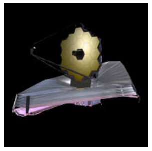

6086 - A First Detailed Exploration of Circumplanetary Disk Gas and Dust with NIRSpec and MIRI/MRS Spectroscopy

Cycle: 3, Proposal Category: GO

INVESTIGATORS

Name	***Institution***
Dr. Kimberly Ward-Duong (PI)	**Smith College**
Dr. Mickael Bonnefoy (CoI) (ESA Member) (CoPI)	Institut de Planetologie et d'Astrophysique de Grenoble
Dr. Benoit Tabone (CoI) (ESA Member)	Institut d'Astrophysique Spatiale
Dr. Cicero Lu (CoI)	NOIRLab - Gemini North (HI)
Dr. Catherine Dougados (CoI) (ESA Member)	Institut de Planetologie et d'Astrophysique de Grenoble
Dr. Laurent Pueyo (CoI)	Space Telescope Science Institute
Dr. Marshall Perrin (CoI)	Space Telescope Science Institute
Julien Girard (CoI)	Space Telescope Science Institute
Dr. Nicole Arulanantham (CoI)	Schmidt Sciences
Dr. Jeffrey S. Bary (CoI)	Colgate University
Dr. Sarah Betti (CoI)	Space Telescope Science Institute
Isabel Rebollido (CoI) (ESA Member)	ESA, European Space Astronomy Centre
Dr. Brendan Bowler (CoI)	University of California - Santa Barbara
Ya-Lin Wu (CoI)	National Taiwan Normal University
Dr. Christine Chen (CoI)	The Johns Hopkins University
Dr. Katherine Brutlag Follette (CoI)	Amherst College
William Balmer (CoI)	Space Telescope Science Institute
Jada Louison (CoI)	University of Massachusetts - Amherst
Dr. Kielan K. W. Hoch (CoI)	Space Telescope Science Institute
Dr. Markus R. Janson (CoI) (ESA Member)	Stockholm University
Simon Christoffer Ringqvist (CoI) (ESA Member)	Totalforsvarets forskningsinstitut

Name	*Institution*
Gayathri Viswanath (CoI) (ESA Member)	Stockholm University
Zoe Roumeliotis (CoI)	Smith College
Ash Messier (CoI)	Smith College
Jingyi Zhang (CoI)	University of Hawaii
Moiz Khalil (CoI)	University of Massachusetts - Amherst
Nathaniel Kerman (CoI)	
Dr. Mathilde Malin (CoI)	The Johns Hopkins University

OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
NIRSpec				
	1	NIRSpec All Gratings	NIRSpec Fixed Slit Spectroscopy	(1) SR-12C-NIR
MRS				
	2	MIRI MRS All Gratings	MIRI Medium Resolution Spectroscopy	(2) SR-12C-MIR
	3	MIRI MRS Dedicated Backgrounds	MIRI Medium Resolution Spectroscopy	(3) Background-for-SR12C-MIR

ABSTRACT

The nature of the Galilean moons of Jupiter and the recent discoveries of accreting protoplanets indicate that circumplanetary disks (CPD) form during the formation of gas giant planets and their satellites. However, these reservoirs of gas and dust have proven more challenging to detect than the disks surrounding brown dwarfs and stars. The dearth of CPD detections in deep submillimeter surveys suggests that they are compact and depleted in large grains suggesting that they are better suited for study in the near- and mid-infrared. Thus, JWST provides excellent capabilities with which to explore these systems in detail. We propose the first in-depth spectral characterization of the gas and dust properties of a CPD by obtaining ~1-27µm spectra of SR 12 c using both NIRSpec and MIRI/MRS. The target is a wide-orbit 11 Jupiter mass companion with the hallmarks of a massive and actively accreting CPD: 1) significant infrared excess, 2) multiwavelength accretion signatures, and 3) a sub-millimeter disk detection, all making it an ideal candidate for this study. The high signal-to-noise observations of SR 12 c will provide a benchmark NIR-MIR spectrum of a CPD, which will allow for a novel study of dust grain processing through measurements of crystalline vs. amorphous silicates, and provide insights into gas composition and disk chemistry by constraining the nature and abundance of volatiles within the CPD.

OBSERVING DESCRIPTION

We propose to use NIRSpec high-resolution fixed slit and MIRI MRS spectroscopy to obtain 0.97 - 27.9 m spectra of the young planetary mass companion SR 12 c, which hosts a circumplanetary disk (CPD). SR 12 c is unique as a CPD host in that it has photometric mid-infrared excesses indicating circumplanetary dust, accretion line emission from multiple diagnostics with measured accretion rates, and the detection of sub-millimeter continuum dust with ALMA. This object is the lowest-mass companion with a disk SED amenable for moderate-resolution spectroscopic study with JWST, and an ideal choice of candidate for detailed disk grain and chemistry characterization in a circumplanetary environment.

The three major anticipated results from this program will be: (1) the first benchmark spectra of a circumplanetary disk spanning the NIR-MIR; (2) the first-ever study of dust grain processing in circumplanetary disks via measurement of crystalline vs. amorphous silicates; (3) and a disk chemistry study that offers the potential for the first-ever detection of volatiles in circumplanetary disks (CO, CO2, H2O, C2H2, HCN) as well as disk winds indicative of disk evolutionary state.

