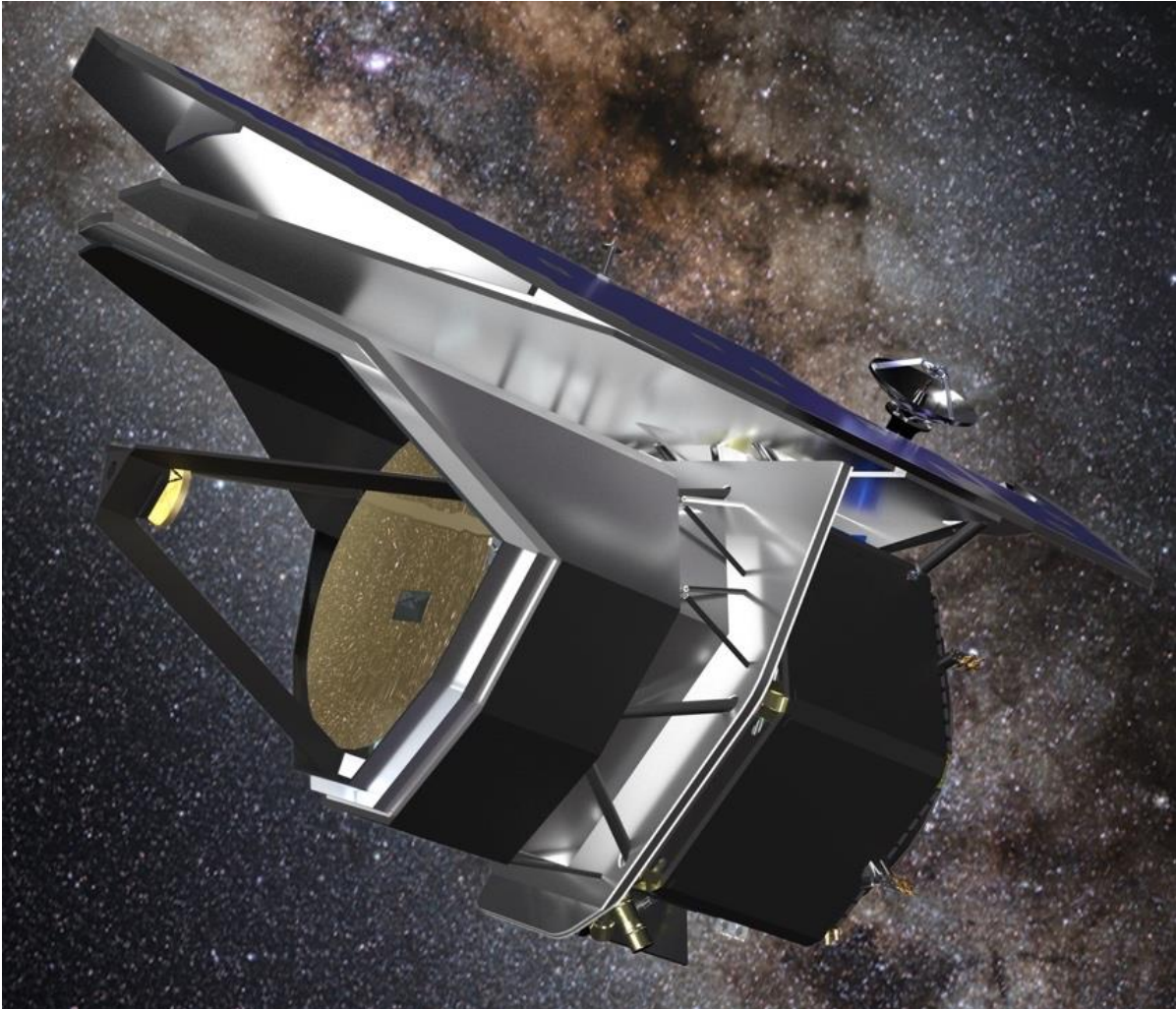
09.01.2026



Jet Propulsion Laboratory
California Institute of Technology

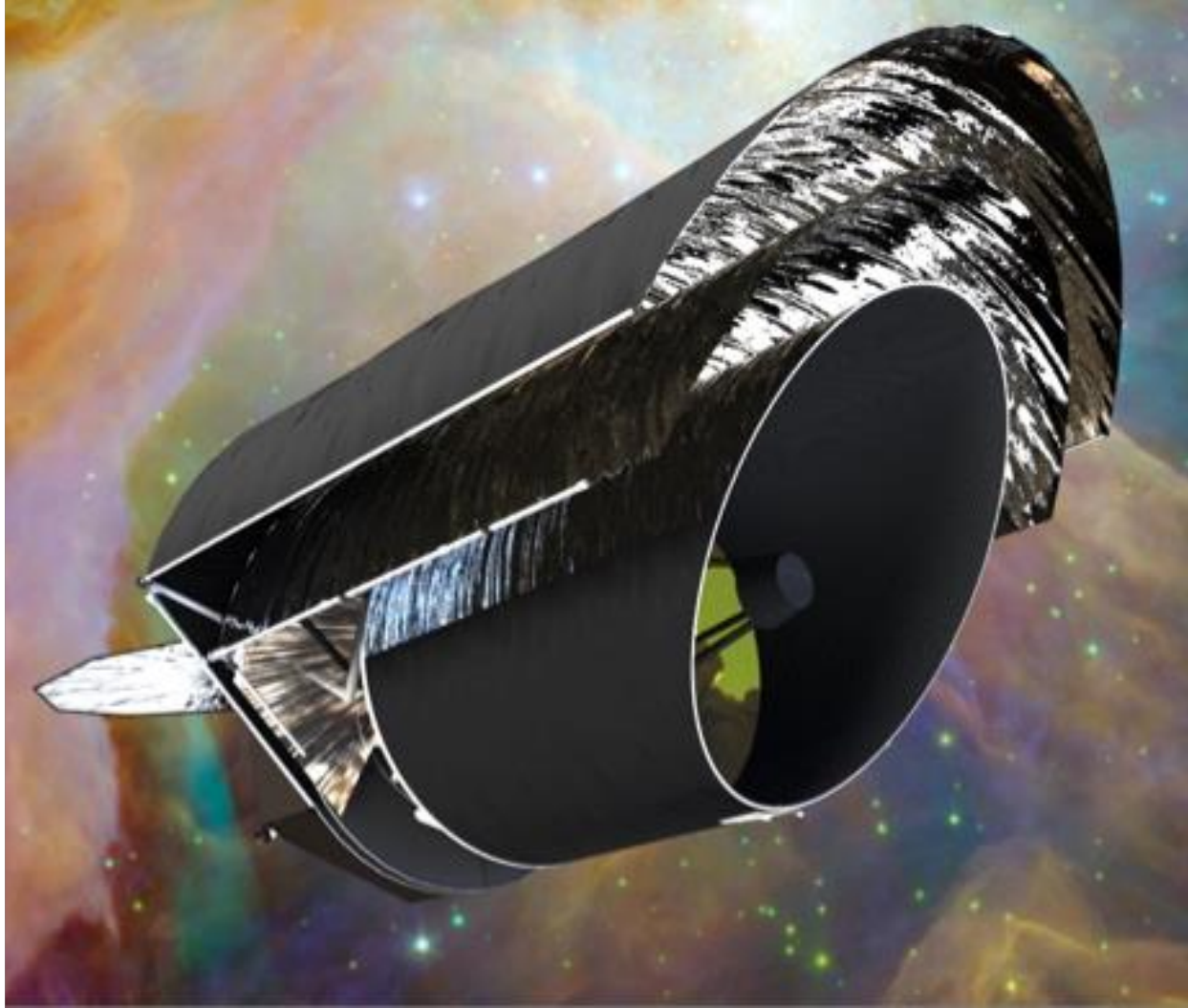


PRobe far-Infrared Mission for Astrophysics (PRIMA), Probe Class



