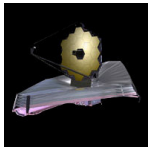

4711 - Efficient and Detailed Characterization of a Temperate Water World Candidate

Cycle: 3, Proposal Category: GO

INVESTIGATORS

Name	*Institution*
Dr. Renyu Hu (PI)	**Jet Propulsion Laboratory**
Dr. Mario Damiano (CoI)	Jet Propulsion Laboratory
Dr. Markus Scheucher (CoI)	Jet Propulsion Laboratory
Dr. Nolan Grieves (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Dr. Aaron Bello-Arufe (CoI)	Jet Propulsion Laboratory
Dr. Jeehyun Yang (CoI)	California Institute of Technology
Prof. Monika Lendl (CoI) (ESA Member)	University of Geneva, Department of Astronomy
Prof. Francois Bouchy (CoI) (ESA Member)	University of Geneva, Department of Astronomy

OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
TOI-4336b				
	1		NIRISS Single-Object Slitless Spectroscopy	(1) TOI-4336
	2		NIRSpec Bright Object Time Series	(1) TOI-4336

ABSTRACT

Temperate water worlds, if they exist, provide a new avenue to expand and accelerate the search for potentially habitable exoplanets in the next decade. This is because many more temperate planets in the 1.5 – 2.2 Earth's radius range are suitable for atmospheric studies than the sole TRAPPIST-1 system that hosts temperate and small rocky planets. Among the sub-Neptunes, however, only temperate water worlds, rather than mini Neptunes, can host liquid-water oceans. It is thus crucial to determine whether temperate sub-Neptunes are water worlds. We identify TOI-4336.01, a

newly discovered 2.1 Earth's radius temperate planet, as a likely water world and the most favorable target for transmission spectroscopy among the planets with similar sizes, equilibrium temperatures <320 K, and measured masses. The planet can have a liquid-water ocean with reasonable planetary albedo. With only one transit using NIRISS/SOSS and another one using NIRSpec/G395H, the resulting spectra will be sensitive and precise enough to measure the abundances of H2O, CH4, NH3, CO2, and CO, and constrain the cloud pressure. The combination of these gases will determine whether the planet is a water world. This observation will also determine whether the planet has a liquid-water ocean if it is a temperate water world. This highly efficient and yet detailed characterization of the temperate sub-Neptune will constrain the suggested population of water worlds around M dwarfs and have the potential to expand the search space of habitable worlds from Earth-sized planets to larger planets.

OBSERVING DESCRIPTION

We will acquire the transmission spectra of the temperate sub-Neptune TOI-4336.01, using NIRISS/SOSS and NIRSpec/BOTS/G395H to cover the wavelength range of 0.85 – 5.2 microns. We choose the number of groups to keep the saturation level within 70%, to make sure that the observations would be well within the detector's linear regime and maximize the efficiency of the observations.

We propose to obtain one transit with NIRISS/SOSS to achieve a precision of 28 ppm per spectral element on average at the resolution of R=50 in 0.85 – 2.8 micron, and one transit with NIRSpec/G395H to achieve a precision of 40 ppm per spectral element on average at the resolution of R=100 in 2.8 – 5.2 micron. The expected precision is sufficient to achieve the science objectives to distinguish the water-world scenario from the mini-Neptune scenario, and to detect the signatures of a liquid-water ocean versus a runaway greenhouse state in the water-world scenario.

As is recommended for exoplanet transit observations, we include an out-of-transit portion of the light curve that lasts 1.5 times the transit duration and splits evenly before and after the transit, as well as 30 min before the transit for the telescope and instrument to settle for the precise time-series observation. The out-of-transit observation is necessary to establish a baseline from which the transit depth can be determined and using which instrumental systematics can be modeled. 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 30 min (scheduling flexibility) + 30 min (settling) + out-of-transit-duration/2 minutes before the predicted start of the transit.

TTVs and TDVs not detected in the literature.

Proposal 4711 - Targets - Efficient and Detailed Characterization of a Temperate Water World Candidate

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	TOI-4336	RA: 13 44 25.4773 (206.1061554d)	Proper Motion RA: 151.813 mas/yr	
		Dec: -40 20 15.52 (-40.33764d)	Proper Motion Dec: 68.402 mas/yr	
		Equinox: J2000	Parallax: 0.0445348"	
			Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[M stars]

Observation

Proposal 4711, Observation 1 Fri Jun 06 13:00:09 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Diagnostics

(Observation 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)	TOI-4336	RA: 13 44 25.4773 (206.1061554d) Dec: -40 20 15.52 (-40.33764d) Equinox: J2000	Proper Motion RA: 151.813 mas/yr Proper Motion Dec: 68.402 mas/yr Parallax: 0.0445348" Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[M stars]

Acquisition

#	Target	Acquisition Mode	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	SOSSFAINT	F480M	NISRAPID	17	1	1	0.839	134288

Template

Subarray	Include Short First Exposure and F277W Exposure?
SUBSTRIP96	true

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	NISRAPID	1	1	1	1	4.448	
2	NISRAPID	9	1040	1	1040	23046.899	134288
3	NISRAPID	9	10	1	10	221.605	134288

Special Requirements	
	Phase 0.9909015473352393 to 0.9934520964384386 with period 16.336351499526266 Days and zero-phase 2459335.5727619864 HJD Aperture PA Range 96.5 to 100.5 Degrees (V3 95.93873283 to 99.93873283) Time Series Observation No Parallel Attachments

Observation

Proposal 4711, Observation 2 Fri Jun 06 13:00:09 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Observation 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)	TOI-4336	RA: 13 44 25.4773 (206.1061554d) Dec: -40 20 15.52 (-40.33764d) Equinox: J2000	Proper Motion RA: 151.813 mas/yr Proper Motion Dec: 68.402 mas/yr Parallax: 0.0445348" Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.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	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	134288

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	14	1701	1	1	1701	23049.366	134288

Special Requirements	
	Phase 0.9909015473352393 to 0.9934520964384386 with period 16.336351499526266 Days and zero-phase 2459335.5727619864 HJD Time Series Observation No Parallel Attachments