An Exploration of Constraining Chemistry in Three-Dimensional Eclipse Mapping

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Eclipse Mapping With ThERESA

- Eclipse mapping is used to build 2D temperature maps of an exoplanet's atmosphere through its transits, can inform us on atmospheric dynamics
- ThERESA (Challener & Rauscher 2022) is a code which builds these 2D maps and interpolates through them to create a 3D temperature-pressure model of an atmosphere

Relaxing Assumptions, Introducing Metallicity

- ThERESA assumes solar chemical abundances, thermochemical equilibrium
- We thus introduce metallicity (logarithm of ratio between atmospheric abundance and solar) as varying parameter in code
- This allows for more accurate characterization of atmosphere through varying chemical species abundances, enabling constraints on composition

Reconstruction of WASP-76b Model Atmosphere

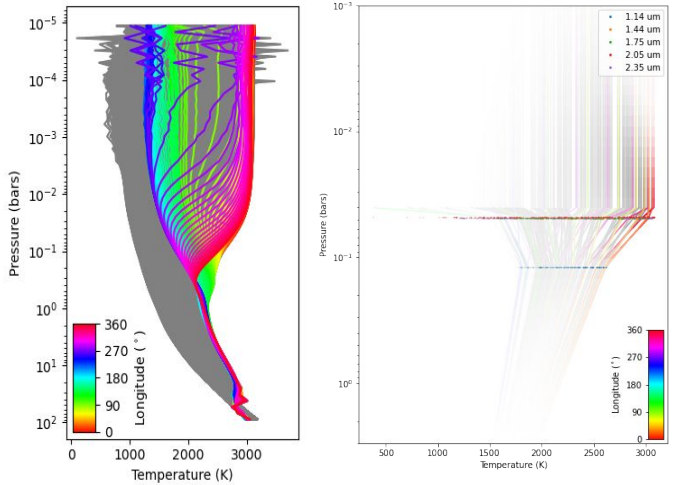

Fig. 1 (left)- The input temperature model of WASP-76b's atmosphere, with colors corresponding to position along the equator.
Fig. 2 (right)- The output temperature model of the atmosphere, using an isobaric retrieval. The points represent the placement of the 2D temperature maps, with most being placed at a pressure of ~0.05 bar and another at ~0.15 bar.

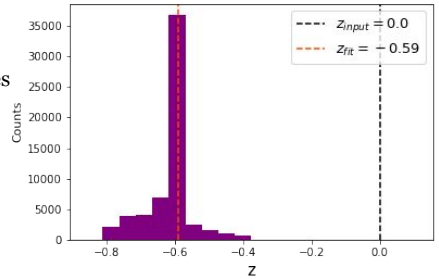

Fig. 3- Histogram of metallicity distribution as explored by ThERESA. One can see the chains have converged clearly to a value of $z = -0.59$, unexpectedly varying from the input value of $z = 0.0$.

Discussion and Looking Ahead

- As can be seen in **Figs. 1, 2**, ThERESA successfully modeled WASP-76b's atmosphere, but **Fig. 3** shows it did not accurately retrieve the input metallicity of $z = 0.0$
  - This suggests fitting to z is complex
  - Once resolved, modified code will use JWST data to more accurately reconstruct exoplanet atmospheres
- Next steps will be to include thermal disequilibrium, individual atomic abundance ratios to increase complexity of model

Summary

- ThERESA is a fantastic code for building a rudimentary 3D temperature model of exoplanet atmospheres, but makes many simplifying assumptions
- We modified the code to take an atmosphere's metallicity into account when converging to a best fit, widening the range of usefulness for the code
- **Fig. 3** suggests fitting to metallicity is complex, but possible- currently working to resolve issue

References- Challener, R., & Rauscher, E. 2022, AJ, 163, 117

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