A Panchromatic Emission Spectrum of Warm Gas Giant WASP-80b with NIRCam & MIRI

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Introduction

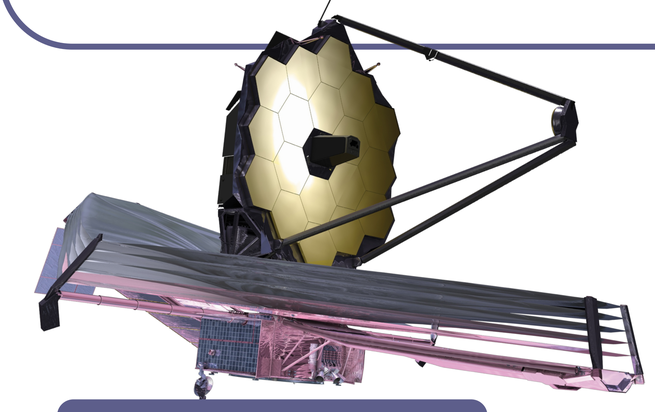
How did WASP-80 b, a gas giant around a low-mass star, form? Formation models and past observations have shown that giant planets around low-mass stars are rare due to less material in the protoplanetary disk. We consider two possibilities: [3]

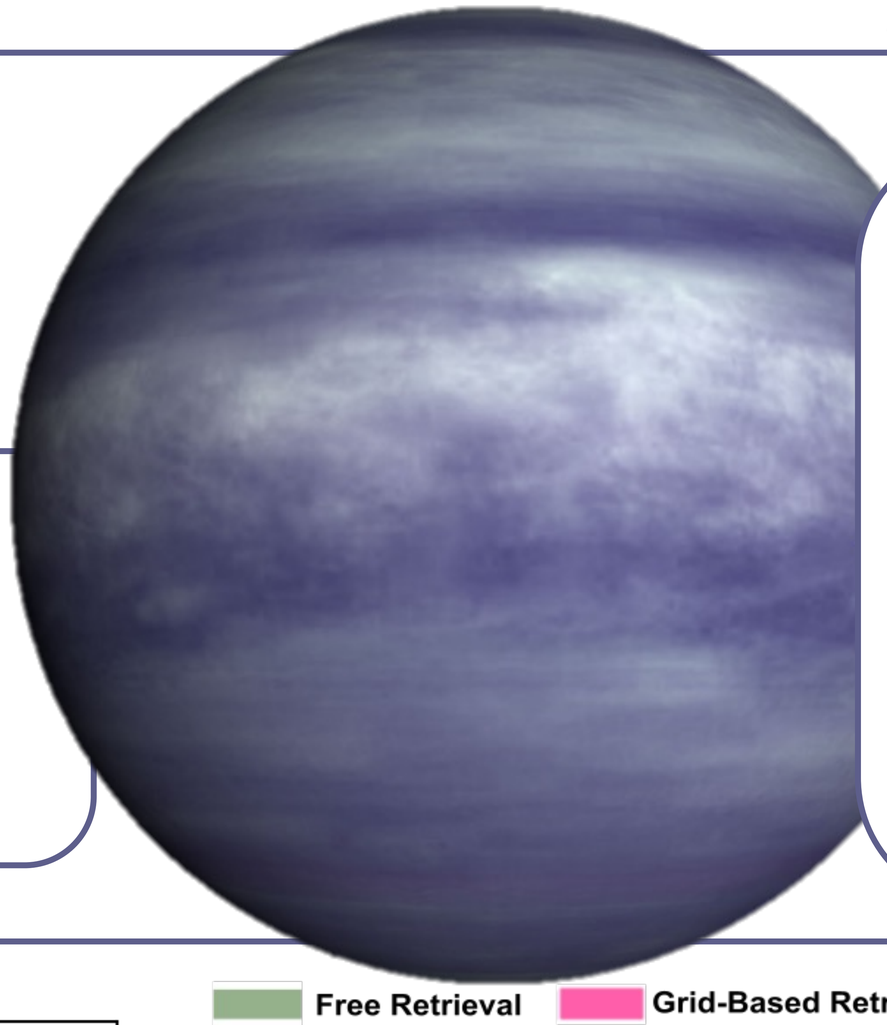
(1) WASP-80 b formed via core accretion, elevated disk mass, & reduced migration speeds.

(2) WASP-80 b formed via disk instability.

With a panchromatic JWST emission spectrum, we constrain major carbon and oxygen species and estimate metallicity and C/O. We find that WASP-80 b's composition is consistent with formation scenario 1.

WASP-80 b: T_{Eq} = 825 K, $M_{Jupiter}$ = 0.54, $R_{Jupiter}$ = 0.95
M-Dwarf Host Star: T = 4145 K, M_{Sun} = 0.58 , R_{Sun} = 0.57





Observations

As part of the MANATEE GTO Program:

- NIRCam F322W2, 2.4-4.0 μm (previously published in [1])
- NIRCam F444W, 4.0-5.0 μm
- MIRI LRS, 5.0-12.0 μm

Modeling

Free Retrieval:

