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.

Bulletin of the AAS • Vol. 54, Issue 5

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

Michael Line[1] Matteo Brogi[2] Jacob Bean[3] Peter Smith[1]
Vivien Parmentier[4] Megan Mansfield[5] Lorenzo Pino[6] Gregory Mace[7]
Jean-Michel Desert[8] Emily Rauscher[9] Siddharth Gandhi[10]
Eliza Kempton[11] Evgenya Shkolnik[1] Jenny Patience[1]
Jonathan Fortney[12] Joost Wardenier[4] Joseph Zalesky[1] Callie Hood[13]
Nicolas Cowan[14] Lisa Dang[14]

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

Published on: Jun 20, 2022

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

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 um, R ~ 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.