



# 11672 - Greedy Big Brother: examining the atmosphere of a Neptune-sized outer companion to an unusual sub-Neptune

Cycle: 5, Proposal Category: GO

## INVESTIGATORS

<i>Name</i>	<i>Institution</i>
<b>Dr. Jegug Ih (PI)</b>	<b>Space Telescope Science Institute</b>
Dr. Matthew Conor Nixon (CoI) (CoPI)	Arizona State University
Dr. William Misener (CoI)	Carnegie Institution of Washington
Dr. Peter Gao (CoI)	Carnegie Institution of Washington
Prof. Eliza M.-R. Kempton (CoI)	University of Chicago
Dr. Rafael Luque (CoI) (ESA Member)	Instituto de Astrofísica de Andalucía (IAA)
Dr. Guangwei Fu (CoI)	The Johns Hopkins University
Brian Davenport (CoI)	University of Maryland
Dr. Drake Deming (CoI)	University of Maryland
Dr. Hannah Diamond-Lowe (CoI) (US Admin CoI)	Space Telescope Science Institute

## OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	NIRISS	NIRISS Single-Object Slitless Spectroscopy	(1) TOI-421
	2	NIRSPEC	NIRSpec Bright Object Time Series	(1) TOI-421

## ABSTRACT

We propose to acquire a 0.9-5.1m transmission spectrum of TOI-421 c, a 600 K Neptune-sized exoplanet orbiting a G9 star, by observing two transits: one with NIRISS/SOSS and one with NIRSpec/G395H. A 900 K sub-Neptune in the same system, TOI-421 b, was

observed with JWST and was found to host a cloud-free, low-metallicity ( $<10\times$  solar) atmosphere. This starkly contrasts with other sub-Neptunes observed using JWST, with typical atmospheric metallicities  $>100\times$  solar. Our observations will determine whether TOI-421 c, the larger, outer planet in the system, is the cause of TOI-421 b's unusual atmosphere. By measuring the atmospheric metallicity of TOI-421 c, we will test the theory of pebble filtering, which could explain the low metallicity of TOI-421 b. We will also use our atmospheric measurements to constrain the core mass of TOI-421 c, which we will directly compare to that of TOI-421 b. Furthermore, this system provides a unique opportunity to ascertain whether cloud and haze formation preferentially occurs on sub-Neptune to Neptune-sized planets at intermediate temperatures (500-800 K).

Our proposal will have a high impact both in the field of exoplanet atmospheres, by enabling comparative planetology, and in planet formation, by helping to understand the origin of this multi-planet system. The TOI-421 system provides a rare opportunity to probe a representative case from the numerous FGK star multi-planet systems discovered by facilities such as Kepler, and enables comparative studies with M dwarf sub-Neptune systems, of which many already have scheduled or executed JWST observations.

## **OBSERVING DESCRIPTION**

We propose a time series transmission spectroscopy of a transiting exo-Neptune using NIRISS SOSS and NIRSpec G395H. The planet has an orbital period of 16.067541 days and transit duration of 2.755 hours. We choose out-of-transit baseline equal to the transit duration and allow 45 minutes for detector settling.

The NIRSpec target acquisition has to be done on a nearby star because the target is too bright.

We will use SUBSTRIP95 for NIRISS. JWST ETC allows for 3 groups per integration without saturation.

We will use SUB2048 subarray for NIRSPEC. JWST ETC allows for 4 groups per integration without saturation.

Proposal 11672 - Targets - Greedy Big Brother: examining the atmosphere of a Neptune-sized outer companion to an unusual sub-Ne...

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	TOI-421	RA: 05 27 24.8259 (81.8534413d) Dec: -14 16 37.05 (-14.27696d) Equinox: J2000	Proper Motion RA: -35.743 mas/yr Proper Motion Dec: 50.387 mas/yr Epoch of Position: 2000	
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=Star Description=[Exoplanet Systems, G dwarfs]					
(2)	Gaia-DR3-2984582227215748224	RA: 05 27 23.7421 (81.8489254d) Dec: -14 16 12.21 (-14.27006d) Equinox: J2000	Proper Motion RA: -36.19 mas/yr Proper Motion Dec: 50.607 mas/yr Epoch of Position: 2000		
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=Star Description=[K stars]					

Proposal 11672 - Observation 1 - Greedy Big Brother: examining the atmosphere of a Neptune-sized outer companion to an unusual s...

Tue Apr 07 20:00:13 GMT 2026

<b>Observation</b>	<p><b>Proposal 11672, Observation 1: NIRISS</b></p> <p><b>Diagnostic Status: Warning</b></p> <p>Observing Template: NIRISS Single-Object Slitless Spectroscopy</p>																													
<b>Diagnostics</b>	<p>(NIRISS (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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<b>Special Requirements</b>	<p>Phase 0.9883175444622588 to 0.9909107643374511 with period 16.067541 Days and zero-phase 2459195.307 HJD</p> <p>Aperture PA Range 30 to 50 Degrees (V3 29.43873283 to 49.43873283)</p> <p>Aperture PA Range 75 to 94 Degrees (V3 74.43873283 to 93.43873283)</p> <p>Aperture PA Range 258 to 276 Degrees (V3 257.43873283 to 275.43873283)</p> <p>Aperture PA Range 292 to 323 Degrees (V3 291.43873283 to 322.43873283)</p> <p>Time Series Observation</p> <p>No Parallel Attachments</p>																													

Proposal 11672 - Observation 2 - Greedy Big Brother: examining the atmosphere of a Neptune-sized outer companion to an unusual s...

Tue Apr 07 20:00:13 GMT 2026

<b>Observation</b>	<p>Proposal 11672, Observation 2: NIRSPEC</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSPEC Bright Object Time Series</p>																															
<b>Diagnostics</b>	<p>(NIRSPEC (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>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>																															
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