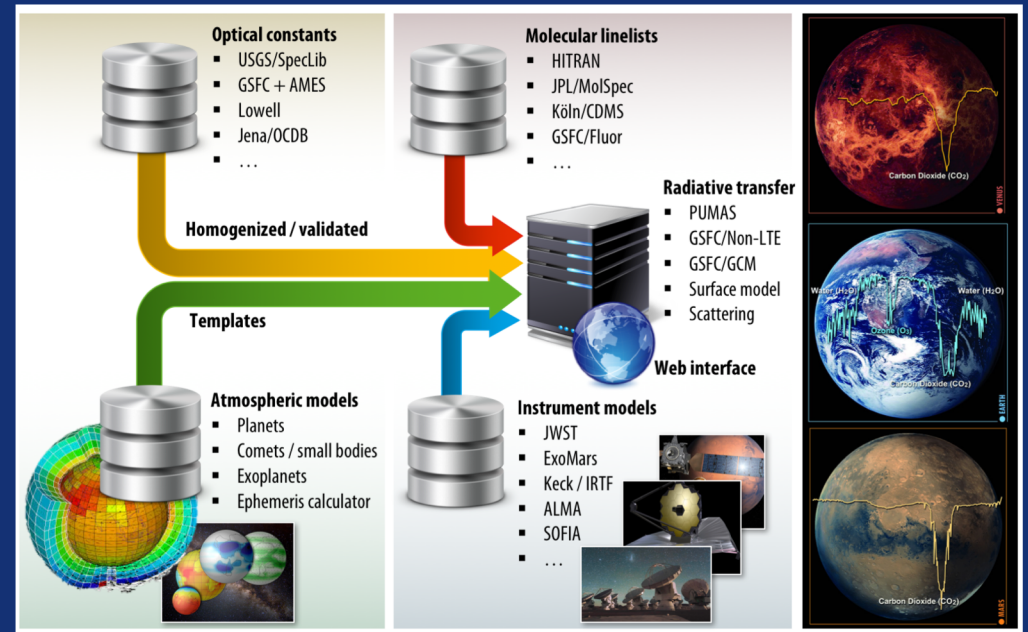


Exploring Potential Targets for the Roman Coronagraph: Some Deeper Dives

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Supported by Roman Turnbull SIT, Sellers
Exoplanet Collaboration, CRESST II

Simulating Reflected Light Spectra with the Planetary Spectrum Generator



Flexible radiative transfer suite that allows the public to implement targeted observing scenarios – see Villanueva et al. (2018)

Ups And d as a Direct Imaging Target

WFIRST-AFTA

Planet name	Planet SMA (AU)	Planet mass (MJ)	Separation (arcsec)	Contrast (rel to star)	Integration time (days)
HD62509b	1.69	2.9	0.1558	2.08E-08	0.0007
HR8974b	2.05	1.85	0.1389	1.39E-08	0.0128
Ups And d	2.55	10.19	0.1805	8.74E-09	0.0298
47 Uma b	2.1	2.53	0.1427	1.34E-08	0.1093
Ups And e	5.25	1.059	0.3717	2.09E-09	0.1995
HD192310c	1.18	0.075	0.1265	2.35E-08	0.2092
47 Uma c	3.6	0.54	0.2446	4.32E-09	0.2353
HD176051b	1.76	1.5	0.113	1.88E-08	0.4871

Recognized as a potentially interesting high contrast target in the 2015 SDT report – but appeared to pose IWA concerns.

However, based on system parameter fitting by McArthur et al. (2010) and Deitrick et al. (2015), Ups And d is likely at sufficient separation at least at apastron.

Models w/different metallicity suggest a significant range of T/P + cloud structure over orbit!

