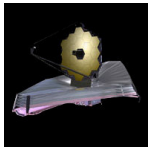

2950 - Exploring sulfur dioxide in H/He-rich hot gas giant atmospheres

Cycle: 2, Proposal Category: GO

INVESTIGATORS

Name	*Institution*
Prof. Rens Waters (PI) (ESA Member)	**Radboud Universiteit Nijmegen**
Dr. Michael Migo Mueller (CoI) (ESA Member)	University of Groningen
Dr. Michiel Min (CoI) (ESA Member)	Space Research Organization Netherlands
Prof. Thomas K. Henning (CoI) (ESA Member)	Max Planck Institute for Astronomy
Dr. Yamila Miguel (CoI) (ESA Member)	Universiteit Leiden
Dr. Nicolas Michael Crouzet (CoI) (ESA Member)	Leiden Observatory
Dr. Jeroen Bouwman (CoI) (ESA Member)	Max Planck Institute for Astronomy
Prof. Manuel Guedel (CoI) (ESA Member)	University of Vienna
Dr. Martin Topinka (CoI) (ESA Member)	Dublin Institute For Advanced Studies
Prof. David Barrado Navascues (CoI) (ESA Member)	Centro de Astrobiologia (CSIC/INTA) Inst. Nac. de Tec. Aero.
Mr. Linus Heinke (CoI) (ESA Member)	Institute of Astronomy, KU Leuven
Dr. Billy Edwards (CoI) (ESA Member)	Space Research Organization Netherlands
Leen Decin (CoI) (ESA Member)	Institute of Astronomy, KU Leuven
Sarah Kendrew (CoI) (ESA Member) (US Admin CoI)	Space Telescope Science Institute - ESA - JWST
Dr. Maria Morales-Calderon (CoI) (ESA Member)	Centro de Astrobiologia (CSIC/INTA) Inst. Nac. de Tec. Aero.
Ms. Niloofar Khorshid (CoI) (ESA Member)	Universiteit van Amsterdam
Jesse Polman (CoI) (ESA Member)	University of Bern
Olaf Renes (CoI) (ESA Member)	Radboud Universiteit Nijmegen
Mr. Francisco Ardevol Martinez (CoI) (ESA Member)	Kapteyn Astronomical Institute
Dr. John P. Pye (CoI) (ESA Member)	University of Leicester
Dr. Pierre-Olivier Lagage (CoI) (ESA Member)	Commissariat a l'Energie Atomique (CEA)

OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
HAT-P-1b transit LRS				
	1	HAT-P-1b transit LRS	MIRI Low Resolution Spectroscopy	(1) HAT-P-1
HD106315c transit LRS				
	2	HD106315c transit LRS	MIRI Low Resolution Spectroscopy	(2) HD106315
HAT-P-11b transit LRS				
	3	HAT-P-11b transit LRS	MIRI Low Resolution Spectroscopy	(3) HAT-P-11
HAT-P-1b bg				
	4	HAT-P-1b bg	MIRI Low Resolution Spectroscopy	(5) HAT-P-1-BG
HD106315c bg				
	5	HD106315c bg	MIRI Low Resolution Spectroscopy	(6) HD106315-BG
HAT-P-11b bg				
	6	HAT-P-11b bg	MIRI Low Resolution Spectroscopy	(4) HAT-P-11-BG

ABSTRACT

The recent detection of sulfur dioxide (SO2) in the atmosphere of the hot Saturn-mass planet WASP-39b by the JWST exoplanet ERS team opens an exciting new tool to study H/He dominated hot planets. The presence of SO2 can be understood as a result of upper atmosphere photochemistry; its abundance is a strong function of the chemical composition (both metallicity and C/O ratio) of the atmosphere. This is because SO2 is the result of the photodissociation of water to OH and a subsequent reaction with atomic sulfur. Because both oxygen (water) and sulfur abundances scale with metallicity, the upper atmosphere SO2 abundance can increase by several orders of magnitude for planets with 10 times the solar metallicity and solar to sub-solar C/O. The presence of SO2 therefore opens a new venue to determine the atmospheric metallicity and C/O ratio and offers for the first time access to an important chemical element.

We propose to obtain transmission spectra using JWST/MIRI in LRS slitless mode in order to measure the presence and abundance of SO2 in three carefully chosen hot planets with H/He dominated atmospheres in which water has been detected. These observations will allow us to (1) test photochemical atmosphere models that predict a strong dependence of SO2 on metallicity and C/O ratio, (2) establish the impact of different stellar radiation properties on the upper atmosphere photochemistry, and (3) constrain the formation history of the planets.

OBSERVING DESCRIPTION

We request transit spectroscopy of a single transit of three hot H/He dominated planets, using the MIRI in slitless LRS mode. The planets have been selected on the basis of the chemical composition of the planets based on HST or other observations, on the brightness of the parent star and its spectral shape, and the planet/star contrast. At the shortest MIRI wavelengths, the signal may approach the 100 per cent saturation limit.

