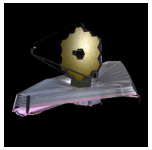

4982 - First image and spectrum of a true Jupiter-Saturn Analog

Cycle: 3, Proposal Category: GO

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
epsilon Eridani				
	1	eps Eri roll 1	NIRSpec IFU Spectroscopy	(1) eps_Eri
	2	eps Eri roll 2	NIRSpec IFU Spectroscopy	(1) eps_Eri
	3	eps Eri roll 2	NIRSpec IFU Spectroscopy	(1) eps_Eri

ABSTRACT

We propose to take the first image and spectrum of a true Solar System gas giant analog, the emblematic eps Eridani b, with the NIRSpec integral field unit (IFU). Eps Eri b is a known radial velocity planet orbiting a nearby Sun-like star (K2V) at ~3.5 au (7.3 yr period) with a dynamical mass between that of Saturn and Jupiter (0.57-0.78 MJup), which means that it can be directly compared to the Solar System gas giants. This adolescent (400-800 Myr) sub-Jupiter is unique because it lies halfway between the transiting and directly imaged exoplanets in terms of semi-major axis, mass, and age. This region of the parameter space has been inaccessible for spectroscopic characterization until now. Additionally, Cycle 3 is the optimal time to observe the planet because it is at its furthest projected separation, which only happens every 4 years. We will obtain a R~2,700 spectrum in 3-5 um targeting the peak flux of this cool sub-Jupiter (~140-215 K) and enable the first measurements of its brightness, effective temperature, and composition (C/H, O/H, N/S). The direct detection of eps Eri b possible is possible thanks to the demonstration from Cycle 1 data that the NIRSpec IFU can reach a contrast (1e-6 at 1" in 35 min) superior to JWST's coronagraphs.

OBSERVING DESCRIPTION

We propose to take the first image and high resolution spectrum (R=2,700) of eps Eridani b, with the NIRSpec integral field unit (IFU; G395H/F290LP; 2.87 - 5.27 microns).

The host star eps Eri is extremely bright (K=1.7), which means that it will saturate up to 0.5". As a mitigation strategy, we will implement a mosaic pattern with 4 overlapping pointings that avoid the core of the PSF. We also require two rolls (10deg) to mitigate the effect of the diffraction spikes. We optimize the number of groups to yield the highest S/N at the expected separation of the planet so we choose 9 groups (NRSRAPID). We also maximize the number of dither positions, 36 with the small cycling pattern, to improve the sub-pixel sampling of the PSF. For 2 rolls x 4 mosaic tiles x 9 groups x 36 dithers, the total exposure time for this program is therefore 8.6 hours (Science time of 7.76 hours). We require the observation to take place between 17 Dec 2024 - 12 Feb 2025 to maximize the expected separation of the planet relative to the star (1-1.1"). No background subtraction or target acquisition (TA) is required given the brightness of the star.

Summary:
- NIRSpec IFU: G395H/F290LP
- The planet should be detected with a S/N between 3-75.
- Observing window: 17 Dec 2024 - 12 Feb 2025 (cycle 3)
- Total exposure time of 8.6 hours: 2 rolls, 4 mosaic tiles, 36 dither (Small cycling pattern), 9 groups (NRSRAPID)
- No TA
- No background subtraction

Proposal 4982 - Targets - First image and spectrum of a true Jupiter-Saturn Analog

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	eps_Eri	RA: 03 32 54.7904 (53.2282933d)	Proper Motion RA: -974.7581 mas/yr	
		Dec: -09 27 29.41 (-9.45817d)	Proper Motion Dec: 20.8758 mas/yr	
		Equinox: J2000	Parallax: 0.3105772928005821"	
			Epoch of Position: 2016	

Comments: coordinates from Gaia DR3 5164707970261890560
Category=Star
Description=[K stars, Proplyds]
Extended=NO

Observation

Proposal 4982, Observation 1: eps Eri roll 1 Fri Jan 10 22:00:16 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Diagnostics

(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)	eps_Eri	RA: 03 32 54.7904 (53.2282933d) Dec: -09 27 29.41 (-9.45817d) Equinox: J2000	Proper Motion RA: -974.7581 mas/yr Proper Motion Dec: 20.8758 mas/yr Parallax: 0.3105772928005821" Epoch of Position: 2016	