Ups And D Parameters

Observation Derived

Planetary Mass - $10.25^{+0.7}_{-3.3} M_{Jupiter}$

Planetary Radius - $1.02 R_{Jupiter}$

Semi-major Axis - 2.53 au

Orbital Eccentricity - 0.316

Orbital Inclination - 23.758°

Model Parameters

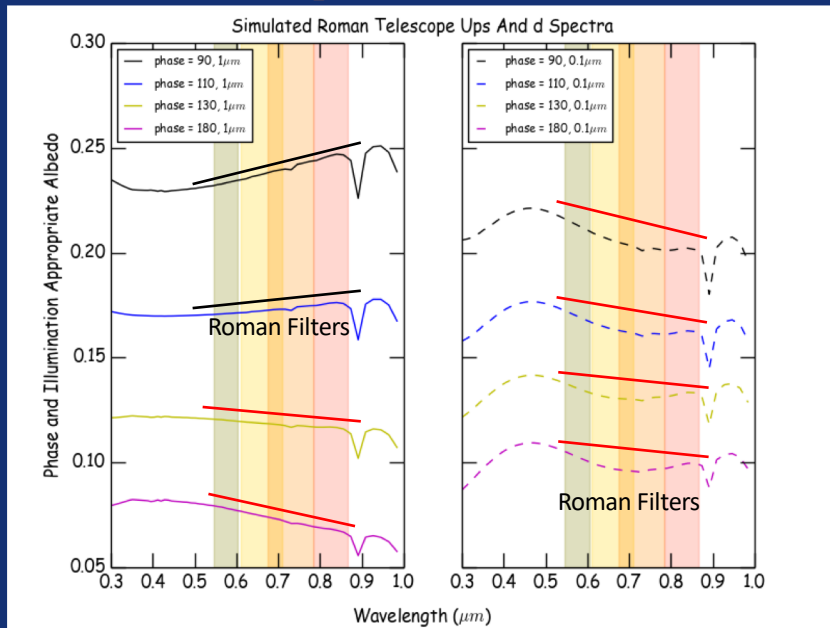
T_{eff} (max, min, mean) - 260, 188, 215 K

Planetary Gravity (g) - $244.23 m/s^2$

Metallicity ($[Fe/H]_{star} = 0.131$) = 1/3/5/10x

Config files + more info at Saxena et al 2021 AJ 162 30

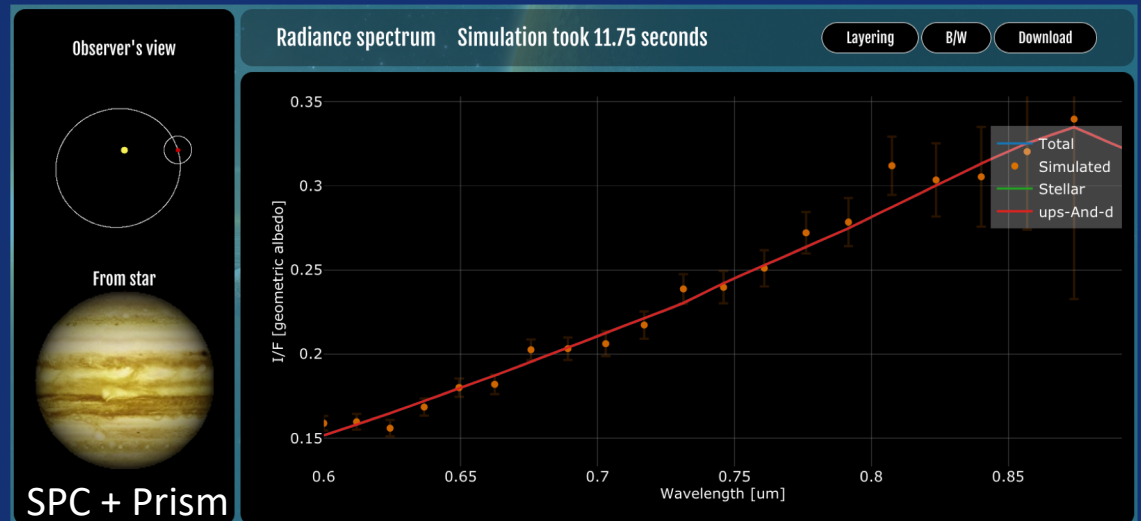
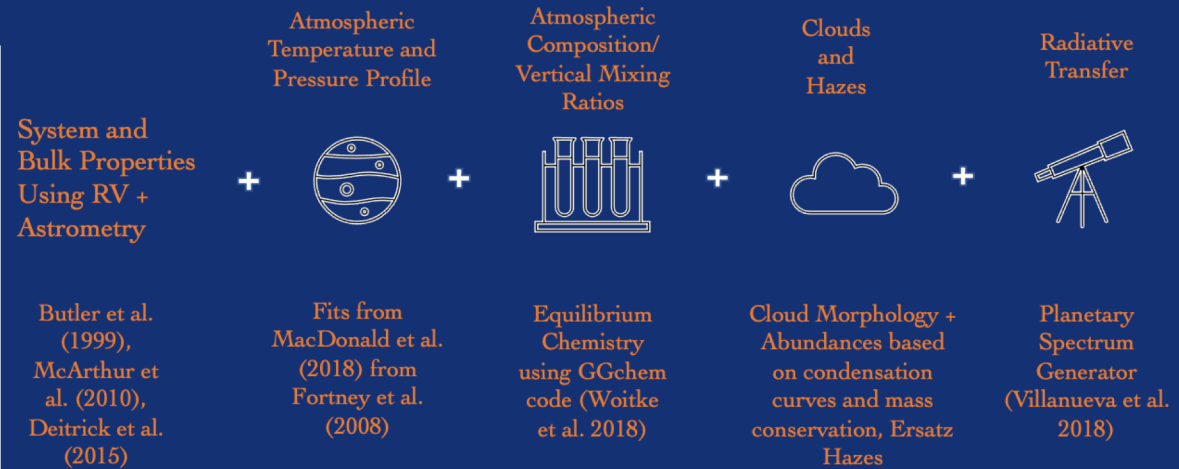
Filter color-color ratio flips depending on cloud particle size!