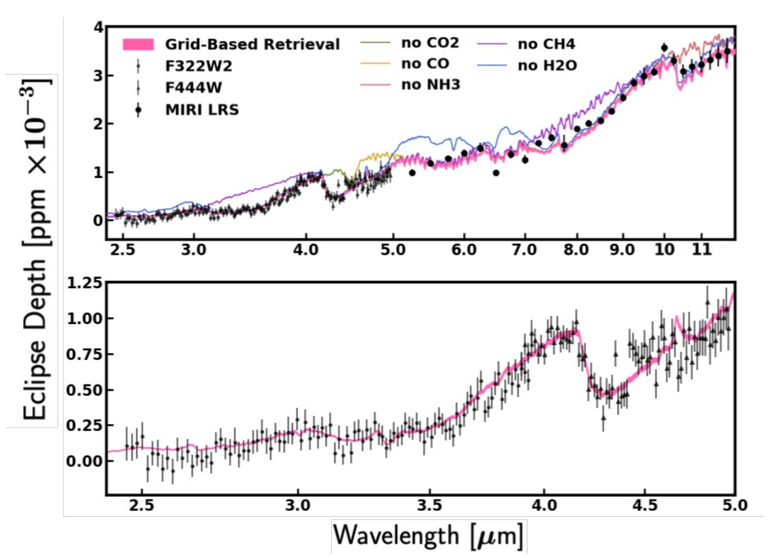
- Using the CHIMERA code, we estimate molecular abundances, the vertical pressure-temperature structure, and a uniform grey cloud opacity.

Grid-Based Retrieval:

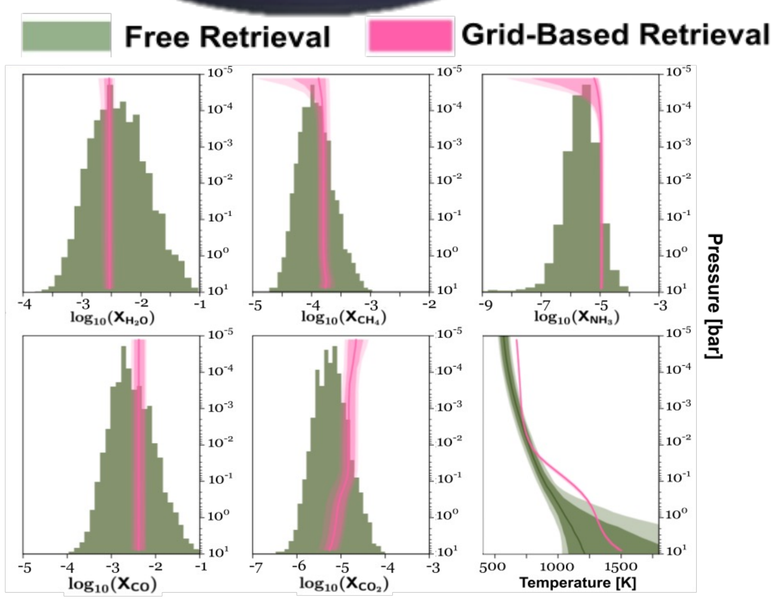
- We generate a self-consistent grid of atmosphere models in radiative-convective-photochemical equilibrium using ScCHIMERA and a kinetics code, VULCAN[5].
- Using nested sampling with PyMultiNest[2], we compare grid models to observations to estimate irradiation temperature, internal temperature, metallicity, C/O, vertical mixing, and a uniform grey cloud opacity.

Modeling methods are similar to those in references [1] and [6].

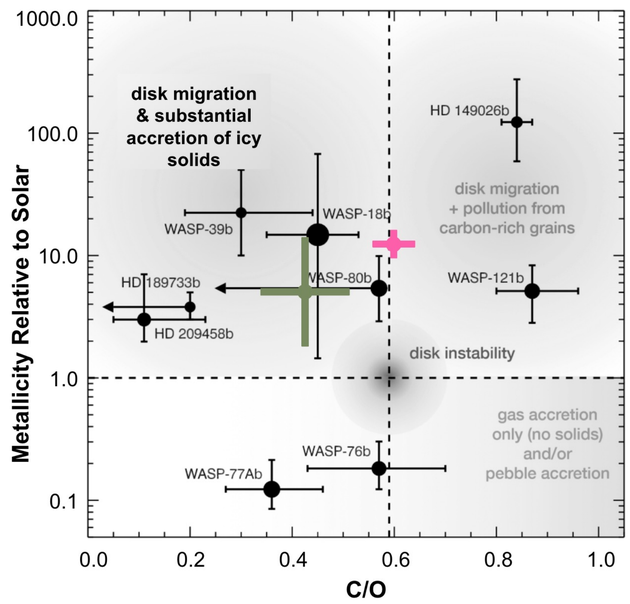
Results



Pink: modelled emission spectrum from the grid-based retrieval. **Colored Lines:** the spectrum with individual molecules turned "off," illustrating their spectral signatures



Molecular abundance estimates and the pressure-temperature profile from the free and grid-based retrievals. CO_2, CO, CH_4, and H_2O are confidently detected to > 7σ. NH_3 in non-decisively detected.



Metallicity and C/O estimates are consistent with formation via core accretion and disk migration, possibly with substantial accretion of icy solids. Figure adapted from reference [4].

References

[1] Bell, T. J., Welbanks, L., Schlawin, E., et al., 2023, Nature, 623, 709.
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[5] Tsai, S. M., Lyons, J. R., Grosheintz, L., et al. 2017, ApJS, 228, 20.
[6] Welbanks, L., Bell, T. J., Beatty, T. G., et al., 2024, arXiv:2405.11018.

Image credit for WASP-80b and JWST icons: NASA.

Learn more about the MANATEE GTO Program

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