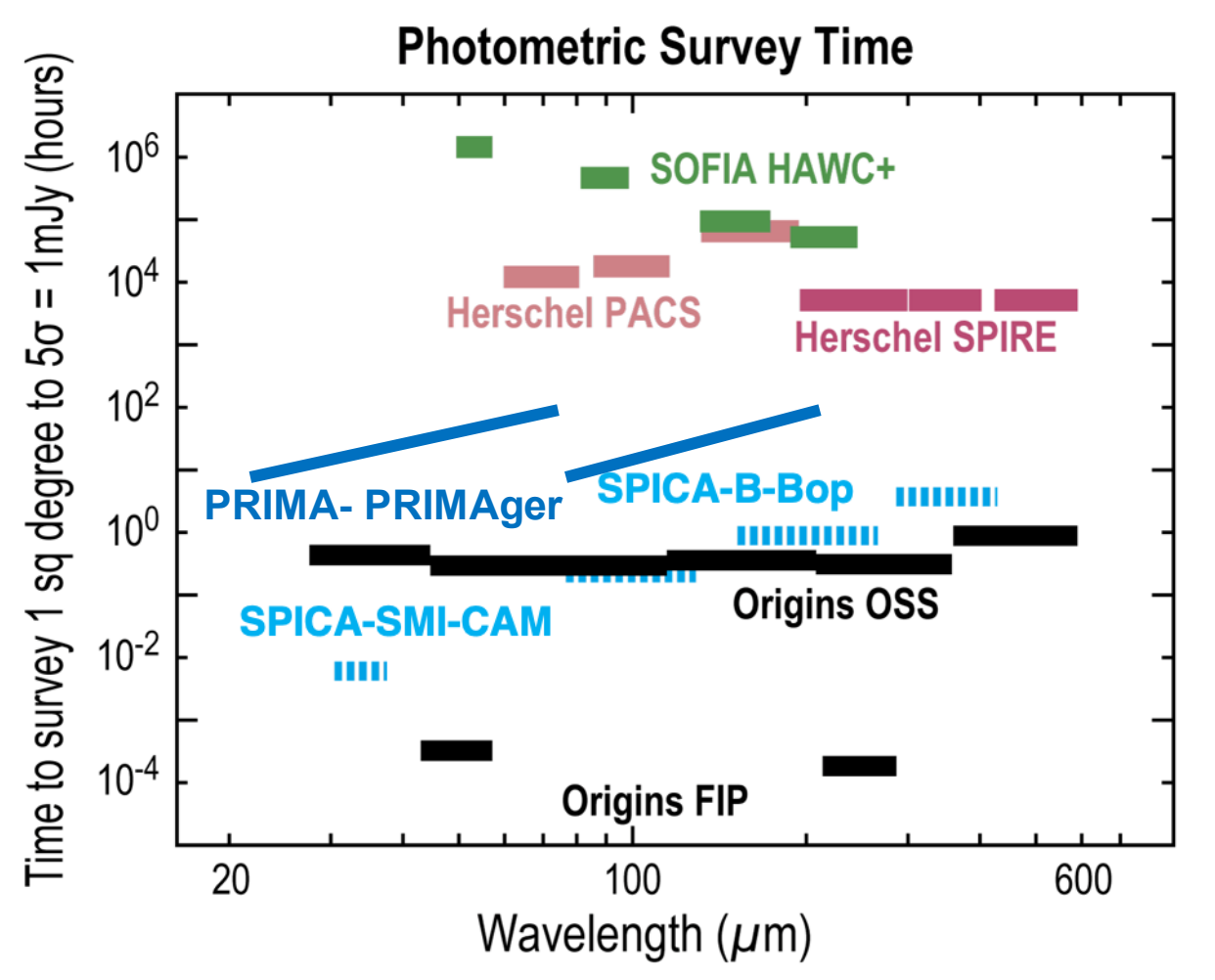
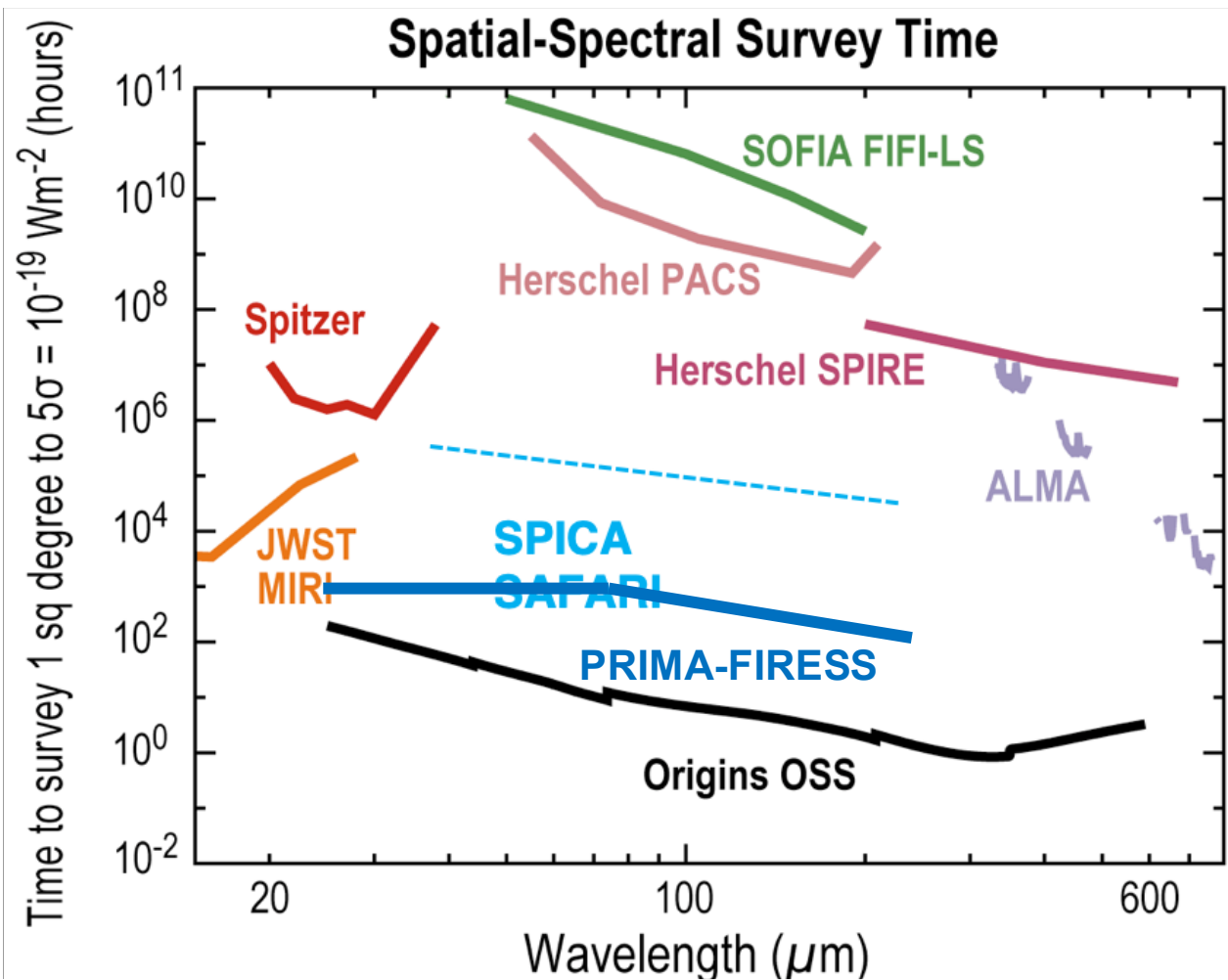
Telescope	1.8-m, all aluminum, 4.5 Kelvin
wavelength	24-261 μm
PRIMAger Imager & polarimeter	R = 10 hyperspectral imaging 25-80 μm R= 4 imaging & polarimetry 91-261 μm
FIRESS Spectrometer	R > 85 spectroscopy 24-235 μm High-Res mode R = 4,400 x ($112\mu\text{m}/\lambda$)
Detectors	100 mK KID arrays (~12k total)
Data	IPAC
Orbit	Earth-Sun L2
Launch	2032
Observations	75% GO, 25% PI ($\rightarrow$ GI)

