Observability of Exoplanets with varying composition using Space Telescopes

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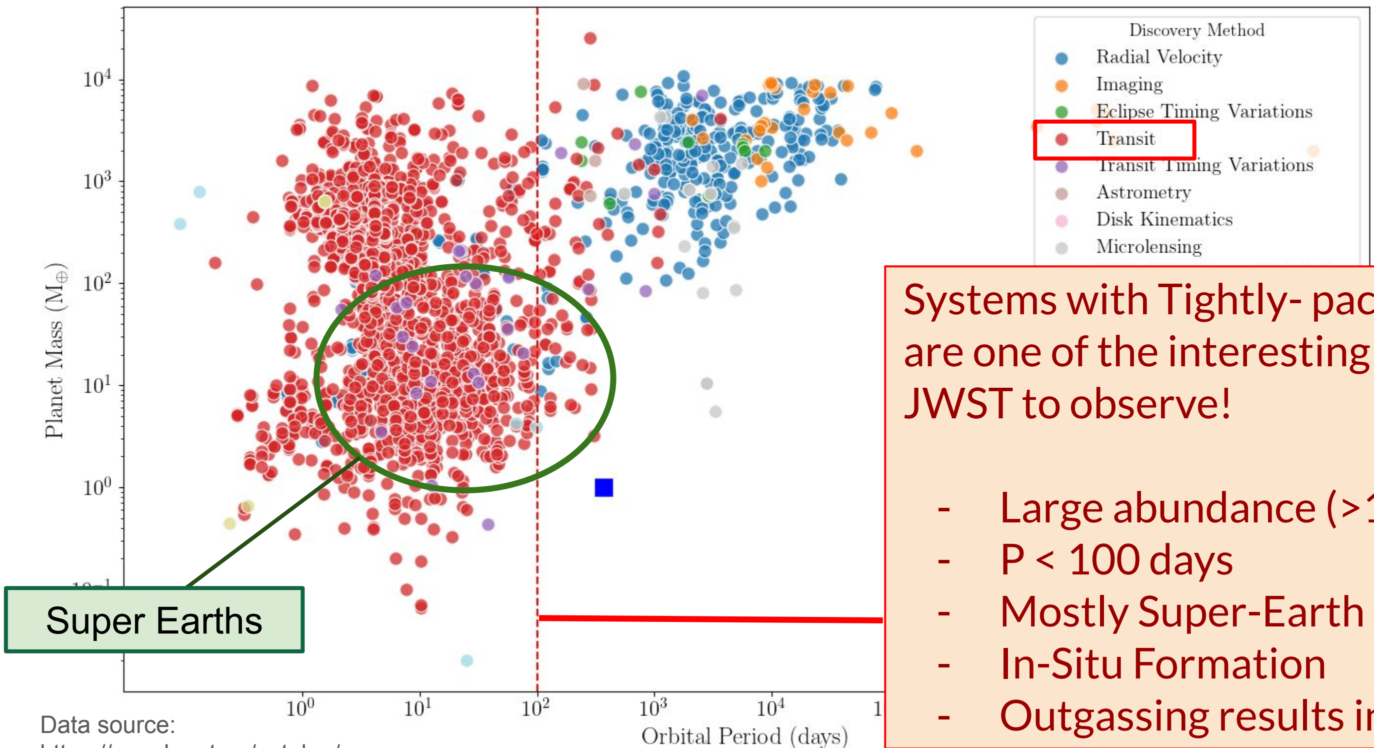
Exoplanet Formation and Classification in JWST Era!



