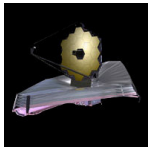

2372 - Deep Characterization of the Atmosphere of a Temperate Sub-Neptune

Cycle: 1, Proposal Category: GO

INVESTIGATORS

Name	*Institution*
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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	K2-18 b G235H	NIRSpec Bright Object Time Series	(1) K2-18
	2	K2-18 b G235H	NIRSpec Bright Object Time Series	(1) K2-18
	3	K2-18 b G395H	NIRSpec Bright Object Time Series	(1) K2-18
	7	K2-18 b G395H - Repeat of observation 3	NIRSpec Bright Object Time Series	(1) K2-18
	4	K2-18 b G395H	NIRSpec Bright Object Time Series	(1) K2-18
	5	K2-18 b G395H	NIRSpec Bright Object Time Series	(1) K2-18
	6	K2-18 b G395H	NIRSpec Bright Object Time Series	(1) K2-18

ABSTRACT

Characterizing the atmospheres of small and temperate exoplanets observationally will make a great stride forward in determining their potential habitability. With an equilibrium temperature <300 K, the sub-Neptune K2-18 b has spectral features detected at 1.1 – 1.7 microns in transmission, and thus an H2/He-dominated atmosphere amenable for further characterization via transmission spectroscopy. This planet presents a uniquely low-risk path for detailed studies of its atmospheric composition, photochemistry, and potential habitability. We propose to use NIRSpec to measure the planet's transmission spectrum in 1.7 – 5.2 microns at a resolution of R=100. The transmission spectrum will be sensitive and precise enough to measure the abundances of H2O, CH4, NH3, CO2, and CO, constrain the cloud pressure, and detect photochemical products such as HCN and N2O

in the atmosphere of K2-18 b. The combination of these gases would determine whether the planet is a mini-Neptune with a massive H2 atmosphere or an ocean planet with a thinner atmosphere. Our program will thus usher in an era of deep characterization of temperate and volatile-rich exoplanets.

OBSERVING DESCRIPTION

We will acquire a transmission spectrum of the temperate sub-Neptune K2-18 b with NIRSpec, using the G235H and G395H gratings to cover the wavelength range 1.7 – 5.2 microns. We propose to combine two transits with G235H and four transits with G395H to achieve a precision of ~20 ppm per spectral element at a resolution of R=100.

We choose the number of groups to keep the saturation level within 60%, to make sure that the observations would be well within the detector's linear regime and maximize the efficiency of the observations. Due to the brightness of K2-18 b, we perform target acquisition (TA) on a nearby star with precise position and
proper motion from Gaia DR2.

As is recommended for exoplanet transit observations, we include an out-of-transit portion of the light curve. This is necessary to establish a baseline from which the transit depth can be determined and using which instrumental systematics can be modelled. For each visit, we include ~340 minutes of baseline for the 164-minutes (~2.73hrs) eclipse (data from Benneke et al. 2019) (in/out fraction equals to 0.48), half of which is before the eclipse, and half of which is after. Additionally, since any timing constraint narrower than 1 hour is considered "tight" and incurs a 1-hour scheduling overhead penalty, we use a timing window of exactly 1 hour, centered at 170+30 = 200 minutes before the predicted start of the transit. The extra baseline allows the instrument to stabilize and thus reduce systematics. The total time requested of each observation is ~8.9hrs which is well above the calculated "dwell" time recomanded by JDocs.

Proposal 2372 - Targets - Deep Characterization of the Atmosphere of a Temperate Sub-Neptune

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[M stars]*				
(2)	TA-K2-18	RA: 11 30 13.0690 (172.5544542d) Dec: +07 35 11.82 (7.58662d) Equinox: J2000	Proper Motion RA: -80.377 mas/yr Proper Motion Dec: -133.142 mas/yr Parallax: 0.0054575" Epoch of Position: 2015.5	
Comments: Gaia DR2 3910747493159916928, bp=20.7292, g=19.1473, rp=17.6996 *2MASS 11301306+0735116, J=15.693, H=15.017, K=14.694* *WISEA J113013.06+073511.5, W1=14.225, W2=13.967, W3<12.121, W4<8.915* *K2-18/TA-K2-18 separation at epoch=J2023.00 is 21.13 arcsec* *Category=Unidentified* *Description=[Infrared sources]* *Extended=NO*				
(3)	2MASSJ11301306+0735116	RA: 11 30 13.0170 (172.5542375d) Dec: +07 35 11.59 (7.58655d) Equinox: J2000	Proper Motion RA: -48.68017233601054 mas/yr Proper Motion Dec: -13.319284639576672 mas/yr Parallax: 0.005626807196112433" Epoch of Position: 2016	
Comments: This object was generated by the targetselector and retrieved from the 2MASS database. *Updated with GAIA DR3 coordiantes* *Category=Unidentified* *Description=[Infrared sources]*				