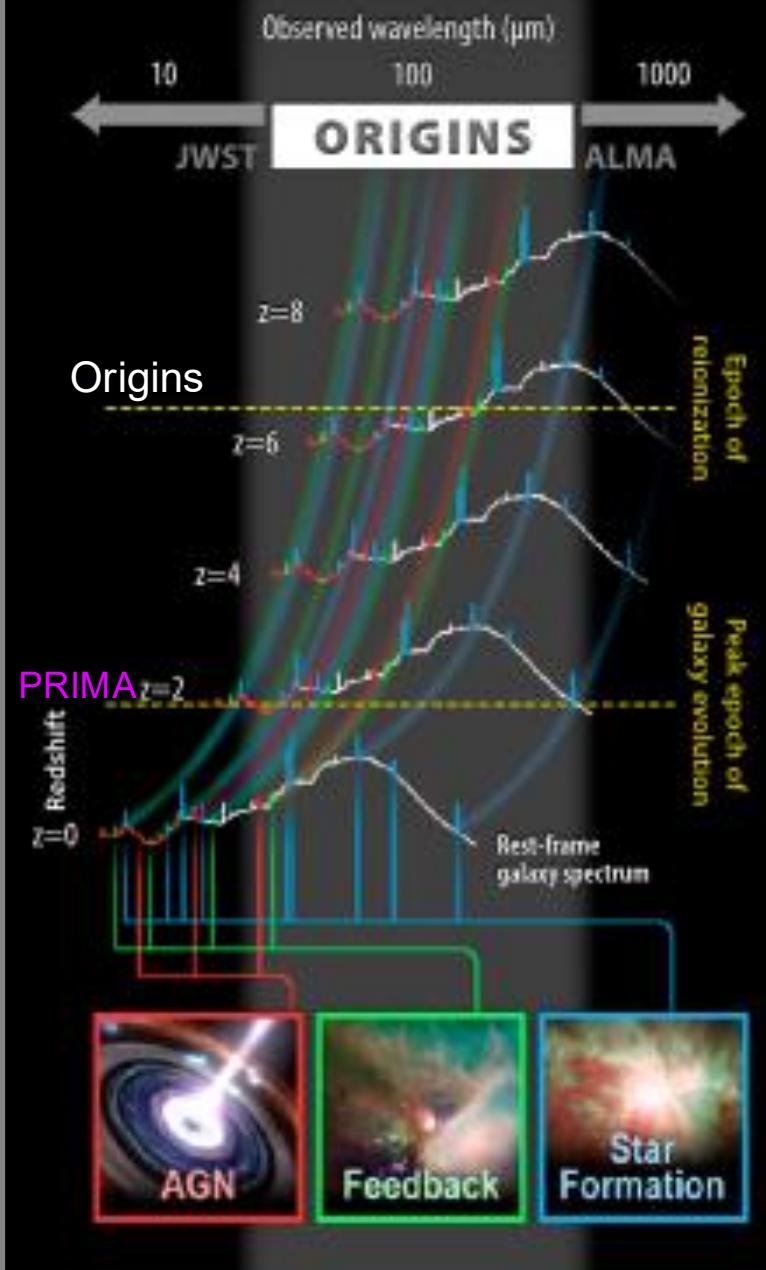
Origins Space Telescope (*Origins*), Flag Ship Class



