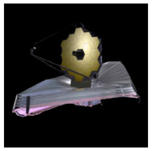

5226 - The Weather Forecast in a Cloudy (or not) Cool Planetary-Mass Brown Dwarf

Cycle: 3, Proposal Category: GO

INVESTIGATORS

Name	*Institution*
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Dr. Theodora Karalidi (CoI) (CoPI)	University of Central Florida Board of Trustees
Dr. Glenn Schneider (CoI) (CoPI)	University of Arizona
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Natalia Oliveros-Gomez (CoI)	The Johns Hopkins University

OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Ross458c				
	1	S1600A1, first rotation	NIRSpec Bright Object Time Series	(1) ROSS458C
	2	S1600A1, second rotation	NIRSpec Bright Object Time Series	(1) ROSS458C

ABSTRACT

Ross 458 c is a ~9 Jupiter mass, T8 spectral type brown dwarf that has similar mass and temperature to some cold directly-imaged exoplanets, like 51 Eri b, GJ 504 b, and GJ 758 b. Due to the high separation between Ross 458 c and its host stars, and to the proximity of the system, it is possible to obtain high signal-to-noise spectra for this exoplanet couterpart using JWST/NIRSpec. We propose to perform prism spectroscopy during two full

rotational period (6.75±1.58 hr) to measure its spectral variability across the 0.6-5.3 micron wavelength range, which is key to understand if this variability is due to clouds or to temperature differences and circulation in the atmosphere of Ross 458c. In addition, we will use an exoplanet mapping software to reveal the 2D maps at different pressure levels of the object, producing a 3D weather map of such a low-mass and cold object for the first time. The results obtained for this planetary-mass brown dwarf might serve as a guidance to further understand the atmospheric dynamics and composition of directly-imaged exoplanets of similar effective temperatures to Ross 458c, for which due to instrumental limitations we are unable to obtain similar high signal-to-noise spectra to this date.

OBSERVING DESCRIPTION

Based on previous HST/WFC3 observations (e.g. Apai et al. 2013, Yang et al. 2015, Lew et al. 2016, Manjavacas et al. 2018, 2019) high signal-to-noise spectra, high cadence, and high stability are the keys to successfully detect intrinsic spectro-photometric variability for brown dwarfs and isolated planetary-mass objects. Since Ross 458 c is relatively bright (JUKIDSS=16.69±0.01), we propose to use the BOTS (Bright Object Time-Series) observing mode, that uses the 1.6" x 1.6" fixed slit aperture (S1600A1). This mode is optimized for exoplanet transit observations requiring stable observing conditions and high photometric precision time-series spectroscopy, which are the same conditions that we require to satisfactory detect few percent of spectro-photometric variability amplitude, as measured previously for Ross 458 c with HST/WFC3 data. For the purpose of stability, no dithering is done in this observing mode. To obtain in one single exposure the entire 0.7-5.3 m spectrum, we propose to use the prism with the clear filter, that offers a resolution of ~100, sufficient to resolve the CH4 and H2O bands expected for Ross 458 c at across the entire wavelength range. We will use the SUB512 subarray for each exposure that reads a subarray of 512 x 32 pixels, and for the PRISM/CLEAR setting records the full wavelength range of the spectrum, but it will also read out extra unilluminated pixels for reference. We will use the NRSRAPID readout pattern, that saves a single frame. In total, to achieve a 0.7-5.3 m spectrum with a signal-to-noise between 50 for the continuum inside CH4 bands in the mid-infrared, and around 300 at the peak of the J-band. We aim at obtaining a minimum accuracy on the spectro-photometric variability of 0.1%, even inside the bands with less signal-to-noise. In particular, we need a signal-to-noise of 50 inside the CH4 band at 3.3 m, that will trace the upper levels of the atmosphere of Ross 458 c (see Fig. 2), providing information about heterogeneous clouds in the upper atmosphere, above ~0.1 bar. According to the ETC for JWST/NIRSpec, we need 357.74 s (~6 min) integrations to achieve a minimum signal-to-noise of 50 in a single Ross 458 c spectrum. We propose to observe using 100 groups per integration, 15 integrations per exposure, and 74 exposures per specification. We propose to monitor Ross 458 c consecutively during 7 hr that is the approximate rotation period estimated for the object using HST/WFC3 spectro-photometric data (6.75±1.58 hr, Manjavacas et al. 2019), doing 357.72 s (~6 min) consecutive integrations. In total, we will obtain 74 high signal-to-noise spectra of the object during the entire rotation period of Ross 458 c, that will allow us to produce the first tomography of the atmosphere of this exoplanet analog to cold directly-imaged exoplanets.

Since Ross 458 c has a relatively high proper motion (Proper Motion RA: -616.31 mas/yr Proper Motion Dec: -13.59 mas/yr), we will need to perform target acquisition exposure at the beginning of the observation to determine the precise location of the target. We will use WATA, with the F110W filter, and the SUB2048, with a NRSRAPID readout pattern. The total integration time for target acquisition is ~4s.

Proposal 5226 - Targets - The Weather Forecast in a Cloudy (or not) Cool Planetary-Mass Brown Dwarf

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	ROSS458C	RA: 13 00 41.7427 (195.1739279d) Dec: +12 21 14.72 (12.35409d) Equinox: J2000	Proper Motion RA: -628.7153 mas/yr Proper Motion Dec: -33.4718 mas/yr Parallax: 0.0869010" Epoch of Position: 2007.9917	

Comments:
Category=Star
Description=[Exoplanets, T dwarfs]
Extended=NO

Observation

Proposal 5226, Observation 1: S1600A1, first rotation

Sat Jun 08 20:00:18 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(S1600A1, first rotation (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.

(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)	ROSS458C	RA: 13 00 41.7427 (195.1739279d) Dec: +12 21 14.72 (12.35409d) Equinox: J2000	Proper Motion RA: -628.7153 mas/yr Proper Motion Dec: -33.4718 mas/yr Parallax: 0.0869010" Epoch of Position: 2007.9917	

Comments:
Category=Star
Description=[Exoplanets, T dwarfs]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	1 ROSS458C	WATA	SUB2048	F110W	NRSRAPID	3	1	1	3.628	60063

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	PRISM/CLEAR	NRSRAPID	300	440	1	1	440	29961.642	60063

Special Requirements

Time Series Observation
No Parallel Attachments

Group Observations 1, 2, Non-interruptible

Observation

Proposal 5226, Observation 2: S1600A1, second rotation

Sat Jun 08 20:00:18 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(S1600A1, second rotation (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.

(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)	ROSS458C	RA: 13 00 41.7427 (195.1739279d) Dec: +12 21 14.72 (12.35409d) Equinox: J2000	Proper Motion RA: -628.7153 mas/yr Proper Motion Dec: -33.4718 mas/yr Parallax: 0.0869010" Epoch of Position: 2007.9917	

Comments:
Category=Star
Description=[Exoplanets, T dwarfs]
Extended=NO

Template

TA Method	Subarray
NONE	SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	PRISM/CLEAR	NRSRAPID	300	440	1	1	440	29961.642	60063

Special Requirements

Time Series Observation
No Parallel Attachments

Group Observations 1, 2, Non-interruptible