Z104a Probing Two-dimensional Asymmetries of an Exoplanet Atmosphere from Chromatic Transit Variation

Shotaro Tada, Hajime Kawahara (ISAS/JAXA), Yui Kawashima (Kyoto University), Takayuki Kotani (ABC/NAOJ/SOKENDAI), Kento Masuda (The University of Osaka)

Recent advances in observational instruments have greatly accelerated the study of exoplanetary atmospheres. Because their extended atmospheres yield large transmission signals, hot giant planets have become prime targets for detailed atmospheric characterization, including the detection of inhomogeneities. Fully exploiting the precision of facilities like the James Webb Space Telescope (JWST), however, still requires further methodological developments.

We introduce a new method for investigating atmospheric inhomogeneities in exoplanets using transmission spectroscopy. This approach relates chromatic variations in the conventional transit parameters—mid-transit time, total and full transit durations, and transit depth—to atmospheric asymmetries. In this way, we can probe differences between planetary limbs slightly offset from the terminator on the dayside and the nightside. We apply this technique, in combination with the JAX-based atmospheric spectral model ExoJAX, to JWST/NIRSpec-G395H observations of the hot Saturn exoplanet WASP-39 b, demonstrating its ability to reveal limb-to-limb contrasts in chemical composition. We also discuss our use of automatic differentiation to examine the degeneracy between atmospheric signals and orbital parameters.