Telescope	5.9-m (JWST collecting area), 4.5 Kelvin
wavelength	2.8-588 μm
MISC-T Transit spectrometer	R =50-295, 2.8-20 μm Ultra-stable (more than JWST)
OSS Survey Spectrometer	25-588 μm : R ~ 300 survey map High-Res mode R ~ 43,000 100-200 μm : R ~ 325,000
FIP Far-infrared Imager Polarimeter	50 or 250 μm : polarimetric imaging 1.75" @ 50; 8.75" @ 200 PSF/FWHM
Detectors	KID arrays or TES arrays
Orbit	Earth-Sun L2

PRIMA vs. Origins Sensitivity





Origins Theme 1: How do galaxies form stars, build up metals, and grow their supermassive black holes from Reionization to today?

Origins Science Objective 1: Measure the redshifts, star formation rates, and black hole accretion rates in main-sequence galaxies since the Epoch of Reionization, down to SFR $1 M_{\text{sun}}/\text{yr}$ at $z \sim 3$ and $10 M_{\text{sun}}/\text{yr}$ at $z \sim 5$, the first unbiased survey of the co-evolution of stars and SMBHs over cosmic time.

Origins Science Objective 2: Measure the metal content of galaxies with a sensitivity down to 10% Solar in a galaxy with a stellar mass similar to the Milky Way at $z=6$, as a function of cosmic time, tracing the rise of heavy elements, dust and organic molecules across redshift, morphology and environment.

Origins Science Objective 3: Determine how energetic feedback from AGN and supernovae regulate galaxy growth, quench star formation, and drive galactic ecosystems, by measuring galactic outflows (using OH absorption lines) as a function of SFR, AGN luminosity and redshift over the past 10 Gyr.

PRIMA PI: Measure the star formation rates and black hole accretion rates in luminous galaxies since the peak epoch of galaxy evolution/star formation ($z=0.5-2.5$, a.k.a. cosmic noon).

PRIMA PI: Measure the metal and polycyclic aromatic hydrocarbon (PAH) content of galaxies with metallicity as low as 30% solar cosmic noon ($z=0.5-2.5$). Calibrate N/O metallicity relation in a local galaxy survey.

PRIMA PI: Measure polarization in nearby galaxies to distinguish how the structure of interstellar dust grains change across environments.

PRIMA PI: Determine if winds in luminous galaxies ($z=1.0-2.0$) quench star formation by measuring the cool, molecular component using absorption OH lines.

Origins Theme 2: How do the conditions for habitability develop during the process of planet formation?

Origins Science Objective 1: Measure the water abundance at all evolutionary stages of planet formation and across the range of stellar mass tracing water vapor and ice at all temperatures between 10 and 1000 K.