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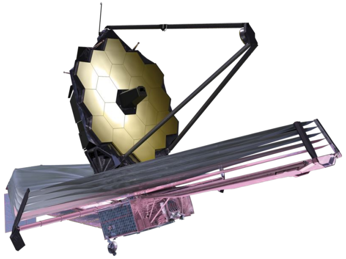
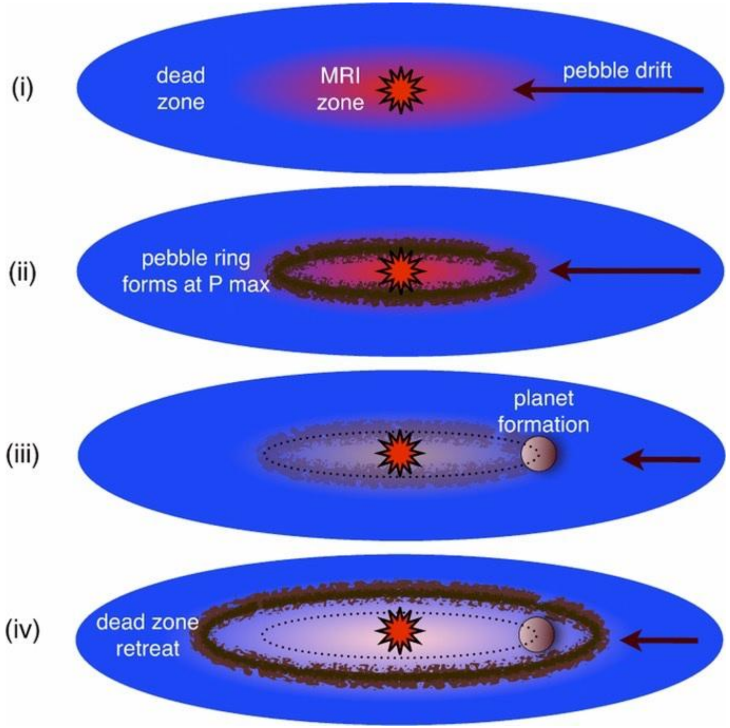


Systems with Tightly- packed Inner Planets (**STIPs**) are one of the interesting subclass of planets for JWST to observe!

- Large abundance (>10% of stars)
- P < 100 days
- Mostly Super-Earth
- In-Situ Formation
- Outgassing results in Atmosphere

Inside-Out Planet Formation (IOPF) Chatterjee & Tan (2014)

- ❑ Seeks to explain STIPs found by Kepler
- ❑ Main idea:
  - ❑ Pebbles drift toward star via gas drag
  - ❑ Pebble ring forms close to star at local pressure maximum
  - ❑ Core is formed, begins to accrete material
  - ❑ Shallow gap is opened, pressure maximum retreats
  - ❑ Repeat



Chatterjee & Tan (2014) Fig. 1

7 IOPF Papers discuss implications of model

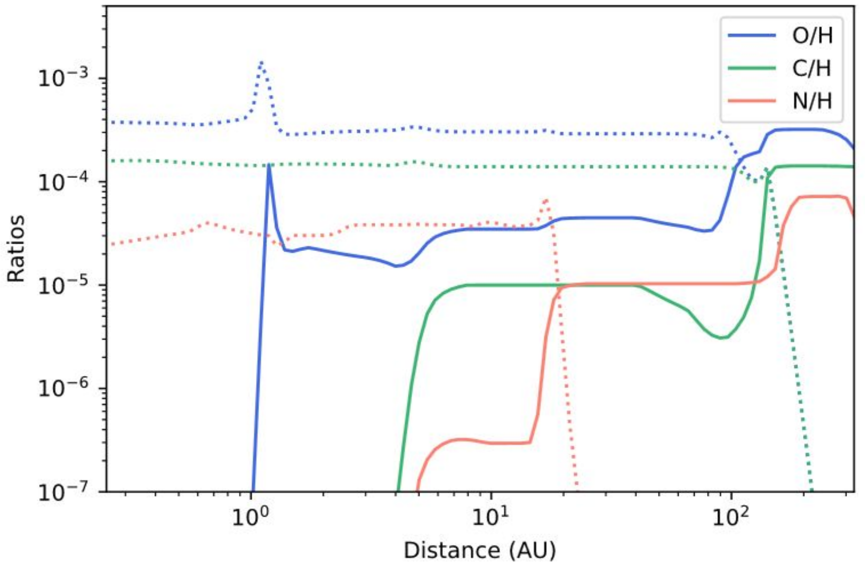
Cevallos Soto et al. (2022), IOPF 7 - chemodynamical modeling

- **Key prediction:** Inner disk (< 5 AU) should have very low C/O abundance (~0.1)