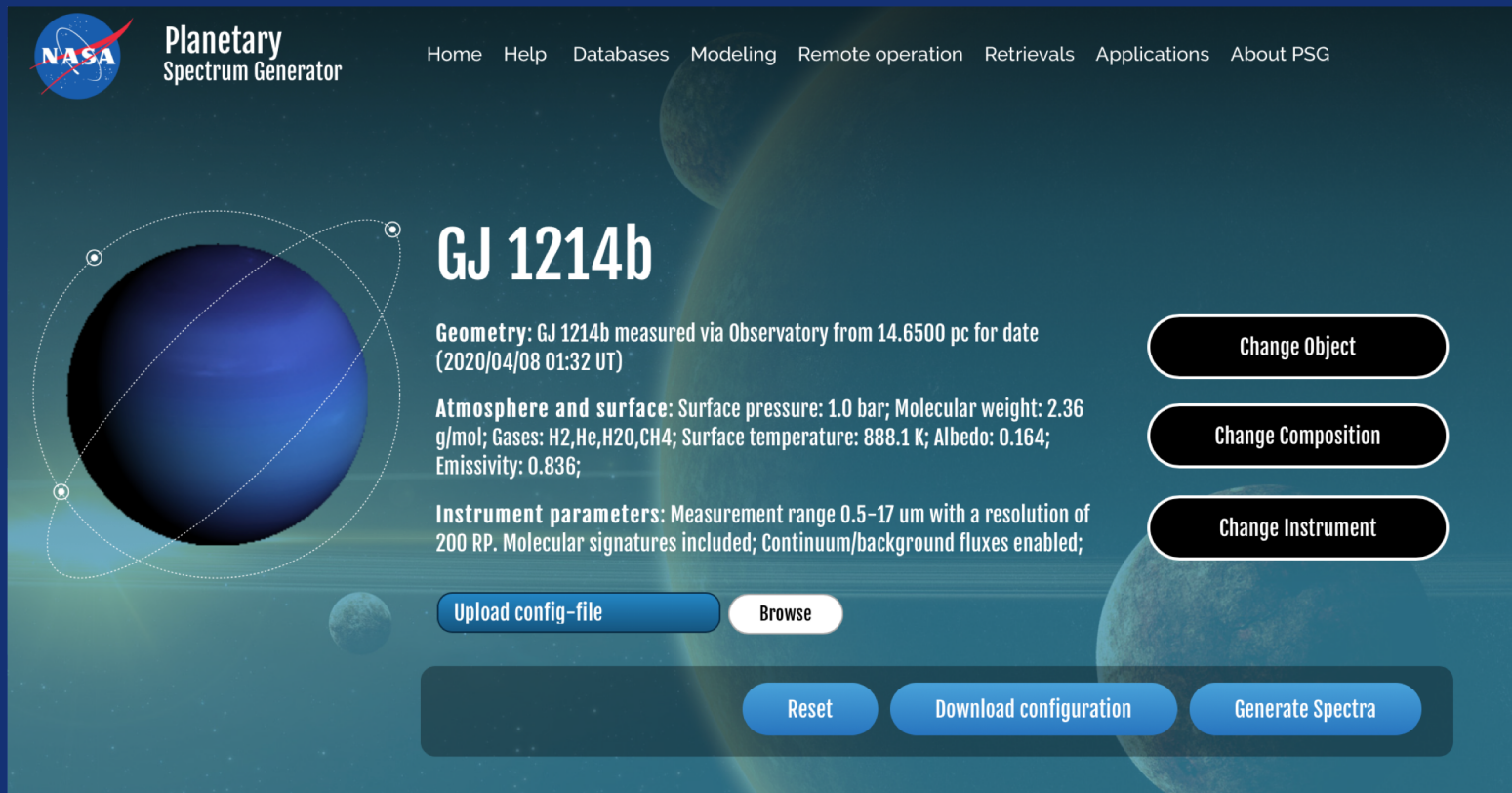
Preliminary results:

