



2243 - A direct detection of the closest Jupiter analog with JWST/MIRI

Cycle: 1, Proposal Category: GO

INVESTIGATORS

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Dr. Ian Crossfield (CoI)	University of Kansas Center for Research, Inc.
Dr. Ewan S Douglas (CoI)	University of Arizona
Dr. Jennifer Burt (CoI)	Jet Propulsion Laboratory

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	BG_dituc F1550C	MIRI Coronagraphic Imaging	(3) BG-NEAR-DI-TUC
	2	BG_epsindi F1550C	MIRI Coronagraphic Imaging	(3) BG-NEAR-DI-TUC
	3	BG_dituc F1065C	MIRI Coronagraphic Imaging	(3) BG-NEAR-DI-TUC
	4	BG_epsindi F1065C	MIRI Coronagraphic Imaging	(3) BG-NEAR-DI-TUC
	5	DITuc F1065C	MIRI Coronagraphic Imaging	(2) V-DI-TUC
	6	DITuc F1550C	MIRI Coronagraphic Imaging	(2) V-DI-TUC
	7	EpsIndi F1550C	MIRI Coronagraphic Imaging	(1) -EPS-IND
	8	EpsIndi F1065C	MIRI Coronagraphic Imaging	(1) -EPS-IND

ABSTRACT

JWST Proposal 2243 (Created: Thursday, May 25, 2023 at 10:01:26 AM Eastern Standard Time) - Overview

We will collect the first direct images of a radial velocity planet, by targeting Eps Indi Ab with JWST/MIRI. This recently discovered Jovian mass exoplanet has been identified with long-term radial velocity and astrometry measurements, around a star at just 3.6pc. The planet has mass 3.3M_{Jup} and semi-major axis 11au, and at an age ~4Gyr the planet is ~200K, far colder than any directly imaged planet to date. Our simulations confirm that we will detect Eps Indi Ab's thermal emission at high confidence, regardless of its cloud properties or thermal evolution.

Eps Indi Ab provides a unique opportunity to measure both the luminosity and the dynamical mass of a true Jupiter-analog, with a well constrained age. We will image the system in two filters, and thereby derive a constraint on the temperature and cloudiness of the system. The system is also particularly interesting in the context of planet formation: Eps Indi A is co-moving with the low mass binary brown dwarf Eps Indi BA/BB. The planet and brown dwarfs have similar ages and formed in similar environments, but have very different masses, making this an excellent benchmark system for formation models.

This project will pave the way for future studies of this system: the flux and orbital constraints derived here will allow complex observations, such as MIRI medium resolution spectroscopy or variability studies, in future cycles. As the closest Jupiter analog to the Solar System, Eps Indi Ab will be the highest-priority target for comparative studies of cold gas giant atmospheres for the foreseeable future. That long-term legacy starts here with the first mid-infrared characterization of the planet spectrum.

OBSERVING DESCRIPTION

We will observe Eps Indi Ab with JWST/MIRI coronagraphic imaging, with the F1065C and F1550C filters. We will also collect PSF reference images of DI Tuc, using the 5-point small grid dither technique. This allows data to be reduced using reference differential imaging (RDI); we do not use angular differential imaging (ADI) for this target. Even with the maximum JWST roll (10 degrees), the companion PSF (separated by 1.4'' from the host star) would overlap between the two roll angles, and therefore be significantly self-subtracted. Instead, our simulated observations demonstrate that RDI-only, with a 5-point small grid dither, is sufficient to detect the companion, and we do not include a roll on the science target.

We require that the companion is not positioned near any of the linear boundaries between adjacent quadrants of the 4QPM coronagraphic mask, which limits the schedulable dates for this observation. Based on our RV and astrometric orbital fitting and for a nominal date of 2022-09-30, we require that companion position angles 190-216 degrees are unobstructed at separations greater than 1.1''. This corresponds to an aperture position angle constraint of 68-78degrees (+90n degrees, with n an integer, since the companion can be observed in any quadrant). Aperture position angles at the center of this range are the best for this target. The target should be acquired in a different quadrant than the companion: since the target is unschedulable in quadrant 2, we specify target acquisition in this quadrant. If the cycle 1 observations are significantly delayed beyond the nominal

date, then the position angle constraints will be updated. There are no orientation constraints for the reference star.