Super-Solar Oxygen Abundance

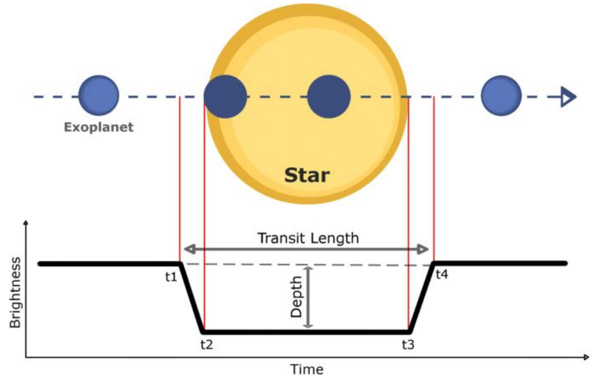
- **Prediction**: Planets in these systems may exhibit super-solar (higher than solar) abundances of oxygen.
- **Reasoning**: Despite the high C/O ratio, if there is significant accretion of oxygen-rich materials, these planets can end up with higher oxygen abundances compared to solar values.
- **Goal of this work:** Test this prediction of IOPF by modeling the atmosphere of a close-in rocky planet and compare the result to JWST data

Recreation of Cevallos Soto (2022) Fig. 8(f)



Exoplanetary Atmosphere Detection

1



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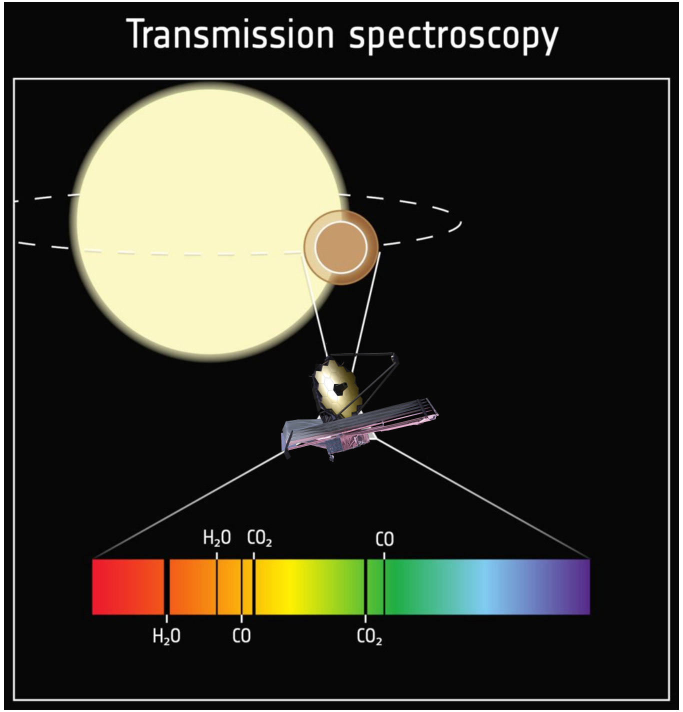

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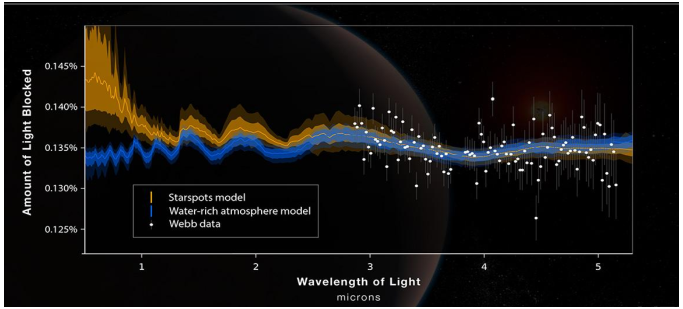