At 90 degrees from periastron, SNR=10 in 400h, with speckles and jitter in 675 – 785 nm band (SPC) – peak contrast of $3.5\text{E}-9$, also a promising target for HLC

Noise characteristics taken from https://roman.ipac.caltech.edu/sims/Param_db.html



Using PSG and the Coronagraph Template



The screenshot shows the NASA Planetary Spectrum Generator (PSG) interface. At the top left is the NASA logo and the text "Planetary Spectrum Generator". A navigation menu includes "Home", "Help", "Databases", "Modeling", "Remote operation", "Retrievals", "Applications", and "About PSG". The main content area features a 3D model of the planet GJ 1214b with its orbital path. To the right of the model, the text "GJ 1214b" is displayed in large white font. Below this, three sections of text provide details: "Geometry: GJ 1214b measured via Observatory from 14.6500 pc for date (2020/04/08 01:32 UT)", "Atmosphere and surface: Surface pressure: 1.0 bar; Molecular weight: 2.36 g/mol; Gases: H2, He, H2O, CH4; Surface temperature: 888.1 K; Albedo: 0.164; Emissivity: 0.836;", and "Instrument parameters: Measurement range 0.5-17 um with a resolution of 200 RP. Molecular signatures included; Continuum/background fluxes enabled;". On the right side, there are three buttons: "Change Object", "Change Composition", and "Change Instrument". At the bottom, there are buttons for "Upload config-file" (with a "Browse" button next to it), "Reset", "Download configuration", and "Generate Spectra".

NASA Planetary Spectrum Generator

Home Help Databases Modeling Remote operation Retrievals Applications About PSG

GJ 1214b

Geometry: GJ 1214b measured via Observatory from 14.6500 pc for date (2020/04/08 01:32 UT)

Atmosphere and surface: Surface pressure: 1.0 bar; Molecular weight: 2.36 g/mol; Gases: H₂, He, H₂O, CH₄; Surface temperature: 888.1 K; Albedo: 0.164; Emissivity: 0.836;

Instrument parameters: Measurement range 0.5-17 um with a resolution of 200 RP. Molecular signatures included; Continuum/background fluxes enabled;

Change Object

Change Composition

Change Instrument

Upload config-file Browse

Reset Download configuration Generate Spectra

psg.gsfc.nasa.gov/

Atmosphere Properties that can be changed

Abundances

Particle Size

The screenshot displays the configuration interface for the psg atmospheric model. It features several sections for defining atmospheric components:

- Gas Species:** A list of gas species including CH4, CO2, and NH3. Each entry includes a search button, a type field (e.g., EXO[CH4]), an abundance input field (set to 1), a scaler button, and a 3: XSEC button. Chemical structures are shown to the right of each species.
- Continuum Processes:** A section for defining continuum processes, including Rayleigh, Refraction, CIA_all, and UV_all, each with an Add button and a status indicator (X).
- Atmospheric Scattering Aerosols:** A section for defining aerosols, including a stream-pairs (NMAX) / phase LMAX selector (set to 2 / 4).
- Aerosol Properties:** A specific aerosol entry for 'Dust' (Jager_MgSiO3) with a radius range of 0.01-100.00um and 0.32-500.00um. It includes a Type field, an Abundance input field (set to 0), a scaler button, and a Radius [reff] input field (set to 10) with a unit selector (set to μm).

Red and yellow circles and arrows highlight the Abundance and Radius [reff] fields for NH3 and Dust, respectively, indicating that these properties can be changed.