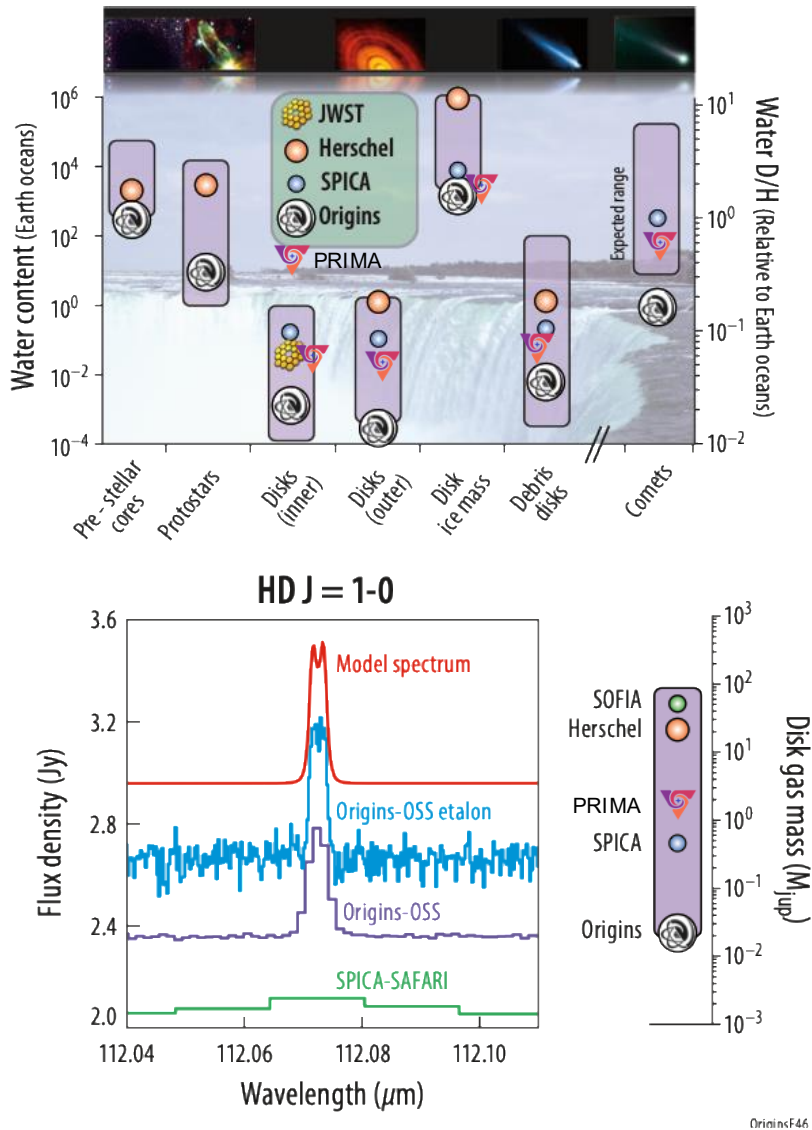
PRIMA PI: Measure water mass near the snowline of protoplanetary disks to determine if there is enough to drive the formation of planetesimals and giant planet cores.

Origins Science Objective 2: Determine the ability of planet-forming disks at all evolutionary stages and around stars of all masses to form planets with masses as low as one Neptune with a confidence of at least 99% using the HD 1-0 line to measure the total disk gas mass.

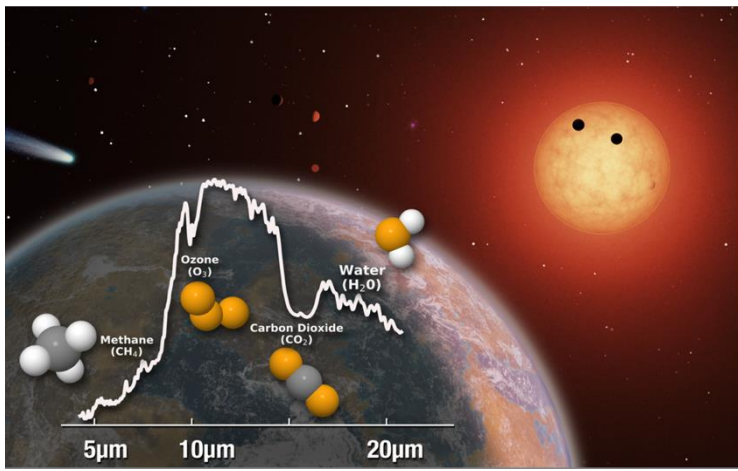
PRIMA PI: Determine if protoplanetary disks in regions of planet formation have nonsolar carbon and oxygen abundances by measuring the total disk gas mass using the HD 1-0 line to understand the origins of transiting giant exoplanets.

Origins Science Objective 3: Definitively determine the cometary contribution to Earth's water by measuring the D/H ratio with high precision (>0.5 VSMOW) in over 100 comets in 5 years by measuring the HDO and H_2O lines in 100 comets.

