



Universiteit
Leiden
The Netherlands

Roasting marshmallows: a campaign to disentangle composition & climate in hot Jupiter atmospheres with near infrared high resolution cross-correlation spectroscopy

Line, M.; Brogi, M.; Bean, J.; Smith, P.; Parmentier, V.; Mansfield, M.; ... ; Dang, L.

Citation

Line, M., Brogi, M., Bean, J., Smith, P., Parmentier, V., Mansfield, M., ... Dang, L. (2022). Roasting marshmallows: a campaign to disentangle composition & climate in hot Jupiter atmospheres with near infrared high resolution cross-correlation spectroscopy, (5). Retrieved from <https://hdl.handle.net/1887/3513233>

Version: Publisher's Version

License: [Creative Commons CC BY 4.0 license](https://creativecommons.org/licenses/by/4.0/)

Downloaded from: <https://hdl.handle.net/1887/3513233>

Note: To cite this publication please use the final published version (if applicable).

Roasting Marshmallows: A Campaign to Disentangle Composition & Climate in Hot Jupiter Atmospheres with Near Infrared High Resolution Cross-Correlation Spectroscopy

**Michael Line¹ Matteo Brogi² Jacob Bean³ Peter Smith¹
Vivien Parmentier⁴ Megan Mansfield⁵ Lorenzo Pino⁶ Gregory Mace⁷
Jean-Michel Desert⁸ Emily Rauscher⁹ Siddharth Gandhi¹⁰
Eliza Kempton¹¹ Evgenya Shkolnik¹ Jenny Patience¹
Jonathan Fortney¹² Joost Wardenier⁴ Joseph Zalesky¹ Callie Hood¹³
Nicolas Cowan¹⁴ Lisa Dang¹⁴**

¹Arizona State University, ²University of Warwick, ³University of Chicago, ⁴University of Oxford,
⁵University of Arizona, ⁶INAF - Osservatorio Astrofisico di Arcetri, ⁷UT Austin,
⁸University of Amsterdam, ⁹University of Michigan, Ann Arbor, ¹⁰Leiden University,
¹¹University of Maryland, ¹²University of California, Santa Cruz,
¹³University of California-Santa Cruz, ¹⁴McGill University

Published on: Jun 20, 2022

URL: <https://baas.aas.org/pub/2022n5i108p01>

License: [Creative Commons Attribution 4.0 International License \(CC-BY 4.0\)](https://creativecommons.org/licenses/by/4.0/)

Determining the nature of planetary atmospheres is a key objective of exoplanet science. A planet's atmosphere contains a wealth of diagnostic information on basic planetary conditions like climate (temperature, dynamics) and composition. This information has been primarily obtained at low resolution ($R \lesssim 50$) with space-based platforms like the Hubble and Spitzer Space Telescopes. However, a complimentary ground based approach that leverages high spectral resolution and cross-correlation techniques has been steadily gaining traction, owing to the method's high sensitivity to molecular detections, thermal structures, and global wind patterns, enabled by stable, broad wavelength coverage, high resolution spectrometers on large aperture telescopes. Leveraging the success of past works utilizing these methods, our team recently observed the dayside thermal emission of a typical hot Jupiter (WASP-77Ab) with IGRINS (1.4–2.6 μm , $R \sim 45,000$) on Gemini South. When combined with novel high resolution retrieval techniques, we were able to obtain (Line et al. 2021, Nature) unprecedented constraints on the temperature profile and the water and carbon-monoxide abundances, enabling ultra-precise constraints on the atmospheric metallicity and C/O at a level rivaling those anticipated from JWST. Building off of the success of this result, we are currently undergoing a 117 hr Large-and-Long program (beginning in Fall 2021), aimed at measuring the dayside thermal structures and compositions of over a dozen hot Jupiters. We will present an overview of the program objectives and early results, including precision carbon and oxygen abundance determinations, isotopic abundance ratios, and a diversity of vertical thermal structures for well known planets like HD 209458b, WASP-18b, MASCARA-1b, and WASP-77Ab. We will also identify synergies with low-resolution HST/JWST observations as well as with optical high-resolution instruments like MAROON-X. The overall goal of this programs (and other related programs) is to demonstrate the reliability and the potential of ground based high-resolution spectroscopy to rigorously inform our understanding of the nature of exoplanet atmospheres as well as to pave a pathway for future characterization with the next generation of giant ground based telescopes.