We include all four observations in a non-interruptible block. It is crucial that the science and PSF observations are collected in a non-interruptible block since the JWST PSF is time-variable. We prefer to also collect the observations in the two filters immediately sequentially: if the F1065C detection is marginal (see Science & Technical Justification) then this will ensure we are able to accurately pinpoint the source location and quantify the F1065C flux or flux upper limit. If absolutely necessary the observations at the two wavelengths could be made on separate occasions.

Proposal 2243 - Targets - A direct detection of the closest Jupiter analog with JWST/MIRI

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	-EPS-IND	RA: 22 03 21.6536 (330.8402233d) Dec: -56 47 9.52 (-56.78598d) Equinox: J2000	Proper Motion RA: 3.966661 arcsec/yr Proper Motion Dec: -2.536192 arcsec/yr Parallax: 0.2748" Epoch of Position: 2000.0	
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>				
<i>Updated to Gaia DR3 coordinates, using SIMBAD values & SIMBAD reference epoch.</i>				
<i>Category=Star</i>				
<i>Description=[Exoplanet Systems, Exoplanets]</i>				
<i>Extended=NO</i>				
(2)	V-DI-TUC	RA: 22 16 8.1950 (334.0341458d) Dec: -57 34 5.06 (-57.56807d) Equinox: J2000	Proper Motion RA: 0.018257 arcsec/yr Proper Motion Dec: -0.012327 arcsec/yr Parallax: 0.0029221" Epoch of Position: 2000.0	
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>				
<i>Updated to Gaia DR3 coordinates, using SIMBAD values & SIMBAD reference epoch.</i>				
<i>Category=Star</i>				
<i>Description=[M giants]</i>				
(3)	BG-NEAR-DI-TUC	RA: 22 17 54.0000 (334.4750000d) Dec: -57 28 50.00 (-57.48056d) Equinox: J2000		
<i>Comments:</i>				
<i>Category=Calibration</i>				
<i>Description=[Coronagraphic]</i>				

Fixed Targets

Proposal 2243 - Observation 1 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:26 GMT 2023

Observation	<p>Proposal 2243, Observation 1: BG_dituc F1550C</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: MIRI Coronagraphic Imaging</p> <p>Background Observation For: [DITuc F1065C (Obs 5), DITuc F1550C (Obs 6), EpsIndi F1550C (Obs 7), EpsIndi F1065C (Obs 8)]</p>												
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			
	(3)	BG-NEAR-DI-TUC	RA: 22 17 54.0000 (334.4750000d) Dec: -57 28 50.00 (-57.48056d) Equinox: J2000										
	<i>Comments:</i> <i>Category=Calibration</i> <i>Description=[Coronagraphic]</i>												
Acquisition	#											Target	
	1											NONE	
Template	AcqFilter	Repeat observation					Background Quadrant						
		YES					1						
Dithers	#											Dither Type	
	1											BACKGROUND	
Spectral Elements	#	Coron Mask/Filter	Subarray	Mask	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	4QPM/F1550C	MASK1550	4QPM	F1550C	FASTR1	811	14	1	2	28	5448.885	
PSF References	Additional Justification: false												

Proposal 2243 - Observation 1 - A direct detection of the closest Jupiter analog with JWST/MIRI

Special Requirements

No Parallel Attachments

Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible

Proposal 2243 - Observation 2 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:27 GMT 2023