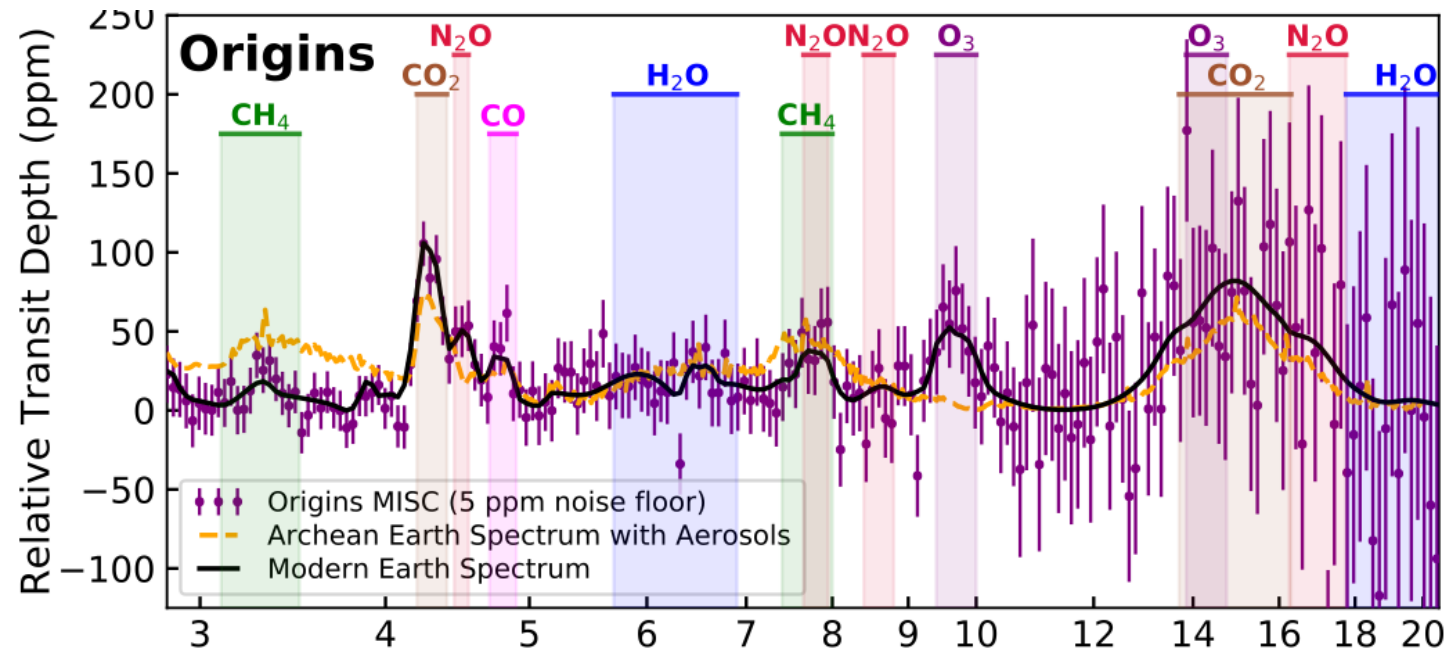
PRIMA GO: A General Observer (GO) case tackles some of these observations.



Origins Theme 3: Do planets orbiting M-dwarfs support life?



Origins Science Objective 1: Distinguish between tenuous, clear, and cloudy atmospheres on at least 28 temperate, terrestrial planets orbiting M and K dwarfs using CO_2 and other spectral features.



Origins Science Objective 2: Establish the apparent surface temperatures of at least 17 terrestrial exoplanets with the clearest atmospheres and distinguish between boiling and freezing surface water at >3 sigmas confidence ($\pm 33\text{K}$).

Origins Science Objective 3: Search for biosignatures on at least 10 planets, highest ranked from Objectives 1 and 2, and if present, detect biosignatures at >3.6 sigma (assuming an Earth-like atmosphere).

Origins Objectives: remaining questions from science drivers

- Investigations of galaxy evolution starting at the Epoch of Reionization ($z=6$);
 - PRIMA may see the brightest of galaxies at this redshift, but not a statistical sample
 - Studies of super massive black holes, star formation, dust and gas could be studied at these higher redshifts
- Investigations of lower mass protoplanetary disks around lower mass stars and later stages of disk evolution
 - water and gas mass (HD line) studies of M stars
 - water and gas mass (HD line) studies of debris systems
 - Studies of more and distant comets
- Investigations of terrestrial planets orbiting M-dwarfs
 - Not touched by PRIMA (wavelength stops at 24 microns)
 - JWST will make headway, but likely need a new mission to test habitability of these
- Discovery space for Origins Space Telescope is much larger than for PRIMA, so GO potential is even higher,
 - For both Origins and PRIMA more GO programs than time on the missions.

