16685 - Low Mass Evaporating Planets: A Search for the Star-Planet Interaction in Kepler-535

Cycle: 29, Proposal Category: GO

(UV Initiative)

(Availability Mode: SUPPORTED)

INVESTIGATORS

Name	*Institution*
Dr. Raghvendra Sahai (PI) (Contact)	**Jet Propulsion Laboratory**
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VISITS

Visit	*Targets used in Visit*	*Configurations used in Visit*	*Orbits Used*	*Last Orbit Planner Run*	*OP Current with Visit?*
01	(2) KOI-355	COS/FUV COS/NUV	1	06-Mar-2023 13:00:13.0	yes
02	(2) KOI-355	COS/FUV COS/NUV	1	06-Mar-2023 13:00:14.0	yes
03	(2) KOI-355	COS/FUV COS/NUV	1	06-Mar-2023 13:00:15.0	yes
04	(2) KOI-355	COS/FUV COS/NUV	1	06-Mar-2023 13:00:15.0	yes
05	(2) KOI-355	COS/FUV COS/NUV	1	06-Mar-2023 13:00:16.0	yes

5 Total Orbits Used

ABSTRACT

Exoplanet-host stars with planets at short separations can influence each other (commonly termed the star-planet interaction or SPI), via a variety of mechanisms. Understanding SPI in exoplanet host stars is thus crucial for understanding the evolution of both the planet and its host star, but observational evidence for SPI is generally scarce. An important signature of SPI is UV emission, and time-resolved FUV spectroscopy with HST/COS has provided compelling evidence for, and details of, the SPI phenomenon in HD189733, which has a Jupiter-mass planet.

We now propose to search for SPI in the exoplanet host star Kepler-535, which hosts a 0.21 Jupiter-radius (Rjup) planet. Our search is motivated by an intriguing new result that we have found using GALEX data: stars in which the innermost planet has a radius less than about 0.4 Rjup are statistically much more likely to have high FUV/NUV flux ratios, compared to those where the radius is significantly larger. We hypothesize that this is because it may be easier to get mass-loss from the atmosphere of Neptune and sub-Neptune mass planets as a result of irradiation by the star. When material from this evaporated mass falls onto the star, it gets heated to high temperatures (~50,000K) as has been been observed in HD189733. The high temperature plasma results in a high FUV/NUV ratio. We propose to use COS spectroscopy of diagnostic FUV lines that can effectively probe the amount of mass evaporating from the planet, and help in determining the dynamics of the gas around the planet. The results from this study will enable testing state-of-art MHD models of such systems.

OBSERVING DESCRIPTION

Our goal is to obtain time-resolved spectroscopy of the planet bearing star Kepler-535 with COS, at planetary orbital phases in the range ~ 0.5-0.63. We will use the G130M grating with central wavelength set to 1281 A in order to cover the range ~1150-1450 A, as in the study of FUV-line variability in the exoplanet host-star HD 189733 by Pillitteri et al. (2015), in order to cover the major FUV lines that probe hot gas (~20, 000 to 100,000 K). The main lines in this range are the H Lya, Si II, Si III, Si IV, C II, C III lines, and N V lines. We will need 5 orbits to observe the egress of the planet from secondary transit sampling the same orbital phase range in Petal15 (0.499-0.625). By taking the observations in TIME-TAG mode, we will be able to look for any changes in the line profiles in the 1150-1450 A range on short time-scales (1-40 min).

We have used the GALEX FUV-band flux density for Kepler-535 (32 uJy) to estimate the expected line fluxes for it as follows. Taking the average flux of each lines observed with COS in HD189733 (table 4 of Petal15) that lies in the FUV GALEX bandpass (1344-1786A A), from epoch 1, we estimate the contribution of each line to a GALEX band-averaged FUV flux density - the strongest of these lines (e.g., Si IV 1403) have typical fluxes of few X 10|^-15 erg cm^-2 s^-1. In contrast, the brightest lines observed by Petal15 lie shortwards of the blue edge of the GALEX FUV

bandpass, e.g., the CII 1335 doublet, which has a typical flux of few X 10^-14 erg cm^-2 s^-1.