The proposed observations involve both NIRSpec and MIRI in tandem. We proposed for observations across all three of the NIRSpec high-resolution gratings, including the S200A1 and S200A2 modes in order to bridge the detector wavelength gaps. A total integrated science time of 1.2 hours on source for all three gratings will yield SNR~50 across the spectrum, enabling detection of molecular species at levels requisite to determining gas-to-dust ratios and C/O compositions. For MRS, we propose to obtain the full MRS spectrum across all three sub-band configurations, which will provide observations of the suite of molecular gas features (water vapor, CO2, and hydrocarbons) and silicate features requisite for determining the gas abundances of the CPD and the state of its disk dust grain evolution. The MRS observations are designed to reach SNR~50-60 in the continuum excess across Channels 1-3 in 3.7 hours/sub-band (11.1 hrs total science time on source). Considering all slew and acquisition and related overheads, we request 17.3 hours in total to provide the first ever NIR-MIR spectrum of a CPD.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SR-12C-NIR	RA: 16 27 19.6577 (246.8319071d) Dec: -24 41 49.24 (-24.69701d) Equinox: J2000	Proper Motion RA: -7.703 mas/yr Proper Motion Dec: -25.327 mas/yr Parallax: 0.0089034" Epoch of Position: 2016.0	
Comments: Coordinates are from the Gaia DR3 2016.0 epoch, and proper motions are taken from Gaia DR2 for primary star. Both values are cross-referenced with 2021 astrometry using HST WFC3/UVIS and ALMA. *Category=Star* *Description=[Exoplanets, L dwarfs, Protoplanetary disks, Substellar companions]* *Extended=NO*				
(2)	SR-12C-MIR	RA: 16 27 19.6577 (246.8319071d) Dec: -24 41 49.24 (-24.69701d) Equinox: J2000	Proper Motion RA: -7.703 mas/yr Proper Motion Dec: -25.327 mas/yr Parallax: 0.0089034" Epoch of Position: 2016.0	
Comments: Coordinates are from the Gaia DR3 2016.0 epoch, and proper motions are taken from Gaia DR2 for primary star. Both values are cross-referenced with 2021 astrometry using HST WFC3/UVIS and ALMA. *Category=Star* *Description=[Exoplanets, L dwarfs, Protoplanetary disks, Substellar companions]* *Extended=NO*				
(3)	Background-for-SR12C-MIR	RA: 16 27 19.6635 (246.8319312d) Dec: -24 42 0.06 (-24.70002d) Equinox: J2000		
Comments: Similar coordinates as the MRS science target, with a small offset. This target location will be placed within the MIRI imager, in order to obtain MRS backgrounds off-source. *Category=Calibration* *Description=[Telescope/sky background]*				

Observation

Proposal 6086, Observation 1: NIRSpec All Gratings

Tue Jul 15 17:00:22 GMT 2025

Diagnostic Status: Warning

Observing Template: NIRSpec Fixed Slit 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)	SR-12C-NIR	RA: 16 27 19.6577 (246.8319071d) Dec: -24 41 49.24 (-24.69701d) Equinox: J2000	Proper Motion RA: -7.703 mas/yr Proper Motion Dec: -25.327 mas/yr Parallax: 0.0089034" Epoch of Position: 2016.0	

Comments: Coordinates are from the Gaia DR3 2016.0 epoch, and proper motions are taken from Gaia DR2 for primary star. Both values are cross-referenced with 2021 astrometry using HST WFC3/UVIS and ALMA.
Category=Star
Description=[Exoplanets, L dwarfs, Protoplanetary disks, Substellar companions]
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 SR-12C-NIR	WATA	SUB32	F140X	NRSRAPIDD6	3	1	1	0.26	253065.29

Template

HFF Readout Mode	Slit	Subarray
false	S200A1 and S200A2	FULL

Dithers

#	Primary Dither Positions	Sub-Pixel Pattern
1	3	NONE

Spectral Elements

#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp	#	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G140H/F100LP	S200A1	NRSIRS2RAPID	10	1	1	NONE	3	3	481.433	253065.32
2	G140H/F100LP	S200A2	NRSIRS2RAPID	10	1	2	NONE	3	3	481.433	
3	G235H/F170LP	S200A2	NRSIRS2RAPID	18	1	3	NONE	3	3	831.567	
4	G235H/F170LP	S200A1	NRSIRS2RAPID	18	1	4	NONE	3	3	831.567	253065.31
5	G395H/F290LP	S200A1	NRSIRS2RAPID	20	1	5	NONE	3	3	919.1	253065.30
6	G395H/F290LP	S200A2	NRSIRS2RAPID	20	1	6	NONE	3	3	919.1	

Special Requirements	
	Group Observations 1, 2 within 1 Days

Observation

Proposal 6086, Observation 2: MIRI MRS All Gratings

Tue Jul 15 17:00:22 GMT 2025

Diagnostic Status: Warning

Observing Template: MIRI Medium Resolution Spectroscopy

Background Observations:[MIRI MRS Dedicated Backgrounds (Obs 3)]

Comments: These observations are linked as non-interruptible with dedicated MRS backgrounds, and also grouped within 1 day with the NIRSpec observations to minimize the impact of astrophysical variability on the observations (approved change request 89377).