Origins and PRIMA Objectives: questions drove maximum sensitivity within budget (telescope aperture) constraints. What if questions would benefit from higher angular resolution?

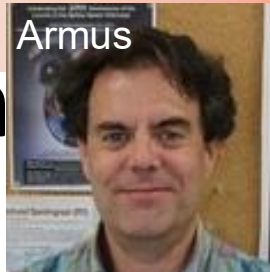
- Studies of planetary system formation that directly observe a forming exoplanet within a protoplanetary disk would provide significant insight into the formation of planets with evolutionary stage of a forming star.
- Studies of exoplanets require higher point source sensitivity and shorter wavelengths
- Forming free-floating Jupiters and brown dwarfs require really high point source sensitivity far-infrared observations
- Formation of the SMBH and galaxies require both higher angular resolution and sensitivity of really high red-shift galaxies
- High angular resolution measurements of far-infrared polarization could teach us more about the variation in dust and how magnetic fields in galaxies change on a wide range of scales.

An international team of
astro/ technology
experts

Co-I's shown, plus a
strong corps of
engineers at JPL,
GSFC, & BAE Systems

Partner Institutions
JPL • GSFC • BAE
Systems (prev. Ball) •
ASI / INAF • Cardiff •
IPAC • LAM • MPIA •
SRON

+ science affiliates
+ *many* community science
working group members!!



Armus



Baselmans



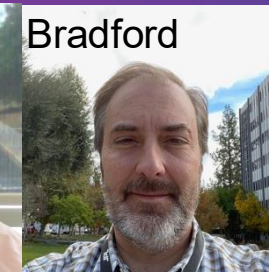
Battersby



Bergin



Bolatto



Bradford



Burgarella



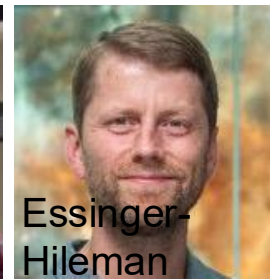
Ciesla



Cleeves



Dowell



Essinger-
Hileman



Glenn



Di Giorgio



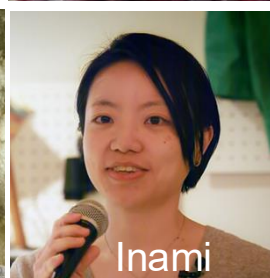
Gruppioni



Henning



Hensley



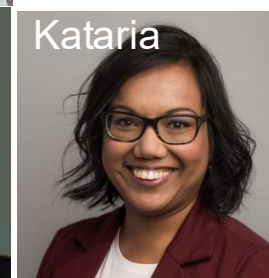
Inami



Jellema



Jeong



Kataria



Kogut



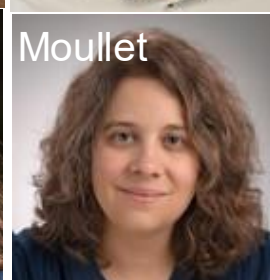
Krause



Meixner



Mills



Moullet



Oliver



Pontoppidan



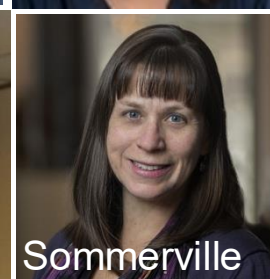
Pope



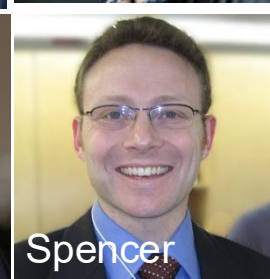
Sauvage



Smith



Sommerville



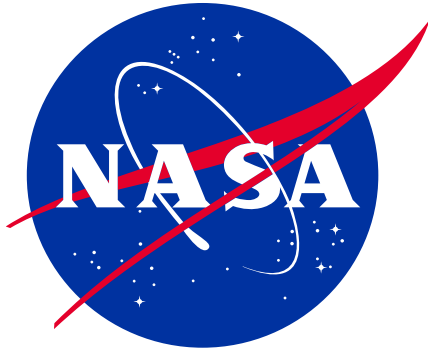
Spencer



Staguhn



Origins Science and Technology Definition Team



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