We have selected the following targets:

planet	HAT-P-1b	HAT-P-11b	HD 106315c
Sp. T.	G0V	K4	F5 V
V magnitude	10.4	9.59	9.0
M(pl, in M(jup))	0.525	0.073	0.05
C/O	0.64	0.47	0.51
log(Met)	1.73	1.59	1.61
T((pl) (K)	1322	880	890
R(pl) R(Jup)	1.32	0.39	0.39

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	HAT-P-1	RA: 22 57 46.8872 (344.4453633d) Dec: +38 40 29.71 (38.67492d) Equinox: J2000	Proper Motion RA: 0.002768612151740113 sec of time/yr Proper Motion Dec: -0.04194900002403301 arcsec/yr Parallax: 0.0062438" Epoch of Position: 2015.5	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Exoplanets, G dwarfs]* *Extended=NO*				
(2)	HD106315	RA: 12 13 53.3938 (183.4724742d) Dec: -00 23 36.37 (-.39344d) Equinox: J2000	Proper Motion RA: -1.5733704271420778E-4 sec of time/yr Proper Motion Dec: 0.011942999999999999 arcsec/yr Parallax: 0.0091725" Epoch of Position: 2015.5	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Exoplanets, F dwarfs]* *Extended=NO*				
(3)	HAT-P-11	RA: 19 50 50.4423 (297.7101763d) Dec: +48 04 54.71 (48.08186d) Equinox: J2000	Proper Motion RA: 0.012583048033303935 sec of time/yr Proper Motion Dec: 0.232726 arcsec/yr Parallax: 0.0264274" Epoch of Position: 2015.5	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[Exoplanets, K dwarfs]* *Extended=NO*				
(4)	HAT-P-11-BG	RA: 19 50 46.1614 (297.6923392d) Dec: +48 05 4.71 (48.08464d) Equinox: J2000	Proper Motion RA: 0 sec of time/yr Proper Motion Dec: 0 arcsec/yr Parallax: 0" Epoch of Position: 2015.5	
Comments: Background field near HAT-P-11 *Category=Star* *Description=[Exoplanets, K dwarfs]* *Extended=NO*				
(5)	HAT-P-1-BG	RA: 22 57 44.5682 (344.4357008d) Dec: +38 41 19.74 (38.68882d) Equinox: J2000	Proper Motion RA: 0 sec of time/yr Proper Motion Dec: 0 arcsec/yr Parallax: 0" Epoch of Position: 2015.5	
Comments: Background field near HAT-P-1 *Category=Star* *Description=[Exoplanets, G dwarfs]* *Extended=NO*				

	(6)	HD106315-BG	RA: 12 13 53.3938 (183.4724742d) Dec: -00 23 36.37 (-.39344d) Equinox: J2000	Proper Motion RA: -1.5733704271420778E-4 sec of time/yr Proper Motion Dec: 0.011942999999999999 arcsec/yr Parallax: 0.0091725" Epoch of Position: 2015.5

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanets, F dwarfs]
Extended=NO

Observation

Proposal 2950, Observation 1: HAT-P-1b transit LRS Fri Apr 26 20:00:14 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Background Observations:[HAT-P-1b bg (Obs 4)]

Comments: PA constraint: to avoid contamination due to near-by (11") star

Diagnostics

(HAT-P-1b transit LRS (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.

(Visit 1:1) Informational (Form): Visit schedulable, but most scheduling windows are when JWST is pointed in direction of greatest micrometeoroid impact risk. This is likely due to scheduling special requirements.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	HAT-P-1	RA: 22 57 46.8872 (344.4453633d) Dec: +38 40 29.71 (38.67492d) Equinox: J2000	Proper Motion RA: 0.002768612151740113 sec of time/yr Proper Motion Dec: -0.04194900002403301 arcsec/yr Parallax: 0.0062438" Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanets, G dwarfs]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	F560W	FAST	6	1	1	0.954	144861.2

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	6	1	1	1	1	0.954		F560W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	49	3486	3486	1	1	27720.513	144861.1

Special Requirements

Phase 0.9547 to 0.9645 with period 4.46529958 Days and zero-phase 2454381.80898 HJD
Aperture PA Range 118.35344897 to 144.30144897 Degrees (V3 113.518 to 139.466)
Aperture PA Range 181.48344897 to 182.35244897 Degrees (V3 176.648 to 177.517)
Aperture PA Range 200.78544897 to 209.06944897 Degrees (V3 195.95 to 204.234)
Time Series Observation
No Parallel Attachments

Sequence Observations 1, 4, Non-interruptible

Observation

Proposal 2950, Observation 2: HD106315c transit LRS

Fri Apr 26 20:00:14 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Background Observations:[HD106315c bg (Obs 5)]