Our Target Toy Planet: GJ 486b

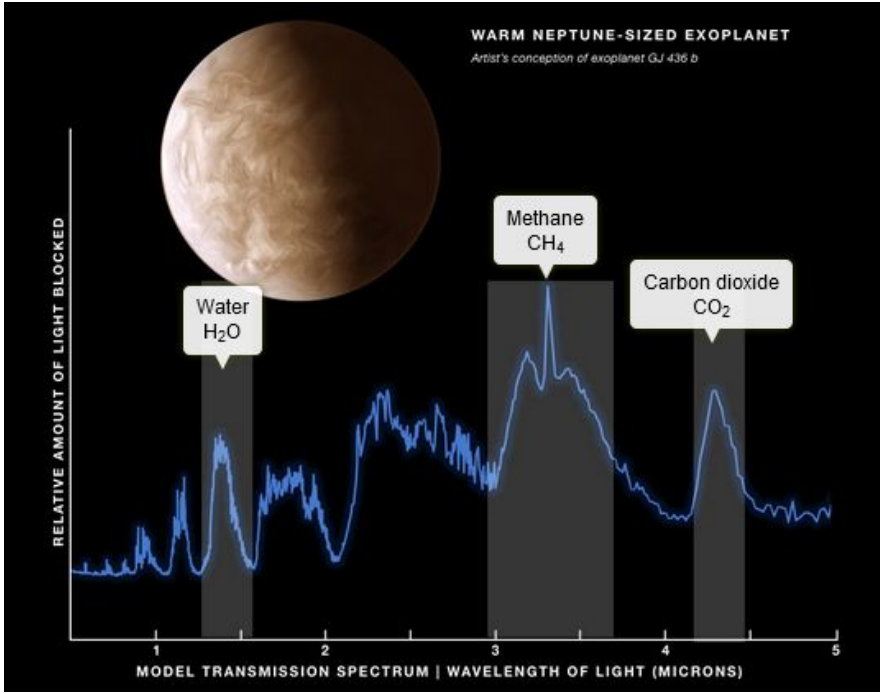
1. Planet Parameters:

- Mass: $3\,\mathrm{M}_\oplus$
- Radius: $1.3\,\mathrm{R}_\oplus$
- Period: 1.47 days

2. Host:

- M-dwarf star ($T_{\mathrm{eff}} = 3291$ K)
- Mass: $0.32\,\mathrm{M}_\odot$

3. Model Planetary Atmposphere Contains: H, C, O

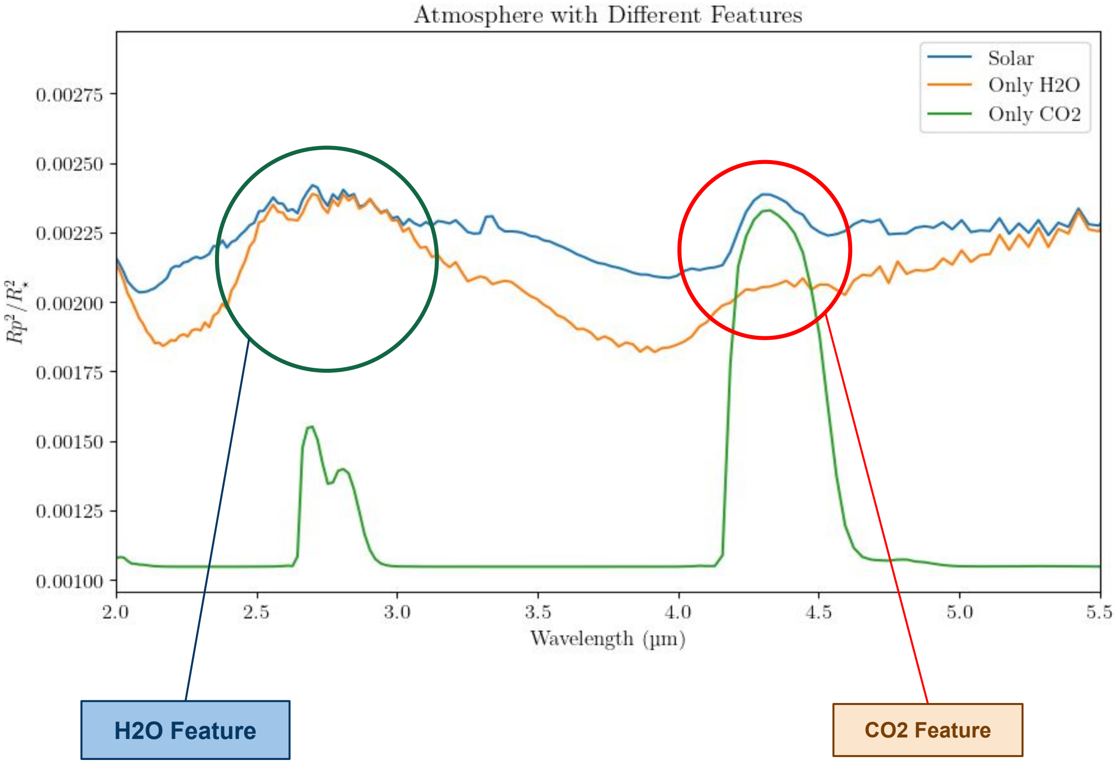


https://viewspace.org/interactives/unveiling_invisible_universe/exoplanet_diversity/atmospheres