Comments: coordinates from Gaia DR3 5164707970261890560
Category=Star
Description=[K stars, Proplyds]
Extended=NO

Template

TA Method	HFF Readout Mode
NONE	false

Mosaic

Rows	Columns	Row Overlap %	Column Overlap %	Row shift (deg)	Column shift (deg)	Tile Order
3	3	22.58	33.06	0.0	0.0	ROW_ORDER

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	SPARSE-CYCLING	SMALL			5, 7, 8, 10, 11, 15, 16, 18, 19, 21, 22, 23, 25, 26, 27, 28, 29, 30, 32, 33, 34, 36, 38, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 56, 58, 59

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G395H/F290LP	NRSRAPID	9	1	false	true	NONE	36	36	3865.237	169516.4

Special Requirements	
	Between Dates 17-DEC-2024:00:00:00 and 12-FEB-2025:00:00:00 Offset -0.033 arcsec, -0.024 arcsec Aperture PA Offset 2 from 1 by 10 to 15 Degrees (Same offsets in V3) Aperture PA Offset 3 from 1 by 10 to 30 Degrees (Same offsets in V3)

Observation

Proposal 4982, Observation 2: eps Eri roll 2 Fri Jan 10 22:00:16 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Diagnostics

(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)	eps_Eri	RA: 03 32 54.7904 (53.2282933d) Dec: -09 27 29.41 (-9.45817d) Equinox: J2000	Proper Motion RA: -974.7581 mas/yr Proper Motion Dec: 20.8758 mas/yr Parallax: 0.3105772928005821" Epoch of Position: 2016	

Comments: coordinates from Gaia DR3 5164707970261890560
Category=Star
Description=[K stars, Proplyds]
Extended=NO

Template

TA Method	HFF Readout Mode
NONE	false

Mosaic

Rows	Columns	Row Overlap %	Column Overlap %	Row shift (deg)	Column shift (deg)	Tile Order
3	3	22.58	33.06	0.0	0.0	ROW_ORDER

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	SPARSE-CYCLING	SMALL			5, 7, 8, 10, 11, 15, 16, 18, 19, 21, 22, 23, 25, 26, 27, 28, 29, 30, 32, 33, 34, 36, 38, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 56, 58, 59

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G395H/F290LP	NRSRAPID	9	1	false	true	NONE	36	36	3865.237	

Special Requirements	
	Between Dates 17-DEC-2024:00:00:00 and 12-FEB-2025:00:00:00 Offset -0.033 arcsec, -0.024 arcsec Aperture PA Offset 2 from 1 by 10 to 15 Degrees (Same offsets in V3)

Observation

Proposal 4982, Observation 3: eps Eri roll 2 Fri Jan 10 22:00:16 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Comments: New obs 3 is a duplicate of obs 2 for repeat observation after failed guide star acquisition for obs 2

Diagnostics

(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	eps_Eri	RA: 03 32 54.7904 (53.2282933d) Dec: -09 27 29.41 (-9.45817d) Equinox: J2000	Proper Motion RA: -974.7581 mas/yr Proper Motion Dec: 20.8758 mas/yr Parallax: 0.3105772928005821" Epoch of Position: 2016	

Comments: coordinates from Gaia DR3 5164707970261890560
Category=Star
Description=[K stars, Proplyds]
Extended=NO

Template

TA Method	HFF Readout Mode
NONE	false

Mosaic

Rows	Columns	Row Overlap %	Column Overlap %	Row shift (deg)	Column shift (deg)	Tile Order
3	3	22.58	33.06	0.0	0.0	ROW_ORDER

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	SPARSE-CYCLING	SMALL			5, 7, 8, 10, 11, 15, 16, 18, 19, 21, 22, 23, 25, 26, 27, 28, 29, 30, 32, 33, 34, 36, 38, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 56, 58, 59

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G395H/F290LP	NRSRAPID	9	1	false	true	NONE	36	36	3865.237	

Special Requirements	
	Between Dates 17-DEC-2024:00:00:00 and 12-FEB-2025:00:00:00 Offset -0.033 arcsec, -0.024 arcsec Aperture PA Offset 3 from 1 by 10 to 30 Degrees (Same offsets in V3)