Diagnostics

(HD106315c transit LRS (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
(2)	HD106315	RA: 12 13 53.3938 (183.4724742d) Dec: -00 23 36.37 (-.39344d) Equinox: J2000	Proper Motion RA: -1.5733704271420778E-4 sec of time/yr Proper Motion Dec: 0.011942999999999999 arcsec/yr Parallax: 0.0091725" Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanets, F dwarfs]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	F1000W	FAST	12	1	1	1.908	144862.2

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	12	1	1	1	1	1.908		F1000W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	19	6382	12764	2	1	40599.413	144862.1

Special Requirements

Phase 0.98686 to 0.98894 with period 21.056614 Days and zero-phase 2458432.34123 HJD
Time Series Observation
No Parallel Attachments

Sequence Observations 2, 5, Non-interruptible

Observation

Proposal 2950, Observation 3: HAT-P-11b transit LRS Fri Apr 26 20:00:14 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Background Observations:[HAT-P-11b bg (Obs 6)]

Comments: PA constraint to avoid contamination due to near-by faint bg star

Diagnostics

(HAT-P-11b transit LRS (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
(3)	HAT-P-11	RA: 19 50 50.4423 (297.7101763d) Dec: +48 04 54.71 (48.08186d) Equinox: J2000	Proper Motion RA: 0.012583048033303935 sec of time/yr Proper Motion Dec: 0.232726 arcsec/yr Parallax: 0.0264274" Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanets, K dwarfs]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	F1000W	FAST	6	1	1	0.954	144863.2

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	6	1	1	1	1	0.954		F1000W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	9	15229	15229	1	1	24220.043	144863.1

Special Requirements

Phase 0.9628 to 0.9718 with period 4.88780232 Days and zero-phase 2457631.44091 HJD
Aperture PA Range 74.16644897 to 79.82544897 Degrees (V3 69.331 to 74.99)
Time Series Observation
No Parallel Attachments

Sequence Observations 3, 6, Non-interruptible

Observation

Proposal 2950, Observation 4: HAT-P-1b bg

Fri Apr 26 20:00:14 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Background Observation For: [HAT-P-1b transit LRS (Obs 1)]

Comments: Offset to a neighboring field that appears blank in Aladin

Diagnostics

(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(5)	HAT-P-1-BG	RA: 22 57 44.5682 (344.4357008d) Dec: +38 41 19.74 (38.68882d) Equinox: J2000	Proper Motion RA: 0 sec of time/yr Proper Motion Dec: 0 arcsec/yr Parallax: 0" Epoch of Position: 2015.5	

Comments: Background field near HAT-P-1
Category=Star
Description=[Exoplanets, G dwarfs]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	1 HAT-P-1	F560W	FAST	6	1	1	0.954	144861.2

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	6	1	1	1	1	0.954		F560W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	49	10	10	1	1	79.361	144861.1

Special Requirements

Time Series Observation
No Parallel Attachments

Sequence Observations 1, 4, Non-interruptible

Observation

Proposal 2950, Observation 5: HD106315c bg

Fri Apr 26 20:00:14 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Background Observation For: [HD106315c transit LRS (Obs 2)]

Comments: Phase constraint: to ensure that the non-target planet b is _not_ in transit during the observed transit of target planet c

Diagnostics

(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(6)	HD106315-BG	RA: 12 13 53.3938 (183.4724742d) Dec: -00 23 36.37 (-.39344d) Equinox: J2000	Proper Motion RA: -1.5733704271420778E-4 sec of time/yr Proper Motion Dec: 0.011942999999999999 arcsec/yr Parallax: 0.0091725" Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[Exoplanets, F dwarfs]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	2 HD106315	F1000W	FAST	12	1	1	1.908	144862.2

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	12	1	1	1	1	1.908		F1000W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	19	10	20	2	1	63.298	144862.1

Special Requirements

Phase 0.0962 to 0.9656 with period 9.55287 Days and zero-phase 2457586.5476 HJD
Offset -19.838898812358273 arcsec, 21.15447112171198 arcsec
Time Series Observation
No Parallel Attachments

Sequence Observations 2, 5, Non-interruptible

Observation

Proposal 2950, Observation 6: HAT-P-11b bg Fri Apr 26 20:00:14 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Background Observation For: [HAT-P-11b transit LRS (Obs 3)]

Diagnostics

(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(4)	HAT-P-11-BG	RA: 19 50 46.1614 (297.6923392d) Dec: +48 05 4.71 (48.08464d) Equinox: J2000	Proper Motion RA: 0 sec of time/yr Proper Motion Dec: 0 arcsec/yr Parallax: 0" Epoch of Position: 2015.5	

Comments: Background field near HAT-P-11
Category=Star
Description=[Exoplanets, K dwarfs]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 HAT-P-11	F1000W	FAST	6	1	1	0.954	144863.2

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	6	1	1	1	1	0.954		F1000W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	9	10	10	1	1	15.745	144863.1

Special Requirements

Time Series Observation
No Parallel Attachments

Sequence Observations 3, 6, Non-interruptible