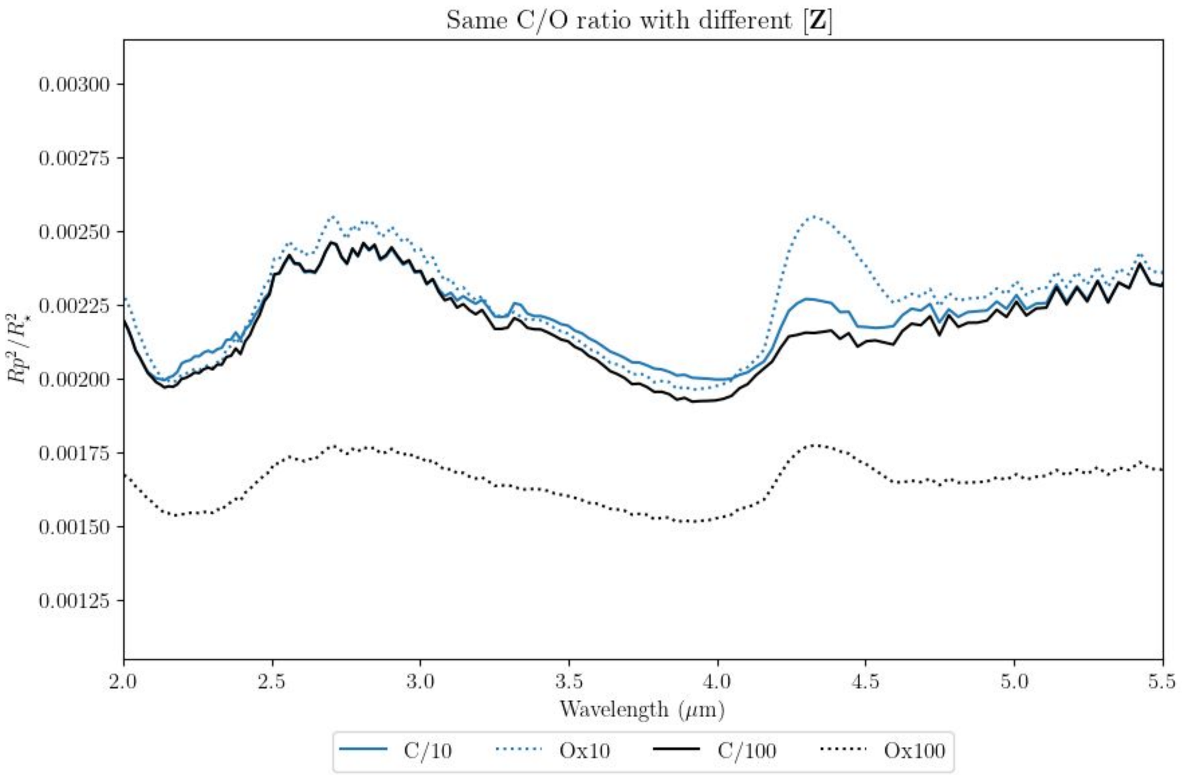
Method: Transmission Spectra Modelling

ARtful modelling Code for exoplanet Science (ARCiS)

