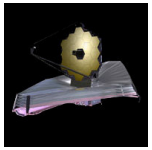

2783 - MIRI LRS follow up on SO2 detection in WASP-39b

Cycle: 1, Proposal Category: DD

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	Transit observation	MIRI Low Resolution Spectroscopy	(1) WASP-39
	2	Background observation	MIRI Low Resolution Spectroscopy	(1) WASP-39

ABSTRACT

The recent JWST early release science (ERS) exoplanet program using the NIRSpec PRISM and g395h modes discovered an unexpected feature at 4.05 um in the transit spectrum of WASP-39b thought to be caused by SO2. Photochemical modelling of the atmosphere has shown SO2 to be a robust outcome of the chemical environment in WASP-39b's atmosphere. By observing a timely follow up transit of WASP-39b using MIRI low resolution spectrometer (LRS), we will be able to directly detect the SO2 feature that peaks at 7.5 um which is expected to have 3 times the amplitude of the 4.05 um feature.

In addition, a broad feature of SO2 is present at 8.8um, able to to be distinguished through binning to low resolution.

The detection of the 7.5 um and 8.8 um features will unambiguously confirm the presence of SO2 in the atmosphere of WASP-39b, place tight constraints on the atmospheric metallicity and robustly conclude that active photochemistry is happening in a exoplanet atmosphere.

This detection will also place unprecedented constraints on the sulfur inventory and bulk metallicity of the exoplanet and allow for novel constraints on how the atmospheric composition relates to the formation history of the exoplanet. This observation is particularly timely as the ERS results will motivate many future proposals that will aim to detect SO2 in a broad range of exoplanet atmospheres. We are thus requesting a DDT observation program so that we can produce the first roadmap for observing sulfur in exoplanet atmospheres.

OBSERVING DESCRIPTION

We propose a follow up observation of a single transit of hot Saturn exoplanet WASP-39b using the MIRI low resolution spectrograph (LRS) in slitless mode.

This observation is time critical due to the fact that the earliest observation window for WASP-39b is January 25, too late for Cycle 2 proposals. Cycle 2 targets would be observed across summer-winter 2023, Therefore, to be in time and in advance of Cycle 3 proposals, the observation must be scheduled for the beginning of Cycle 2 (Jan-Feb 2023).

The exoplanet transit ERS program found a hint of a SO2 signature at 4.05 um in the PRISM and g395h NIRSpec modes. Due to the strong 7.5 and 8.8 um features of SO2, MIRI LRS is optimally placed to identify and confirm photochemical signatures of SO2 in the WASP-39b atmosphere, providing unambiguous evidence of photochemical processes occurring in an exoplanet atmosphere for the first time.

Leaning in on the global collaborative spirit and experience of the exoplanet transit ERS program, with open data policies and ERS community input throughout data extraction, reduction, modelling and interpretation, this dataset would provide a final coda to the significant increase in knowledge, development of pipeline and modelling gained during the ERS program so far.

The transit duration of WASP-39b is 2.8 hours. We plan for 2.23 +/0.5 hours before transit and 1.91 +/-0.5 hours after transit. The +/- 0.5 hours accounts for the uncertainty in the timeing window. The observation is not centered on the transit. We shift it earlier to give more time to charaterize or trim the ramp. We replace 20 minutes after the transit observation with an offset background observation.

Our observing plan uses the same duration and timing constraints from the four successful NIR transit observations obtained for WASP-39b in the ERS program. Adapting that plan to MIRI we have a total visit duration of 8.25 hours to cover the transit, give sufficient out-of-transit data to measure the baseline and constrain systematics, and give extra time pre-transit in case some data needs to be discarded as a burn-in. We nominally assume 100 groups per integration and 1850 integrations per exposure.

Proposal 2783 - Targets - MIRI LRS follow up on SO2 detection in WASP-39b

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	WASP-39	RA: 14 29 18.3955 (217.3266479d) Dec: -03 26 40.20 (-3.44450d) Equinox: J2000	Proper Motion RA: -0.0012716973645945132 sec of time/yr Proper Motion Dec: 4.37E-4 arcsec/yr Epoch of Position: 2015.5	

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

Observation

Proposal 2783, Observation 1: Transit observation

Wed Jan 11 17:03:32 GMT 2023

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Diagnostics

(Transit observation (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)	WASP-39	RA: 14 29 18.3955 (217.3266479d) Dec: -03 26 40.20 (-3.44450d) Equinox: J2000	Proper Motion RA: -0.0012716973645945132 sec of time/yr Proper Motion Dec: 4.37E-4 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	1 WASP-39	F1000W	FAST	8	1	1	1.272	126129.1

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

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	FAST	8	1	1	1.272	126129.1

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	100	1779	1779	1	1	28575.989	126129.2

Special Requirements

Phase 0.95248 to 0.96275 with period 4.05527999 Days and zero-phase 2457792.356338 HJD
Time Series Observation
No Parallel Attachments
No Parallel Attachments

Sequence Observations 1, 2, Non-interruptible

Observation

Proposal 2783, Observation 2: Background observation

Wed Jan 11 17:03:32 GMT 2023

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Diagnostics

(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)	WASP-39	RA: 14 29 18.3955 (217.3266479d) Dec: -03 26 40.20 (-3.44450d) Equinox: J2000	Proper Motion RA: -0.0012716973645945132 sec of time/yr Proper Motion Dec: 4.37E-4 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	1 WASP-39	F1000W	FAST	8	1	1	1.272	126129.1

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

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	FAST	8	1	1	1.272	126129.1

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	100	10	10	1	1	160.471	126129.2

Special Requirements

Offset 16.0 arcsec, 0.0 arcsec
Time Series Observation
No Parallel Attachments
No Parallel Attachments

Sequence Observations 1, 2, Non-interruptible