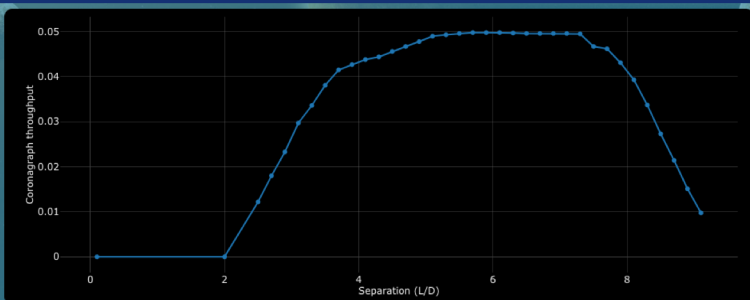
psg.gsfc.nasa.gov/

psg.gsfc.nasa.gov/

Instrument Properties that can be changed

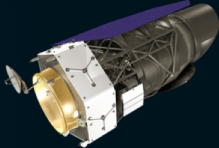
Exozodi

Assuming a 10 hr integration - exposure time/# exposures



Telescope / instrument ⓘ Roman CGI Load template Remove

The Coronagraph Instrument (CGI) of the Roman observatory provides high-contrast observations, key enabling technologies for future exo-Earth imaging missions. CGI is primarily designed to demonstrate space coronagraphy at sensitivity levels of Jovian-mass planets and faint debris disks in reflected starlight. Some key technologies include: precision optical wavefront control with deformable mirrors, sensitive EMCCD photon-counting imaging detectors, low-resolution integral field spectroscopy, and advanced algorithms for wavefront sensing and control.



Spectral range: 0.6 0.9 um Resolution: 50 Resolving power Boxcar

Include molecular signatures ⓘ Include continuum fluxes ⓘ Integrate stellar templates ⓘ

Terrestrial transmittance ⓘ Apply ⓘ Multiply ⓘ

Spectrum intensity unit: Contrast (radiance ratio w.r.t. parent star) Log plot ⓘ

Telescope ⓘ Coronagraph

Beam (FWHM): 1.0 Diffraction (0.080 arcsec) Exozodi level: 4.5

Diameter (m, effective): 2.363 Contrast and IWA (λ/D): 1.8e-7 Table Remove

Noise ⓘ Charge image sensor [e-]

Time / exposure [s]: 30 Number of exposures: 1200 Number of pixels: 15

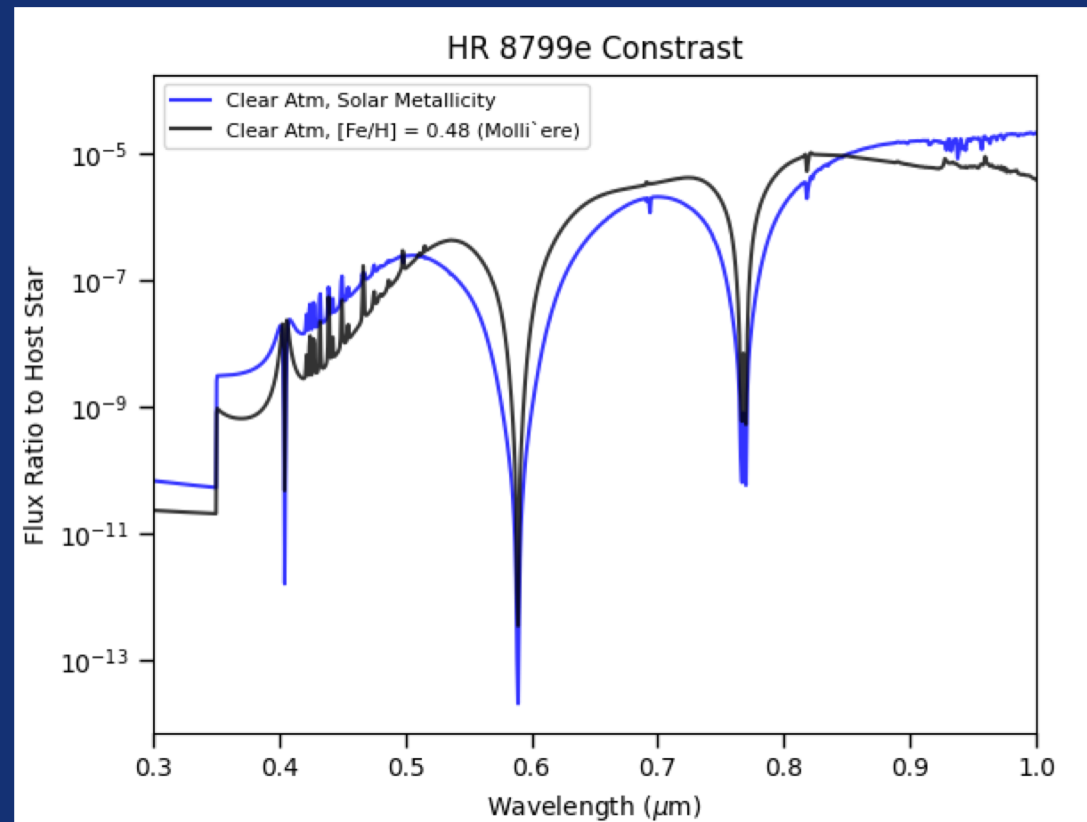
Read [e-]: 0 Dark [e-/s]: 2.69E- Total ε_{opt} T_{opt}[K]: 0.15 0.10 270 Table