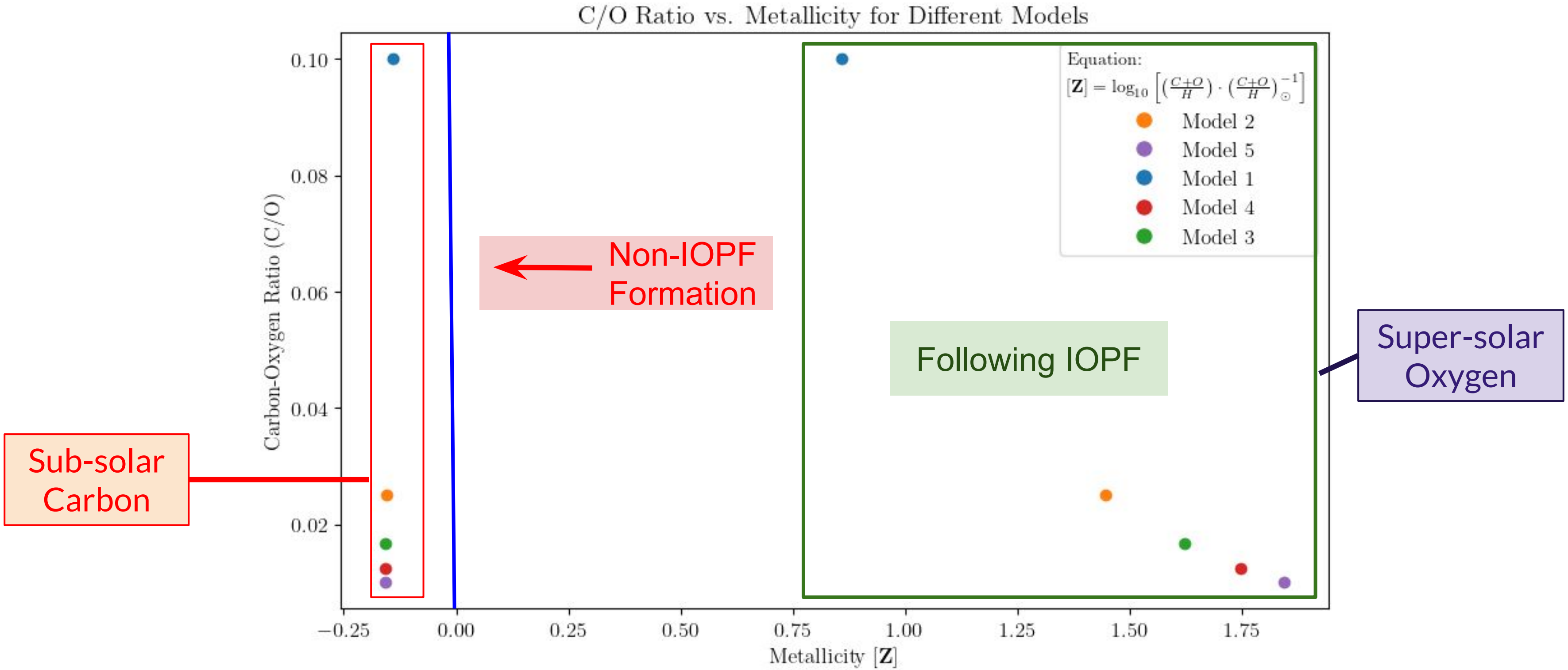
- Developed by Ormel & Min (2019)
- Uses planet, star parameters + chemical abundances to produce atmospheric spectra for planets
- For this work we seek to produce transmission spectra