Observation

Proposal 2372, Observation 1: K2-18 b G235H

Tue Jan 09 17:00:44 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(K2-18 b G235H (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)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 2MASSJ11301306+0735116	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	56508.3

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	G235H/F170LP	NRSRAPID	9	3548	1	1	3548	32075.623	56508.2

Special Requirements

Phase 0.9934329341552374 to 0.9946978585555126 with period 32.940045 Days and zero-phase 2457725.551189 HJD
Time Series Observation
No Parallel Attachments

4 After 1

Observation

Proposal 2372, Observation 2: K2-18 b G235H

Tue Jan 09 17:00:44 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(K2-18 b G235H (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)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 2MASSJ11301306+0735116	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	56508.3

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	G235H/F170LP	NRSRAPID	9	3548	1	1	3548	32075.623	56508.2

Special Requirements

Phase 0.9934329341552374 to 0.9946978585555126 with period 32.940045 Days and zero-phase 2457725.551189 HJD
Time Series Observation
No Parallel Attachments

2 After 4

Observation

Proposal 2372, Observation 3: K2-18 b G395H

Tue Jan 09 17:00:44 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(K2-18 b 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)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	2 TA-K2-18	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	56508.3

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	16	2089	1	1	2089	32075.509	56508.1

Special Requirements

Phase 0.9934329341552374 to 0.9946978585555126 with period 32.940045 Days and zero-phase 2457725.551189 HJD
Time Series Observation
No Parallel Attachments

Observation

Proposal 2372, Observation 7: K2-18 b G395H - Repeat of observation 3

Tue Jan 09 17:00:44 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(K2-18 b G395H - Repeat of observation 3 (Obs 7)) 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 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 2MASSJ11301306+0735116	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	56508.3

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	16	2089	1	1	2089	32075.509	56508.1

Special Requirements

Phase 0.9934329341552374 to 0.9946978585555126 with period 32.940045 Days and zero-phase 2457725.551189 HJD
Time Series Observation
No Parallel Attachments

Observation

Proposal 2372, Observation 4: K2-18 b G395H

Tue Jan 09 17:00:44 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(K2-18 b G395H (Obs 4)) 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 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 2MASSJ11301306+0735116	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	56508.3

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	16	2089	1	1	2089	32075.509	56508.1

Special Requirements

Phase 0.9934329341552374 to 0.9946978585555126 with period 32.940045 Days and zero-phase 2457725.551189 HJD
Time Series Observation
No Parallel Attachments

2 After 4
4 After 1

Observation

Proposal 2372, Observation 5: K2-18 b G395H

Tue Jan 09 17:00:44 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(K2-18 b G395H (Obs 5)) 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 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 2MASSJ11301306+0735116	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	56508.3

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	16	2089	1	1	2089	32075.509	56508.1

Special Requirements

Phase 0.9934329341552374 to 0.9946978585555126 with period 32.940045 Days and zero-phase 2457725.551189 HJD
Time Series Observation
No Parallel Attachments

Observation

Proposal 2372, Observation 6: K2-18 b G395H

Tue Jan 09 17:00:44 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(K2-18 b G395H (Obs 6)) 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 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	K2-18	RA: 11 30 14.4338 (172.5601408d) Dec: +07 35 16.19 (7.58783d) Equinox: J2000	Proper Motion RA: -0.005405801996179021 sec of time/yr Proper Motion Dec: -0.13314200000422716 arcsec/yr Epoch of Position: 2015.5	

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

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	3 2MASSJ11301306+0735116	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	56508.3

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	16	2089	1	1	2089	32075.509	56508.1

Special Requirements

Phase 0.9934329341552374 to 0.9946978585555126 with period 32.940045 Days and zero-phase 2457725.551189 HJD
Time Series Observation
No Parallel Attachments