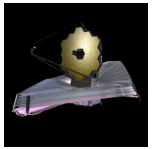

5844 - Starspots, Hazes, and Disequilibrium Chemistry: A Deep Dive into the Atmosphere of HAT-P-18b

Cycle: 3, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
NIRSpec G395M Transit				
	1	Transit 1	NIRSpec Bright Object Time Series	(1) HAT-P-18

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
MIRI LRS Transit				
	2	Transit 2	MIRI Low Resolution Spectroscopy	(1) HAT-P-18

ABSTRACT

The atmospheres of warm Jupiters are hotbeds for disequilibrium processes. Chemical quenching from 3D mixing is predicted to significantly alter the atmosphere composition away from equilibrium expectations. In tandem, photochemistry can alter the landscape of the upper atmosphere; opening chemical pathways for the production of new molecules and even hazes. HAT-P-18b, an inflated warm-Jupiter orbits an active K-type star. Multiple analyses of the JWST NIRISS transit observations of this target have differed on the extent to which the host star's inhomogeneous photosphere affects the slope in the transmission spectrum, resulting in inferences of the planet's atmosphere composition which differ by orders of magnitude. We propose to observe two transits of HAT-P-18b, one each with NIRSpec/G395M and MIRI/LRS, in order to construct a complete 0.6-12μm transmission spectrum of this intriguing target. By leveraging the full capabilities of JWST, we will robustly differentiate between atmospheres sculpted by hazes vs. by stellar heterogeneities, via searching for the 5.8μm C-O haze scattering feature; a detection of which would be a first in an exoplanet atmosphere. This measurement will have wide-reaching implications for the interpretation of transmission spectra of other planets from which the presence of scattering hazes have been inferred on the basis of detecting a blue-wavelength slope. We will moreover, complete the chemical inventory of HAT-P-18b's atmosphere and probe the partitioning of Carbon and Sulfur; thereby gaining a deeper understanding of its formation history as well as the disequilibrium processes governing its evolution.

OBSERVING DESCRIPTION

We will observe two transits of HAT-P-18b, one with NIRSpec/G395M in BOTS mode and one with MIRI/LRS to complement the existing NIRISS/SOSS transit observations of this planet. These will allow us to robustly distinguish between haze scattering and the transit light source effect as the cause of the blue wavelength slope in the SOSS transmission spectrum, and probe the interplay between multiple disequilibrium chemistry processes in the atmosphere of this warm Jupiter. Our program will leverage the full capabilities of JWST to construct a complete 0.6 - 12μm transmission spectrum of HAT-P-18b, enabling one of the most comprehensive analyses of an exoplanet atmosphere attempted to date, and provide a dataset with high legacy value for the community.

For the NIRSpec/G395M observation, target selection is performed on the target itself with WATA and the F110W filter. One single pixel at the center of the TA aperture is saturated, however this should not be an issue for the target selection as has been demonstrated by numerous programs (e.g., DDT #1366). The science exposure is not saturated anywhere on the detector. We opt for G395M over G395H in order to have the potential to detect signatures of H2S, which would otherwise fall in the G395H detector gap. Retrieval analyses on simulated data show that the resolution of

G395M will, in any case, be sufficient to accomplish our stated science goals. Furthermore, changing to G395H vs G395M results in only a marginal increase in the duty cycle (~98% vs. 96%). We include a 1:1 in-transit:baseline ratio, which is standard in the field, and will be sufficient for these observations.

For MIRI/LRS, target selection is once again performed on the target itself using the F1000W filter, with no saturation. We do not include the verifcation image as there is sufficient space on the MIRI detector to perform an accourate background calibration. The science exposures themselves are not saturated anywhere. We include 203 groups per integration, which pushes the detector to just shy of the saturation limit at the blue end, but also significantly improves the S/N at the red end (improvement of ~350 at 12μm). With the large number of groups we are confident that, if the onset of saturation is earlier than predicted, we can trim the affected groups and still retain enough of a ramp to accurately extract the slope. Moreover, previous MIRI programs (e.g., GO #1353, GO #2667; priv. comm.) which have even pushed past the saturation limit did not notice any adverse non-linearity effects. We opt to include an additional 1.5 hours of baseline before the transit in order to correct for a problematic ramp that has been seen in previous MIRI/LRS time series observations (e.g., Bell et al. 2023). Although we will attempt to correct the ramp, in the event that the effected integrations must be cut entirely, including the extra 1.5 hours of padding will still leave a sufficient 1:1 baseline. HAT-P-18b resides in an incredibly sparse field, and thus no PA constraints are needed to avoid contamination of the MIRI detector.

The total time ask for transits with both instruments is ~16 hours, including all overheads.

Two APT warnings remain, which both concern a High Gain Antenna move during the time series (one warning for each instrument). This is expected and acceptable for exoplanet time series observations, and there is no evidence that HGA moves during exposures have negatively impacted data.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	HAT-P-18	RA: 17 05 23.1475 (256.3464479d)	Proper Motion RA: -14.002 mas/yr	
		Dec: +33 00 44.94 (33.01248d)	Proper Motion Dec: -36.75100001601095 mas/yr	
		Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanet Systems, K stars]

Observation

Proposal 5844, Observation 1: Transit 1

Tue Jul 15 18:00:11 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Transit 1 (Obs 1)) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	HAT-P-18	RA: 17 05 23.1475 (256.3464479d)	Proper Motion RA: -14.002 mas/yr	
		Dec: +33 00 44.94 (33.01248d)	Proper Motion Dec: -36.75100001601095 mas/yr	
		Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanet Systems, K stars]

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	171367.2

Template

Subarray
SUB2048

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G395M/F290LP	NRSRAPID	27	774	1	1	774	19563.996	171367.1

Special Requirements

Phase 0.971904619860883 to 0.9794693425693151 with period 5.508023 Days and zero-phase 2459743.853395 HJD
Time Series Observation
No Parallel Attachments

Observation

Proposal 5844, Observation 2: Transit 2

Tue Jul 15 18:00:11 GMT 2025

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Comments: Update Mar 10, 2025:
- Changed observing setup to 164 groups/956 integrations. Original setup was too close to saturation with new ETC calculations. Current setup is max 73% saturation.
- Added verification image per Sarah Kendrew's recommendation.

Diagnostics

(Transit 2 (Obs 2)) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.

(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	HAT-P-18	RA: 17 05 23.1475 (256.3464479d)	Proper Motion RA: -14.002 mas/yr	
		Dec: +33 00 44.94 (33.01248d)	Proper Motion Dec: -36.75100001601095 mas/yr	
		Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanet Systems, K stars]

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	F1000W	FAST	8	1	1	1.272	171367.3

Template

Subarray	Obtain Verification Image?
SLITLESSPRISM	true

Dithers

#	Dither Type	No. Spectral Steps	Spectral Step Offset	No. Spatial Steps	Spatial Step Offset
1	NONE				

Pointing Verification

#	PV Readout Pattern	PV Groups/Int	PV Integrations/Exp	PV Total Integrations	PV Exposures/Dith	PV Total Dithers	PV Total Exposure Time	PV ETC Wkbk.Calc ID	Filter
1	FASTR1	8	1	1	1	1	1.272		F1000W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	164	950	950	1	1	24929.361	171367.4

Special Requirements

Phase 0.9605545113414433 to 0.9681192337751954 with period 5.508023 Days and zero-phase 2459743.853395 HJD
Time Series Observation
No Parallel Attachments