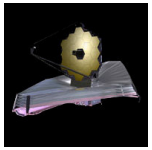

5799 - TOI-3884: A JWST Rosetta Stone for the study of M-dwarf stellar contamination

Cycle: 3, Proposal Category: GO

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
TOI-3884 b				
	1	SOSS	NIRISS Single-Object Slitless Spectroscopy	(1) TOI-3884

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
	2	SOSS	NIRISS Single-Object Slitless Spectroscopy	(1) TOI-3884
	3	G395H	NIRSpec Bright Object Time Series	(1) TOI-3884

ABSTRACT

Transiting exoplanets around late-M dwarfs are of prime importance for the field of exoplanetary science, as the relative size of their host star leads to high signal-to-noise transit signals. By using transmission spectroscopy one can access the composition of the planet's atmosphere, and make links to its formation and evolution history. But interpreting such measurements presents a major challenge: the effect of stellar contamination. Indeed, transmission spectra contain the signatures of stellar surface heterogeneities, such as starspots, able to mimic or hide planetary signals. In this respect, the opportunity offered by late-M dwarfs is balanced by their low effective temperatures, and their large convective nature known to further enhance this issue. As groundbreaking JWST transmission spectroscopy of exoplanets transiting these cool objects are being conducted, stellar contamination remains an unsolved issue, for which strategies and data have yet to be obtained.

In this study, we propose to observe the M4-type star TOI-3884 with the NIRISS and NIRSpec-G395H instruments, as its giant polar spot is being occulted by the large-Neptune companion TOI-3884 b. Beyond enabling the detailed atmospheric characterization of this unique planet free of stellar contamination, these observations will provide the community with the first mid-resolution spectra of a spot on an M dwarf, and the first benchmark of the different strategies widely used to account for their presence in transmission spectra. Overall, these observations will further unlock the immense value of M dwarfs for both the field of stellar physics and exoplanetary science.

OBSERVING DESCRIPTION

We will observe three transits of TOI-3884 b to characterize the chemistry of the planet's atmosphere, the spectroscopic properties of the polar spot on TOI-3884, and to derive good practices to tackle the stellar contamination expected for other targets. We will perform these observations using two different instruments: NIRISS (two transits) and NIRSpec-G395H (one transit). The total transit duration of TOI-3884 b is 1.64 h. For each transit, we propose a continuous observation with a duration of 5.4h, sufficient to stabilize the detectors, to measure the stellar flux and to allow for a one-hour margin for the start of the JWST observation. The science time and the total observing time for this proposal with three transits are 14.91 hours and 21.88 hours respectively.

NIRISS observations will be carried out with the SOSS mode, with an optimal configuration determined using PandExo and the JWST ETC. We chose the subarray SUBSTRIP256l and NISRAPID as the readout pattern and we impose a saturation threshold of 80% when optimizing the number of groups per integration (10 groups/int). The full transit observation is then covered with 321 integrations for 1 exposure (total exposure time of

19405.888s). The target acquisition will be done on TOI-3884 (Method: SOSSFAINT, filter: F480M, readout pattern: NISRAPID, N_group=3) with a total exposure time of 0.2 s, enabling a SNR of 56.

The NIRSpec-G395H observation will be carried out with the Bright Object Time Series (BOTS) mode. We chose the subarray SUB2048, which gives the highest SNR without saturation problems for TOI-3884. We chose NISRAPID as the readout pattern and a number of 70 groups to stay below ~80% of saturation. The full transit observation is then covered with 303 integrations for 1 exposure (total exposure time of 19410.93s). The target acquisition will also be done on TOI-3884 (Method: WATA, subarray: SUB32, filter: F110W, readout pattern: NRSRAPID, N_group=3).

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	TOI-3884	RA: 12 06 17.4371 (181.5726546d)	Proper Motion RA: -186.042 mas/yr	
		Dec: +12 30 24.88 (12.50691d)	Proper Motion Dec: 26.388 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=[M dwarfs]
Extended=NO

Observation

Proposal 5799, Observation 1: SOSS

Thu Apr 03 13:00:09 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Diagnostics

(SOSS (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)	TOI-3884	RA: 12 06 17.4371 (181.5726546d)	Proper Motion RA: -186.042 mas/yr	
		Dec: +12 30 24.88 (12.50691d)	Proper Motion Dec: 26.388 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=[M dwarfs]
Extended=NO

Acquisition

#	Target	Acquisition Mode	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	SOSSFAINT	F480M	NISRAPID	3	1	1	0.202	177969.2

Template

Subarray	Include Short First Exposure and F277W Exposure?
SUBSTRIP256	false

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	NISRAPID	10	321	1	321	19405.888	177969.1

Special Requirements

Phase 0.96724112296 to 0.97640957441 with period 4.5445697 Days and zero-phase 2459642.86314 HJD
Aperture PA Range 112 to 121 Degrees (V3 111.43873283 to 120.43873283)
Time Series Observation
No Parallel Attachments

Observation

Proposal 5799, Observation 2: SOSS

Thu Apr 03 13:00:09 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Diagnostics

(SOSS (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)	TOI-3884	RA: 12 06 17.4371 (181.5726546d)	Proper Motion RA: -186.042 mas/yr	
		Dec: +12 30 24.88 (12.50691d)	Proper Motion Dec: 26.388 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=[M dwarfs]
Extended=NO

Acquisition

#	Target	Acquisition Mode	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	SOSSFAINT	F480M	NISRAPID	3	1	1	0.202	177969.2

Template

Subarray	Include Short First Exposure and F277W Exposure?
SUBSTRIP256	false

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	NISRAPID	10	321	1	321	19405.888	177969.1

Special Requirements

Phase 0.96724112296 to 0.97640957441 with period 4.5445697 Days and zero-phase 2459642.86314 HJD
Aperture PA Range 110 to 120 Degrees (V3 109.43873283 to 119.43873283)
Time Series Observation
No Parallel Attachments

Observation

Proposal 5799, Observation 3: G395H

Thu Apr 03 13:00:10 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(G395H (Obs 3)) 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 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	TOI-3884	RA: 12 06 17.4371 (181.5726546d)	Proper Motion RA: -186.042 mas/yr	
		Dec: +12 30 24.88 (12.50691d)	Proper Motion Dec: 26.388 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=[M dwarfs]
Extended=NO

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	177969.4

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	G395H/F290LP	NRSRAPID	70	303	1	1	303	19410.931	177969.3

Special Requirements

Phase 0.96724112296 to 0.97640957441 with period 4.5445697 Days and zero-phase 2459642.86314 HJD
Aperture PA Range 253 to 263 Degrees (V3 114.14704895 to 124.14704895)
Time Series Observation
No Parallel Attachments