Our Forward Models



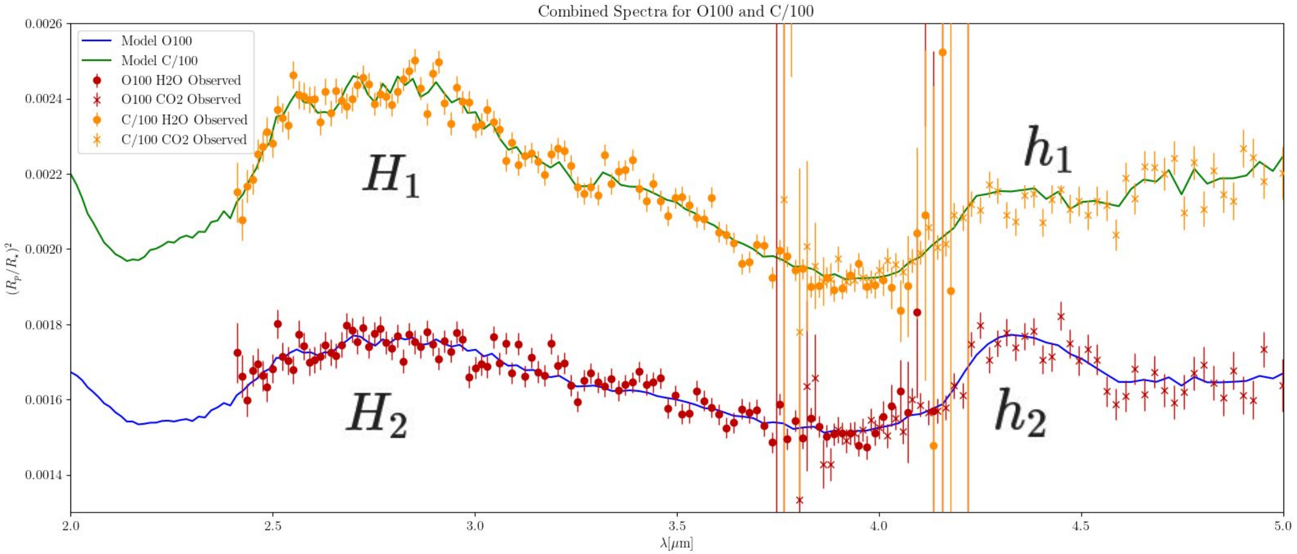
Metallicity [Z] vs C/O



Method: Synthetic Observations

PandExo

- Open source Noise simulator for JWST
- It can create instrument simulations of JWST's NIRSpec, **NIRCam**, NIRISS and NIRCam
- We produced synthetic Observations using Model Spectra.



Model 100x

Analysis

Model	H_2O: Ox H_1	H_2O: C/x H_2	$\frac{H_1}{H_2}$	CO_2: Ox h_1	CO_2: C/x h_2
10x	0.0025 ± 0.000006	0.0024 ± 0.000006	1.0305 ± 0.0036	0.0025 ± 0.000011	0.0022 ± 0.000011
40x	0.0022 ± 0.000006	0.0024 ± 0.000006	0.8935 ± 0.0033	0.0021 ± 0.000011	0.0022 ± 0.000011
60x	0.0020 ± 0.000006	0.0024 ± 0.000006	0.8201 ± 0.0032	0.0020 ± 0.000011	0.0022 ± 0.000011
80x	0.0018 ± 0.000006	0.0024 ± 0.000006	0.7649 ± 0.0031	0.0018 ± 0.000011	0.0021 ± 0.000011
100x	0.0017 ± 0.000006	0.0024 ± 0.000006	0.7230 ± 0.0031	0.0018 ± 0.000011	0.0021 ± 0.000011

Model	$\frac{h_1}{h_2}$	$\frac{H_1}{h_1}$	$\frac{H_2}{h_2}$
10x	1.1072 ± 0.0072	0.9982 ± 0.0050	1.0724 ± 0.0058
40x	0.9794 ± 0.0070	1.0094 ± 0.0059	1.1065 ± 0.0062
60x	0.9139 ± 0.0068	1.0026 ± 0.0063	1.1172 ± 0.0063
80x	0.8637 ± 0.0067	0.9990 ± 0.0067	1.1281 ± 0.0064
100x	0.8263 ± 0.0066	$\boxed{0.9951 \pm 0.0070}$	1.1372 ± 0.0064

$$\frac{H_1}{h_1} = 0.9951 \pm 0.0070 > H_1 = 0.0017 \pm 0.000006$$

$$\frac{H_1}{h_1} = 0.9951 \pm 0.0070 > h_1 = 0.0018 \pm 0.000011$$

$$\boxed{\text{For } R = 100 \text{ we have } \Delta y_{\text{obs}} = 0.025188}$$

Discussion

- So far all model spectra is distinguishable (OOM 2) with the current noise we modeled
- If distinguishable with certainty we can detect planets from IOPF style formation to Non-IOPF formation even though they might have same (low) C/O,
- Currently we maintained a defined Temperature-pressure profile but with observation/Retrieval we might consider having it undefined.

Future Work

- Work with ARIEL simulations,
- Run retrievals for the Models created,
- Consider different target planet to better test IOPF C/O prediction
- Compare with actual observation [if available]

Thank you! Questions?

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