Observation	<p>Proposal 2243, Observation 2: BG_epsindi F1550C</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: MIRI Coronagraphic Imaging</p> <p>Background Observation For: [DITuc F1065C (Obs 5), DITuc F1550C (Obs 6), EpsIndi F1550C (Obs 7), EpsIndi F1065C (Obs 8)]</p>												
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			
	(3)	BG-NEAR-DI-TUC	RA: 22 17 54.0000 (334.4750000d) Dec: -57 28 50.00 (-57.48056d) Equinox: J2000										
	<p>Comments: Category=Calibration Description=[Coronagraphic]</p>												
Acquisition	#											Target	
	1											NONE	
Template	AcqFilter	Repeat observation					Background Quadrant						
		YES					1						
Dithers	#											Dither Type	
	1											BACKGROUND	
Spectral Elements	#	Coron Mask/Filter	Subarray	Mask	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	4QPM/F1550C	MASK1550	4QPM	F1550C	FASTR1	1168	14	1	2	28	7844.726	
PSF References	Additional Justification: false												

Proposal 2243 - Observation 2 - A direct detection of the closest Jupiter analog with JWST/MIRI

Special Requirements

No Parallel Attachments

Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible

Proposal 2243 - Observation 3 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:27 GMT 2023

Observation	<p>Proposal 2243, Observation 3: BG_dituc F1065C</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: MIRI Coronagraphic Imaging</p> <p>Background Observation For: [DITuc F1065C (Obs 5), DITuc F1550C (Obs 6), EpsIndi F1550C (Obs 7), EpsIndi F1065C (Obs 8)]</p>												
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				
(3)	BG-NEAR-DI-TUC	RA: 22 17 54.0000 (334.4750000d) Dec: -57 28 50.00 (-57.48056d) Equinox: J2000											
<p><i>Comments:</i> <i>Category=Calibration</i> <i>Description=[Coronagraphic]</i></p>													
Acquisition	#	Target											
1	NONE												
Template	AcqFilter	Repeat observation				Background Quadrant							
	YES				1								
Dithers	#	Dither Type											
1	BACKGROUND												
Spectral Elements	#	Coron Mask/Filter	Subarray	Mask	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	4QPM/F1065C	MASK1065	4QPM	F1065C	FASTR1	89	122	1	2	244	5262.893		
PSF References	Additional Justification: false												

Proposal 2243 - Observation 3 - A direct detection of the closest Jupiter analog with JWST/MIRI

Special Requirements

No Parallel Attachments

Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible

Proposal 2243 - Observation 4 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:27 GMT 2023

Observation	<p>Proposal 2243, Observation 4: BG_epsindi F1065C</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: MIRI Coronagraphic Imaging</p> <p>Background Observation For: [DITuc F1065C (Obs 5), DITuc F1550C (Obs 6), EpsIndi F1550C (Obs 7), EpsIndi F1065C (Obs 8)]</p>												
Diagnostics	(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.												
Fixed Targets	#	Name	Target Coordinates				Targ. Coord. Corrections			Miscellaneous			
	(3)	BG-NEAR-DI-TUC	RA: 22 17 54.0000 (334.4750000d) Dec: -57 28 50.00 (-57.48056d) Equinox: J2000										
	<p>Comments: Category=Calibration Description=[Coronagraphic]</p>												
Acquisition	#											Target	
	1											NONE	
Template	AcqFilter	Repeat observation						Background Quadrant					
		YES						1					
Dithers	#											Dither Type	
	1											BACKGROUND	
Spectral Elements	#	Coron Mask/Filter	Subarray	Mask	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	4QPM/F1065C	MASK1065	4QPM	F1065C	FASTR1	128	122	1	2	244	7543.688	
PSF References	Additional Justification: false												

Proposal 2243 - Observation 4 - A direct detection of the closest Jupiter analog with JWST/MIRI

Special Requirements

No Parallel Attachments

Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible

Proposal 2243 - Observation 5 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:27 GMT 2023