← Separation Dependent Throughput

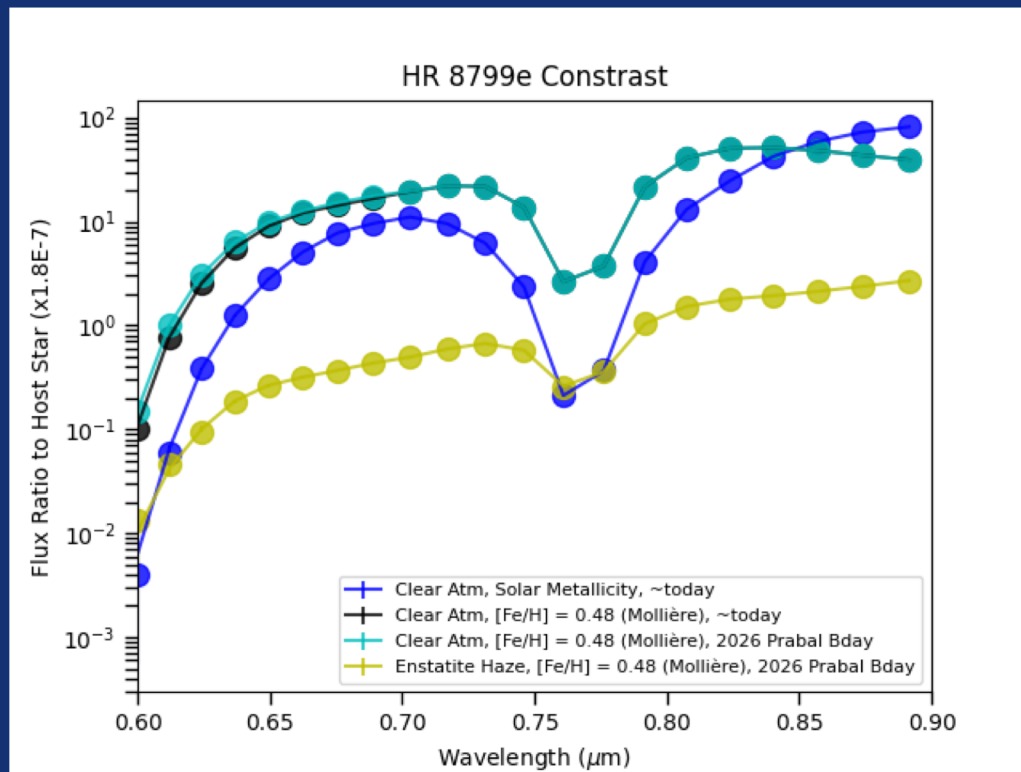
HR 8799e: Solar Metallicity vs super-Solar

- P-T profile and basic cloud profile from Mollière et al (2020). Using atmospheric retrieval on GPI, SPHERE and GRAVITY data

- Abundances using GGchem. Note Ruffio et al. (2021) find solar metallicity seem to fit for b, c + d, A0V star, working on template for star



HR 8799e: Exploring Phase Appropriate Spectra (Birthday Observations)



Assuming a 20 hr observation using Roman CGI SPC template we find:

- Phase driven differences from current to 2026 observations are minimal (may be different in 2030 though!)
- Solar vs $[\text{Fe}/\text{H}] = 0.48$ may be somewhat distinguishable using K line
- An enstatite haze (from Mollière et al (2020)) is likely distinguishable

More to come!