In order to estimate the contribution of lines that lie within the GALEX FUV band but were not covered in the COS spectra taken by Petal15, we used the following procedure. We (i) constructed three high temperature collisionally excited plasma models using the CLOUDY code, at the temperatures of the three components derived for the plasma flow by Petal15 (25,000, 50,000 and 80,000 K) and averaged them, (ii) scaled the resulting average spectrum to an observed flux of the Si IV1403 line of 3 X 10^-15 erg cm^-2 s^-1, and (iii) integrated the resulting spectrum over the GALEX FUV bandpass (using the FUV filter transmission curve) to derive an expected GALEX FUV-band flux of ~10 uJy for HD189733. Since the observed FUV flux of Kepler-535 is 32 uJy, we expect, conservatively assuming that it is experiencing mass-loss at a rate that is one-third that of HD189733b, that its lines will be roughly as bright as those observed towards HD189733. We note that the signal-to-noise ratio of the bright lines observed with COS towards HD189733 is quite high (S/N~20), so even if the lines we observe are a further factor 2 lower than estimated, we will still be able to detect these lines with adequate sensitivity in order to be able to robustly detect flux variations of 25% or more (note that Petal15 find variations of a factor ~2 towards HD189733).

We will 2 sub-exposures per visit (with FP-POS=3 and FP-POS=4since FP-POS=ALL is not available for the grating we need to cover our desired wavelength range) , with typical integration times of 930 sec each, per epoch. Each set of 2 exposures requires one orbit.

Visit

Proposal 16685, Visit 01, implementation Mon Mar 06 18:00:17 GMT 2023

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 4.90331667 D AND ZERO-PHASE HJD2454966.674488; SEQ 01,02 WITHIN 5 H

Diagnostics

(Visit 01) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave. See the COS Instrument Handbook for exceptions that may apply to observations with G130M/1291 or G160M.

Fixed Targets

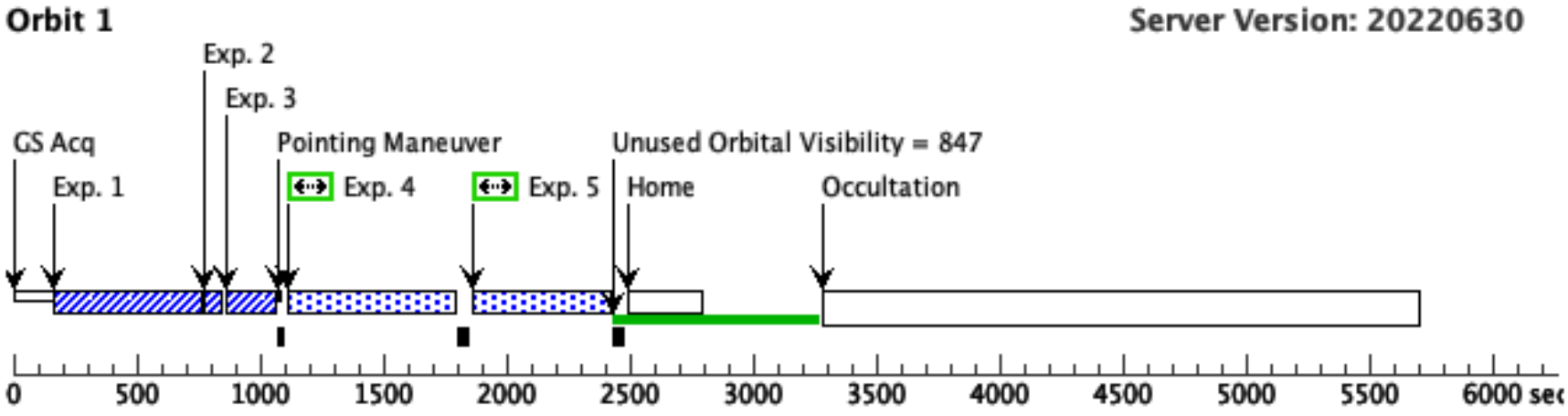
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	KOI-355 Alt Name1: 2MASS-J19461599+4941465	RA: 19 46 15.9981 (296.5666587d) Dec: +49 41 46.23 (49.69617d) Equinox: J2000	Proper Motion RA: -2.2468179957305353E-5 sec of time/yr Proper Motion Dec: -0.01548500008539122 arcsec/yr Parallax: 0.0014297" Epoch of Position: 2015.5 Radial Velocity: 8.6 km/sec	V=13.15+/-0.05 B=13.66, J=12.14, H=11.91, K=11.85	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, G III-I]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.1530170)	(2) KOI-355	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=3; STEP-SIZE=1.767; CENTER=FLUX-WT-FLR	PHASE 0.498 TO 0.502		10 Secs (10 Secs) *[==>]*	*[1]*
2	(COS.sa.1530172)	(2) KOI-355	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM			7.5 Secs (7.5 Secs) *[==>]*	*[1]*
3	(COS.sa.1530170)	(2) KOI-355	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=FLUX-WT-FLR			10 Secs (10 Secs) *[==>]*	*[1]*
4	(COS.sp.1530495)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=2155; FLASH=YES			1050 Secs (510 Secs) *[==>510 Secs]*	*[1]*
5	(COS.sp.1530495)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=2155; FLASH=YES			1050 Secs (510 Secs) *[==>510 Secs]*	*[1]*