Observation	Proposal 2243, Observation 5: DITuc F1065C Diagnostic Status: Warning Observing Template: MIRI Coronagraphic Imaging Background Observations:[BG_dituc F1550C (Obs 1), BG_epsindi F1550C (Obs 2), BG_dituc F1065C (Obs 3), BG_epsindi F1065C (Obs 4), DITuc F1550C (Obs 6)]																																					
	(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																					
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Dithers	Dither Type																																					
	1 5-POINT-SMALL-GRID																																					
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Proposal 2243 - Observation 5 - A direct detection of the closest Jupiter analog with JWST/MIRI

PSF References	PSF Reference: true
Special Requirements	No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible

Proposal 2243 - Observation 6 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:27 GMT 2023

Observation	Proposal 2243, Observation 6: DITuc F1550C Diagnostic Status: Warning Observing Template: MIRI Coronagraphic Imaging Background Observations:[BG_dituc F1550C (Obs 1), BG_epsindi F1550C (Obs 2), BG_dituc F1065C (Obs 3), BG_epsindi F1065C (Obs 4), DITuc F1065C (Obs 5)]																																					
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1	SAME	FND	1	FAST	4	1	1	0.959	62521																													
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1	4QPM/F1550C	MASK1550	4QPM	F1550C	FASTR1	811	14	1	5	70	13622.213	61206																										

Proposal 2243 - Observation 6 - A direct detection of the closest Jupiter analog with JWST/MIRI

PSF References	PSF Reference: true
Special Requirements	No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible

Proposal 2243 - Observation 7 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:27 GMT 2023

Observation	Proposal 2243, Observation 7: EpsIndi F1550C Diagnostic Status: Warning Observing Template: MIRI Coronagraphic Imaging Background Observations:[BG_dituc F1550C (Obs 1), BG_epsindi F1550C (Obs 2), BG_dituc F1065C (Obs 3), BG_epsindi F1065C (Obs 4), EpsIndi F1065C (Obs 8)]																																					
	(EpsIndi F1550C (Obs 7)) Warning (Form): Science observations should be linked to at least one other compatible science observation by an Aperture PA Offset of 1-14 degrees (Visit 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																					
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Proposal 2243 - Observation 7 - A direct detection of the closest Jupiter analog with JWST/MIRI

PSF References	DITuc F1550C (Obs 6) (PSF Reference; Filters [F1550C]) Additional Justification: false
Special Requirements	Aperture PA Range 13 to 23 Degrees (V3 8.16455103 to 18.16455103) Aperture PA Range 103 to 113 Degrees (V3 98.16455103 to 108.16455103) Aperture PA Range 193 to 203 Degrees (V3 188.16455103 to 198.16455103) Aperture PA Range 283 to 293 Degrees (V3 278.16455103 to 288.16455103) No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible

Proposal 2243 - Observation 8 - A direct detection of the closest Jupiter analog with JWST/MIRI

Thu May 25 15:01:27 GMT 2023

Observation	Proposal 2243, Observation 8: EpsIndi F1065C Diagnostic Status: Warning Observing Template: MIRI Coronagraphic Imaging Background Observations:[BG_dituc F1550C (Obs 1), BG_epsindi F1550C (Obs 2), BG_dituc F1065C (Obs 3), BG_epsindi F1065C (Obs 4), EpsIndi F1550C (Obs 7)]																																					
	(EpsIndi F1065C (Obs 8)) Warning (Form): Science observations should be linked to at least one other compatible science observation by an Aperture PA Offset of 1-14 degrees (Visit 8:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																					
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Proposal 2243 - Observation 8 - A direct detection of the closest Jupiter analog with JWST/MIRI

PSF References	DITuc F1065C (Obs 5) (PSF Reference; Filters [F1065C]) Additional Justification: false
Special Requirements	Aperture PA Range 13 to 23 Degrees (V3 8.16455103 to 18.16455103) Aperture PA Range 103 to 113 Degrees (V3 98.16455103 to 108.16455103) Aperture PA Range 193 to 203 Degrees (V3 188.16455103 to 198.16455103) Aperture PA Range 283 to 293 Degrees (V3 278.16455103 to 288.16455103) No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, 7, 8, Non-interruptible