The target's 10 um flux is not accurately known given that the planet has IR excess due to a circumplanetary disk. Therefore, two estimates (bright and faint) have been used in the ETC to determine MRS TA configuration. Four groups in F1000W and FAST readout have been selected to avoid saturation in the bright scenario (SNR~235, with saturation in 27 groups), and still achieve SNR~60 in the conservative faint scenario.

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
(2)	SR-12C-MIR	RA: 16 27 19.6577 (246.8319071d)	Proper Motion RA: -7.703 mas/yr	
		Dec: -24 41 49.24 (-24.69701d)	Proper Motion Dec: -25.327 mas/yr	
		Equinox: J2000	Parallax: 0.0089034"	
			Epoch of Position: 2016.0	

Comments: Coordinates are from the Gaia DR3 2016.0 epoch, and proper motions are taken from Gaia DR2 for primary star. Both values are cross-referenced with 2021 astrometry using HST WFC3/UVIS and ALMA.
Category=Star
Description=[Exoplanets, L dwarfs, Protoplanetary disks, Substellar companions]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	2 SR-12C-MIR	F1000W	FAST	4	1	1	11.1	253065.33

Template

Primary Channel	Simultaneous Imaging	Imager Subarray	Grating Wheel Direction
All MRS	YES	FULL	Allow Auto Reorder

Dithers

#	Dither Type	Optimized For	Direction
1	4-Point	POINT SOURCE	NEGATIVE

Spectral Elements

#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1		IMAGER	F1000W	FASTR1	6	1	1	Dither 1	4	4	66.601	
1	LONG(C)	MRSLONG		SLOWR1	28	5	1	Dither 1	4	20	13760.594	253065.16
1	LONG(C)	MRSSHORT		SLOWR1	28	5	1	Dither 1	4	20	13760.594	253065.17
2		IMAGER	F1000W	FASTR1	6	1	1	Dither 1	4	4	66.601	
2	MEDIUM(B)	MRSLONG		SLOWR1	28	5	1	Dither 1	4	20	13760.594	253065.20
2	MEDIUM(B)	MRSSHORT		SLOWR1	28	5	1	Dither 1	4	20	13760.594	253065.23
3		IMAGER	F1000W	FASTR1	6	1	1	Dither 1	4	4	66.601	
3	SHORT(A)	MRSLONG		SLOWR1	28	5	1	Dither 1	4	20	13760.594	253065.25
3	SHORT(A)	MRSSHORT		SLOWR1	28	5	1	Dither 1	4	20	13760.594	253065.27

Special Requirements

Group Observations 1, 2 within 1 Days
Group Observations 2, 3, Non-interruptible

Observation

Proposal 6086, Observation 3: MIRI MRS Dedicated Backgrounds

Tue Jul 15 17:00:22 GMT 2025

Diagnostic Status: Warning

Observing Template: MIRI Medium Resolution Spectroscopy

Background Observation For: [MIRI MRS All Gratings (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
(3)	Background-for-SR12C-MIR	RA: 16 27 19.6635 (246.8319312d) Dec: -24 42 0.06 (-24.70002d) Equinox: J2000		

Comments: Similar coordinates as the MRS science target, with a small offset. This target location will be placed within the MIRI imager, in order to obtain MRS backgrounds off-source.
Category=Calibration
Description=[Telescope/sky background]

Acquisition

#	Target
1	NONE

Template

AcqFilter	Primary Channel	Simultaneous Imaging	Imager Subarray	Grating Wheel Direction
	Imager	YES	FULL	Allow Auto Reorder

Dithers

#	Dither Type	Optimized For	Direction
1	2-Point	BACKGROUND	NEGATIVE

Spectral Elements

#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1		IMAGER	F1000W	FASTR1	6	1	1	Dither 1	2	2	33.3	
1	LONG(C)	MRSLONG		SLOWR1	28	1	1	Dither 1	2	2	1337.836	
1	LONG(C)	MRSSHORT		SLOWR1	28	1	1	Dither 1	2	2	1337.836	
2		IMAGER	F1000W	FASTR1	6	1	1	Dither 1	2	2	33.3	
2	MEDIUM(B)	MRSLONG		SLOWR1	28	1	1	Dither 1	2	2	1337.836	
2	MEDIUM(B)	MRSSHORT		SLOWR1	28	1	1	Dither 1	2	2	1337.836	
3		IMAGER	F1000W	FASTR1	6	1	1	Dither 1	2	2	33.3	
3	SHORT(A)	MRSLONG		SLOWR1	28	1	1	Dither 1	2	2	1337.836	
3	SHORT(A)	MRSSHORT		SLOWR1	28	1	1	Dither 1	2	2	1337.836	

Special Requirements	
	Group Observations 2, 3, Non-interruptible