Orbit Structure



Visit

Proposal 16685, Visit 02, implementation Mon Mar 06 18:00:17 GMT 2023

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 4.90331667 D AND ZERO-PHASE HJD2454966.674488; SEQ 02,03 WITHIN 5 H

Diagnostics

(Visit 02) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave. See the COS Instrument Handbook for exceptions that may apply to observations with G130M/1291 or G160M.

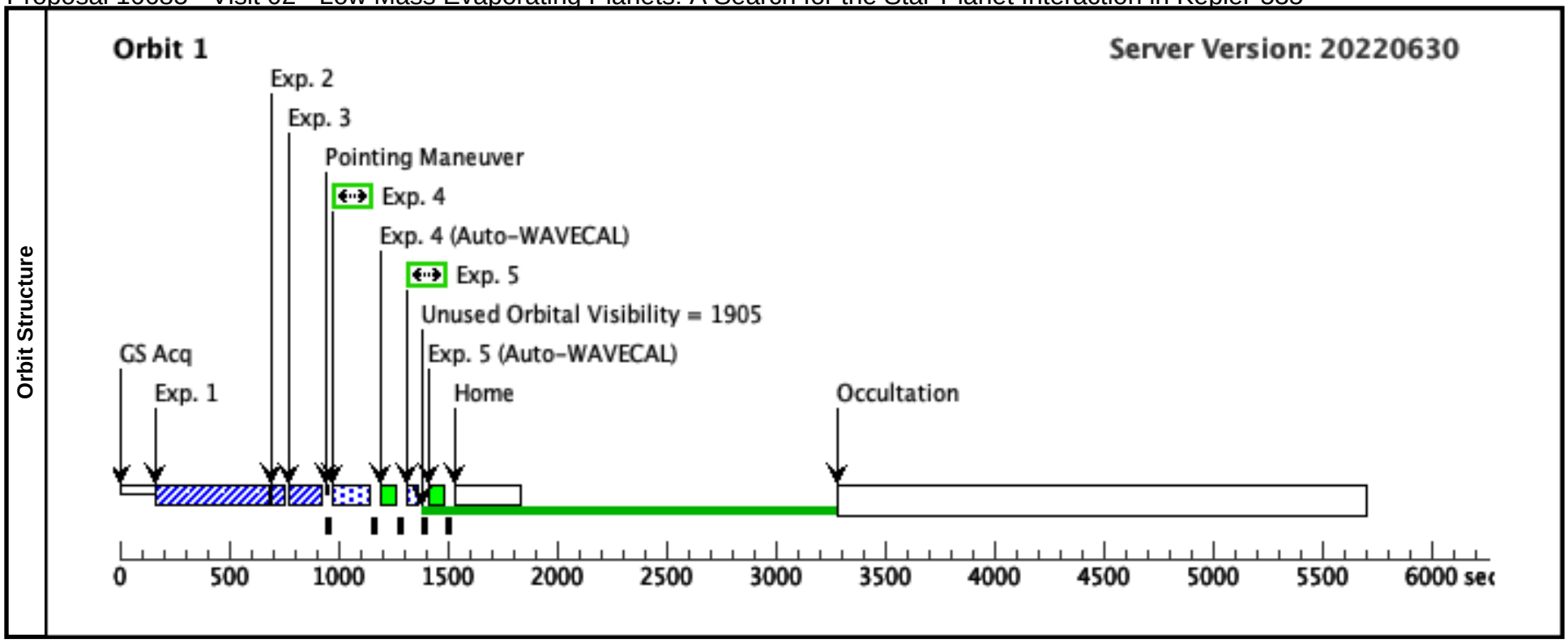
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	KOI-355 Alt Name1: 2MASS-J19461599+4941465	RA: 19 46 15.9981 (296.5666587d) Dec: +49 41 46.23 (49.69617d) Equinox: J2000	Proper Motion RA: -2.2468179957305353E-5 sec of time/yr Proper Motion Dec: -0.01548500008539122 arcsec/yr Parallax: 0.0014297" Epoch of Position: 2015.5 Radial Velocity: 8.6 km/sec	V=13.15+/-0.05 B=13.66, J=12.14, H=11.91, K=11.85	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, G III-I]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.153 0170)	(2) KOI-355	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=3; STEP-SIZE=1.767; CENTER=FLUX-WT-FLR	PHASE 0.528 TO 0.532		1 Secs (1 Secs) *[==>]*	*[1]*
2	(COS.sa.153 0172)	(2) KOI-355	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM			1 Secs (1 Secs) *[==>]*	*[1]*
3	(COS.sa.153 0170)	(2) KOI-355	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=FLUX-WT-FLR			1 Secs (1 Secs) *[==>]*	*[1]*
4	(COS.sp.153 0187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=2155; FLASH=NO			1050 Secs (1 Secs) *[==>1 Secs]*	*[1]*
5	(COS.sp.153 0187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=2155; FLASH=NO			1050 Secs (1 Secs) *[==>1 Secs]*	*[1]*


