



3263 - The First Atmospheric Study of a Bona Fide Water World

Cycle: 2, Proposal Category: GO

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Dr. Rafael Luque (PI)	University of Chicago
Prof. Jacob L. Bean (CoI)	University of Chicago
Dr. Quentin Changeat (CoI) (ESA Member)	Space Telescope Science Institute - ESA
Dr. Enric Pallé (CoI) (ESA Member)	Instituto de Astrofísica de Canarias
Dr. Megan Mansfield (CoI)	University of Arizona
Prof. Edwin S Kite (CoI)	University of Chicago
Dr. Sarah E. Moran (CoI)	University of Arizona
Michael Zhang (CoI)	University of Chicago
Dr. Adina Feinstein (CoI)	University of Colorado at Boulder

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	Phase curve	NIRSpec Bright Object Time Series	(1) TOI-1685

ABSTRACT

Water worlds have been proposed as an explanation for the origin and composition of sub-Neptunes. The hypothesis has regained momentum thanks to new developments in planet formation models, individual planet discoveries, and demographic studies of precisely characterized samples. Alternatively, the more widely assumed scenario suggests that these planets are indeed gas dwarfs, i.e. Earth-like cores with primordial H/He envelopes accounting for a small percentage of their total mass. TOI-1685b, however, does not fit into this picture. The 16-hour orbit planet has a low bulk density inconsistent with being a bare rock despite having a high equilibrium temperature ($T_{eq} \sim 1070\text{K}$). If the planet had a primordial H-rich atmosphere, it would have been stripped long ago. With a water-rich core, however, its size and bulk density are naturally explained.

We propose to observe a full-phase curve of TOI-1685b using NIRSPEC G395H, the optimal trade-off to maximize the information content of the primary transit while detecting the planet's thermal emission. In one fell swoop, our observations will provide meaningful transmission and emission spectra to measure molecular abundances and a broadband phase curve to break the degeneracy of metal-enriched atmospheres with high mean molecular weight ones in transit. By distinguishing between gas dwarf and water world scenarios, TOI-1685b opens a window to unveil the true nature of sub-Neptunes for the first time. The dataset has therefore a legacy component with valuable information to aid observers, theorists, and modelers to investigate the properties of a completely new type of planet with no analog in the solar system.

OBSERVING DESCRIPTION

We request one full phase curve of the planet TOI-1685b with NIRSPEC G395H. The orbital period of the planet is 0.6691406 days (~16h). We aim to start 1h before a secondary eclipse, observe through the eclipse, a transit, and a second eclipse, and continue for 1h after the second eclipse (total time ~19h). The two secondary eclipses provide the essential zero point of the observations because this is the only time during the observing sequence that the planet is not seen. To avoid offsets due to changes in the instrument zero point and slewing and pointing overheads, the observation of the planet's phase curve must be performed as an un-interrupted stare.

We use the online JWST ETC to compute exposure time that ensure the highest S/N without surpassing 80% saturation. For TOI-1685b, the optimal configuration is 16 groups per integration with NIRSPEC G395H grating (S/N=179 at 4 microns). Given the brightness of the target, the NIRSPEC observations can use the full SUB2048 BOTS subarray with NRSRAPID readout pattern. The NIRSPEC target acquisition has to be done on a nearby star because the target is too bright. We will use the nearby fainter star 2MASS 04342242+4302334 (J=13.739 mag), which ensures a S/N=139 at 2.08 microns using the WATA acquisition mode, CLEAR filter, SUB32 subarray and NRSRAPID readout pattern.

The 16h orbital period of the planet leads to numerous windows of opportunity. Uncertainties in the orbital ephemeris have a negligible impact on the scheduling.

Proposal 3263 - Targets - The First Atmospheric Study of a Bona Fide Water World

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	TOI-1685	RA: 04 34 22.5487 (68.5939529d) Dec: +43 02 13.34 (43.03704d) Equinox: J2000	Proper Motion RA: 0.003444278362765186 sec of time/yr Proper Motion Dec: -0.08706200007964071 arcsec/yr Epoch of Position: 2015.5	
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Star</i> <i>Description=[Exoplanet Systems, M dwarfs, M stars]</i></p>					
(2)	TOI-1685.ACQ	RA: 04 34 22.4194 (68.5934142d) Dec: +43 02 33.46 (43.04263d) Equinox: J2000	Proper Motion RA: -2.209 mas/yr Proper Motion Dec: -2.106 mas/yr Epoch of Position: 2015.5		
<p><i>Comments: This object was generated by the targetselector and retrieved from the 2MASS database. This is the nearest star in the 2MASS catalog to TOI-1685.</i> <i>Category=Star</i> <i>Description=[M dwarfs]</i></p>					

Proposal 3263 - Observation 1 - The First Atmospheric Study of a Bona Fide Water World

Tue Jan 09 18:01:02 GMT 2024

Observation	<p>Proposal 3263, Observation 1: Phase curve</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec Bright Object Time Series</p> <p><i>Comments: Doubled TOI-1685b's period, halved its phase range in the NIRSPEC Special Requirements as recommended by the APT for overlapping scheduling windows.</i></p>																															
Diagnostics	<p>(Phase curve (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.</p> <p>(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>																															
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Template	<p>Subarray</p> <p>SUB2048</p>																															
Spectral Elements	<table border="1"> <thead> <tr> <th>#</th> <th>Grating/Filter</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Exposures/Dith</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>G395H/F290LP</td> <td>NRSRAPID</td> <td>16</td> <td>4450</td> <td>1</td> <td>1</td> <td>4450</td> <td>68327.436</td> <td>141068</td> </tr> </tbody> </table>										#	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	4450	1	1	4450	68327.436	141068		
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Special Requirements	<p>Phase 0.17344907 to 0.204583536 with period 1.3382812 Days and zero-phase 2459910.93830 HJD</p> <p>Time Series Observation</p> <p>No Parallel Attachments</p>																															