



6193 - A Search for Exoplanet Satellites that are the Same Size as the Earth's Moon

Cycle: 3, Proposal Category: GO

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Ms. Emily Pass (PI)	Harvard University
Prof. David Charbonneau (CoI)	Harvard University
Prof. Jacob L. Bean (CoI)	University of Chicago
Ms. Juliana Garcia-Mejia (CoI)	Harvard University
Collin Cherubim (CoI)	Harvard University

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
TOI 700 - NIRISS SOSS				
	1	TOI-700 d	NIRISS Single-Object Slitless Spectroscopy	(1) TOI-700
	2	TOI-700 e	NIRISS Single-Object Slitless Spectroscopy	(1) TOI-700

ABSTRACT

With its proven ability to achieve an RMS precision of 5 ppm in white-light transit curves, JWST with NIRISS/SOSS provides a novel opportunity to find Moon-analog ($0.27R_{\text{Earth}}$) exomoons around the terrestrial planets of M dwarfs. While no conclusive detections of exomoons have been reported to date, planet formation theories predict that such satellites should be a common outcome of the collisional dynamics in early exosolar systems. Exomoons have the potential to open the door to a multitude of new avenues to learn about exoplanet systems, speaking to topics of habitability, tidal heating, planet formation, late-stage growth, planetary compositions, and more. The standout best system to conduct a first search for rocky moons is TOI-700, which contains two habitable-zone terrestrial planets that present a large dynamically allowed region in which moons could exist. The next best system is TRAPPIST-1, which has already been observed: We present an analysis of the TRAPPIST-1 h data that shows we can rule out moons down to 40% the size of the Earth's Moon. Although there exist several other known exoplanet systems where JWST could search for such moons, we emphasize that the TOI-700 planets alone account for nearly half of all dynamically allowed phase space when summing

over all systems, owing to their long orbital periods. The discovery of a habitable-zone Earth-Moon analog would be a transformative discovery; likewise, a non-detection would allow us to rule out an occurrence rate in excess of 12%.

OBSERVING DESCRIPTION

We propose to observe one transit of each of TOI-700 d and e with NIRISS/SOSS using the SUBSTRIP256 subarray mode and the NISRAPID readout pattern. Our proposed observations include sufficient out-of-transit baseline to detect the transit of a moon orbiting one of these planets, which can be separated from the planet by as much as half of the Hill radius. The length of our requested out-of-transit observations include this Hill time component, the uncertainty in the transit midpoint time, 0.5 hours for detector burn-in preceding the transit, 0.5 hours of buffer on each end to ensure we have out-of-moon-transit baseline on both sides, and an extra hour to provide a sufficiently large timing window to avoid incurring a scheduling penalty.

The two observations are Time Series Observations with No Parallel Attachments. We set the number of groups per integration such that we do not exceed 90% of saturation. We use the primary source for target acquisition. We include F277W sequences to allow the 1st order to be isolated from the 2nd in the overlap region.

We use the NIRISS contamination planning tool from the Universite de Montreal to select a position angle range that minimizes background contamination. While a small amount of background contamination will not be prohibitive for our white-light search for exomoons, we nevertheless strive to keep this contamination small to maximize the usefulness of the data to those who might wish to use these observations for transmission spectroscopy.

Proposal 6193 - Targets - A Search for Exoplanet Satellites that are the Same Size as the Earth's Moon

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	TOI-700	RA: 06 28 22.9720 (97.0957167d)	Proper Motion RA: -0.016550556455744634 sec of time/yr	
		Dec: -65 34 43.01 (-65.57861d)	Proper Motion Dec: 0.161748 arcsec/yr		
		Equinox: J2000	Epoch of Position: 2015.5		
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>				
	Category=Star				
	Description=[Exomoons, Exoplanets]				

Proposal 6193 - Observation 1 - A Search for Exoplanet Satellites that are the Same Size as the Earth's Moon