Orbit Structure
Orbit 1
Server Version: 20220630
Exp. 2
Exp. 3
Pointing Maneuver
Exp. 4
Exp. 4 (Auto-WAVECAL)
Exp. 5
Unused Orbital Visibility = 1905
Exp. 5 (Auto-WAVECAL)
GS Acq
Exp. 1
Home
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec

Visit

Proposal 16685, Visit 03, implementation Mon Mar 06 18:00:17 GMT 2023

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 4.90331667 D AND ZERO-PHASE HJD2454966.674488; SEQ 03,04 WITHIN 3.5 H

Diagnostics

(Visit 03) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave. See the COS Instrument Handbook for exceptions that may apply to observations with G130M/1291 or G160M.

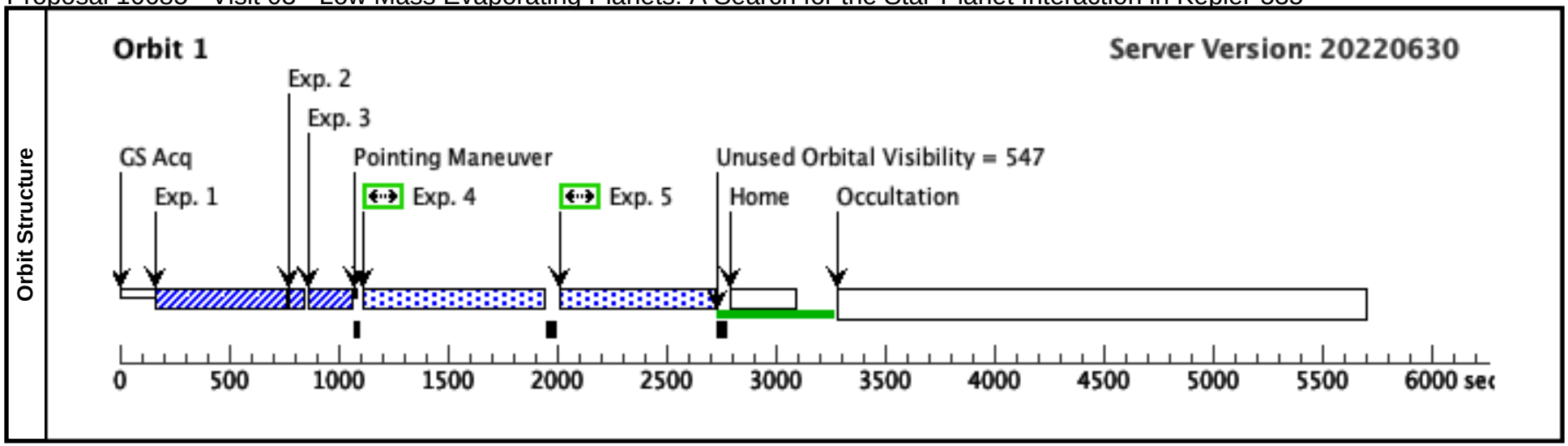
Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	KOI-355 Alt Name1: 2MASS-J19461599+4941465	RA: 19 46 15.9981 (296.5666587d) Dec: +49 41 46.23 (49.69617d) Equinox: J2000	Proper Motion RA: -2.2468179957305353E-5 sec of time/yr Proper Motion Dec: -0.01548500008539122 arcsec/yr Parallax: 0.0014297" Epoch of Position: 2015.5 Radial Velocity: 8.6 km/sec	V=13.15+/-0.05 B=13.66, J=12.14, H=11.91, K=11.85	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, G III-I]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.153 0170)	(2) KOI-355	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=3; STEP-SIZE=1.767; CENTER=FLUX-WT-FLR	PHASE 0.558 TO 0.564		10 Secs (10 Secs) *[==>]*	*[1]*
2	(COS.sa.153 0172)	(2) KOI-355	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM			7.5 Secs (7.5 Secs) *[==>]*	*[1]*
3	(COS.sa.153 0170)	(2) KOI-355	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=FLUX-WT-FLR			10 Secs (10 Secs) *[==>]*	*[1]*
4	(COS.sp.153 0187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=2155; FLASH=YES			1050 Secs (660 Secs) *[==>660 Secs]*	*[1]*
5	(COS.sp.153 0187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=2155; FLASH=YES			1050 Secs (660 Secs) *[==>660 Secs]*	*[1]*


Orbit Structure
Orbit 1
Server Version: 20220630
Exp. 2
Exp. 3
GS Acq
Pointing Maneuver
Unused Orbital Visibility = 547
Exp. 1
Exp. 4
Exp. 5
Home
Occultation
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000 sec

Visit

Proposal 16685, Visit 04, implementation Mon Mar 06 18:00:17 GMT 2023

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 4.90331667 D AND ZERO-PHASE HJD2454966.674488; SEQ 04,05 WITHIN 3.5 H

Diagnostics

(Visit 04) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave. See the COS Instrument Handbook for exceptions that may apply to observations with G130M/1291 or G160M.

Fixed Targets

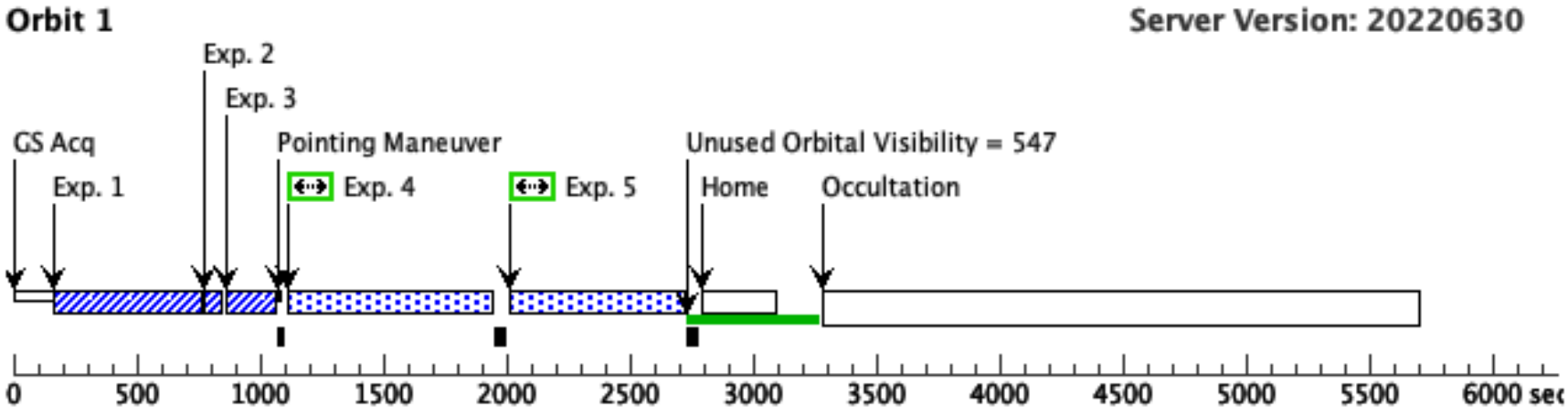
#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	KOI-355 Alt Name1: 2MASS-J19461599+4941465	RA: 19 46 15.9981 (296.5666587d) Dec: +49 41 46.23 (49.69617d) Equinox: J2000	Proper Motion RA: -2.2468179957305353E-5 sec of time/yr Proper Motion Dec: -0.01548500008539122 arcsec/yr Parallax: 0.0014297" Epoch of Position: 2015.5 Radial Velocity: 8.6 km/sec	V=13.15+/-0.05 B=13.66, J=12.14, H=11.91, K=11.85	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, G III-I]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.153 0170)	(2) KOI-355	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=3; STEP-SIZE=1.767; CENTER=FLUX-WT-FLR	PHASE 0.588 TO 0.594		10 Secs (10 Secs) *[==>]*	*[1]*
2	(COS.sa.153 0172)	(2) KOI-355	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM			7.5 Secs (7.5 Secs) *[==>]*	*[1]*
3	(COS.sa.153 0170)	(2) KOI-355	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=FLUX-WT-FLR			10 Secs (10 Secs) *[==>]*	*[1]*
4	(COS.sp.153 0187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=2155; FLASH=YES			1050 Secs (660 Secs) *[==>660 Secs]*	*[1]*
5	(COS.sp.153 0187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=2155; FLASH=YES			1050 Secs (660 Secs) *[==>660 Secs]*	*[1]*