Fri Mar 01 07:02:50 GMT 2024

Observation	Proposal 6193, Observation 1: TOI-700 d Diagnostic Status: Warning Observing Template: NIRISS Single-Object Slitless Spectroscopy																																									
Diagnostics	(TOI-700 d (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. (Exposure) 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	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>TOI-700</td> <td>RA: 06 28 22.9720 (97.0957167d) Dec: -65 34 43.01 (-65.57861d) Equinox: J2000</td> <td>Proper Motion RA: -0.016550556455744634 sec of time/yr Proper Motion Dec: 0.161748 arcsec/yr Epoch of Position: 2015.5</td> <td></td> </tr> </tbody> </table> <p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=Star Description=[Exomoons, Exoplanets]</p>										#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous	(1)	TOI-700	RA: 06 28 22.9720 (97.0957167d) Dec: -65 34 43.01 (-65.57861d) Equinox: J2000	Proper Motion RA: -0.016550556455744634 sec of time/yr Proper Motion Dec: 0.161748 arcsec/yr Epoch of Position: 2015.5																							
#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous																																						
(1)	TOI-700	RA: 06 28 22.9720 (97.0957167d) Dec: -65 34 43.01 (-65.57861d) Equinox: J2000	Proper Motion RA: -0.016550556455744634 sec of time/yr Proper Motion Dec: 0.161748 arcsec/yr Epoch of Position: 2015.5																																							
Acquisition	<table border="1"> <thead> <tr> <th>#</th> <th>Target</th> <th>Acquisition Mode</th> <th>Filter</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>ETC Wkbk.Calc ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>SAME</td> <td>SOSSFAINT</td> <td>F480M</td> <td>NISRAPID</td> <td>3</td> <td>1</td> <td>1</td> <td>0.202</td> <td>175314.12</td> </tr> </tbody> </table>										#	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	175314.12												
#	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	175314.12																																	
Template	<table border="1"> <thead> <tr> <th>Subarray</th> <th>Include Short First Exposure and F277W Exposure?</th> </tr> </thead> <tbody> <tr> <td>SUBSTRIP256</td> <td>true</td> </tr> </tbody> </table>										Subarray	Include Short First Exposure and F277W Exposure?	SUBSTRIP256	true																												
Subarray	Include Short First Exposure and F277W Exposure?																																									
SUBSTRIP256	true																																									
Spectral Elements	<table border="1"> <thead> <tr> <th>#</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Total Dithers</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>ETC Wkbk.Calc ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>NISRAPID</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>11.008</td> <td></td> </tr> <tr> <td>2</td> <td>NISRAPID</td> <td>4</td> <td>1181</td> <td>1</td> <td>1181</td> <td>32466.257</td> <td>175314.4</td> </tr> <tr> <td>3</td> <td>NISRAPID</td> <td>4</td> <td>10</td> <td>1</td> <td>10</td> <td>274.905</td> <td>175314.11</td> </tr> </tbody> </table>										#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID	1	NISRAPID	1	1	1	1	11.008		2	NISRAPID	4	1181	1	1181	32466.257	175314.4	3	NISRAPID	4	10	1	10	274.905	175314.11
#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID																																			
1	NISRAPID	1	1	1	1	11.008																																				
2	NISRAPID	4	1181	1	1181	32466.257	175314.4																																			
3	NISRAPID	4	10	1	10	274.905	175314.11																																			
Special Requirements	Phase 0.9941436805012974 to 0.9952570492272865 with period 37.42396 Days and zero-phase 2458816.9952 HJD Aperture PA Range 40 to 100 Degrees (V3 39.43873283 to 99.43873283) Time Series Observation No Parallel Attachments																																									

Proposal 6193 - Observation 2 - A Search for Exoplanet Satellites that are the Same Size as the Earth's Moon

Fri Mar 01 07:02:50 GMT 2024

Observation	<p>Proposal 6193, Observation 2: TOI-700 e</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRISS Single-Object Slitless Spectroscopy</p>																																									
Diagnostics	<p>(TOI-700 e (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.</p> <p>(Exposure) 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.</p> <p>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>																																									
Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>TOI-700</td> <td>RA: 06 28 22.9720 (97.0957167d) Dec: -65 34 43.01 (-65.57861d) Equinox: J2000</td> <td>Proper Motion RA: -0.016550556455744634 sec of time/yr Proper Motion Dec: 0.161748 arcsec/yr Epoch of Position: 2015.5</td> <td></td> </tr> </tbody> </table> <p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[Exomoons, Exoplanets]</i></p>										#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous	(1)	TOI-700	RA: 06 28 22.9720 (97.0957167d) Dec: -65 34 43.01 (-65.57861d) Equinox: J2000	Proper Motion RA: -0.016550556455744634 sec of time/yr Proper Motion Dec: 0.161748 arcsec/yr Epoch of Position: 2015.5																							
#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous																																						
(1)	TOI-700	RA: 06 28 22.9720 (97.0957167d) Dec: -65 34 43.01 (-65.57861d) Equinox: J2000	Proper Motion RA: -0.016550556455744634 sec of time/yr Proper Motion Dec: 0.161748 arcsec/yr Epoch of Position: 2015.5																																							
Acquisition	<table border="1"> <thead> <tr> <th>#</th> <th>Target</th> <th>Acquisition Mode</th> <th>Filter</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>ETC Wkbk.Calc ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>SAME</td> <td>SOSSFAINT</td> <td>F480M</td> <td>NISRAPID</td> <td>3</td> <td>1</td> <td>1</td> <td>0.202</td> <td>175314.12</td> </tr> </tbody> </table>										#	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	175314.12												
#	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	175314.12																																	
Template	<table border="1"> <thead> <tr> <th>Subarray</th> <th>Include Short First Exposure and F277W Exposure?</th> </tr> </thead> <tbody> <tr> <td>SUBSTRIP256</td> <td>true</td> </tr> </tbody> </table>										Subarray	Include Short First Exposure and F277W Exposure?	SUBSTRIP256	true																												
Subarray	Include Short First Exposure and F277W Exposure?																																									
SUBSTRIP256	true																																									
Spectral Elements	<table border="1"> <thead> <tr> <th>#</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Total Dithers</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>ETC Wkbk.Calc ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>NISRAPID</td> <td>1</td> <td>1</td> <td>1</td> <td>1</td> <td>11.008</td> <td></td> </tr> <tr> <td>2</td> <td>NISRAPID</td> <td>4</td> <td>1087</td> <td>1</td> <td>1087</td> <td>29882.152</td> <td>175314.14</td> </tr> <tr> <td>3</td> <td>NISRAPID</td> <td>4</td> <td>10</td> <td>1</td> <td>10</td> <td>274.905</td> <td>175314.11</td> </tr> </tbody> </table>										#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID	1	NISRAPID	1	1	1	1	11.008		2	NISRAPID	4	1087	1	1087	29882.152	175314.14	3	NISRAPID	4	10	1	10	274.905	175314.11
#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID																																			
1	NISRAPID	1	1	1	1	11.008																																				
2	NISRAPID	4	1087	1	1087	29882.152	175314.14																																			
3	NISRAPID	4	10	1	10	274.905	175314.11																																			
Special Requirements	<p>Phase 0.992658458043657 to 0.9941567319122985 with period 27.80978 Days and zero-phase 2458964.811200 HJD Aperture PA Range 40 to 100 Degrees (V3 39.43873283 to 99.43873283) Time Series Observation No Parallel Attachments</p>																																									