Orbit Structure



Visit

Proposal 16685, Visit 05, implementation Mon Mar 06 18:00:17 GMT 2023

Diagnostic Status: Warning

Scientific Instruments: COS/FUV, COS/NUV

Special Requirements: Period 4.90331667 D AND ZERO-PHASE HJD2454966.674488; SEQ 04,05 WITHIN 3.5 H

Diagnostics

(Visit 05) Warning (Form): For the best data quality, it is generally required to use all four FP-POS positions when observing at a given COS cenwave. See the COS Instrument Handbook for exceptions that may apply to observations with G130M/1291 or G160M.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Fluxes	Miscellaneous
(2)	KOI-355 Alt Name1: 2MASS-J19461599+4941465	RA: 19 46 15.9981 (296.5666587d) Dec: +49 41 46.23 (49.69617d) Equinox: J2000	Proper Motion RA: -2.2468179957305353E-5 sec of time/yr Proper Motion Dec: -0.01548500008539122 arcsec/yr Parallax: 0.0014297" Epoch of Position: 2015.5 Radial Velocity: 8.6 km/sec	V=13.15+/-0.05 B=13.66, J=12.14, H=11.91, K=11.85	Reference Frame: ICRS

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=STAR
Description=[EXTRA-SOLAR PLANET, G III-I]
Extended=NO

Exposures

#	Label (ETC Run)	Target	Config,Mode,Aperture	Spectral Els.	Opt. Params.	Special Reqs.	Groups	Exp. Time (Total)/[Actual Dur.]	Orbit
1	(COS.sa.1530170)	(2) KOI-355	COS/NUV, ACQ/SEARCH, PSA	G230L 3000 A	SCAN-SIZE=3; STEP-SIZE=1.767; CENTER=FLUX-WT-FLR	PHASE 0.618 TO 0.624		10 Secs (10 Secs) *[==>]*	*[1]*
2	(COS.sa.1530172)	(2) KOI-355	COS/NUV, ACQ/PEAKXD, PSA	G230L 3000 A	STRIPE=MEDIUM			7.5 Secs (7.5 Secs) *[==>]*	*[1]*
3	(COS.sa.1530170)	(2) KOI-355	COS/NUV, ACQ/PEAKD, PSA	G230L 3000 A	STEP-SIZE=0.9; NUM-POS=5; CENTER=FLUX-WT-FLR			10 Secs (10 Secs) *[==>]*	*[1]*
4	(COS.sp.1530187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=3; BUFFER-TIME=2155; FLASH=YES			1050 Secs (230 Secs) *[==>230 Secs]*	*[1]*
5	(COS.sp.1530187)	(2) KOI-355	COS/FUV, TIME-TAG, PSA	G130M 1291 A	FP-POS=4; BUFFER-TIME=2155; FLASH=YES			1050 Secs (230 Secs) *[==>230 Secs]*	*[1]*

Orbit Structure