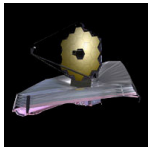

5229 - Super-Jupiters in our backyard: MIRI coronagraphic imaging of a massive planet/brown dwarf orbiting an M dwarf at 12pc

Cycle: 3, Proposal Category: GO

INVESTIGATORS

Name	*Institution*
Dr. Elisabeth C Matthews (PI) (ESA Member)	**Max Planck Institute for Astronomy**
Celia Desgrange (CoI) (ESA Member) (CoPI)	European Southern Observatory - Chile
Dr. Melissa Janice Hobson (CoI) (ESA Member)	Geneva Observatory
Michael Kreuziger (CoI) (ESA Member)	University of Cambridge
Dr. Trifon Trifonov (CoI) (ESA Member)	Max Planck Institute for Astronomy
Dr. Ben Sutlieff (CoI) (ESA Member)	University of Edinburgh, Institute for Astronomy
Dr. Paul Molliere (CoI) (ESA Member)	Max Planck Institute for Astronomy
Prof. Thomas K. Henning (CoI) (ESA Member)	Max Planck Institute for Astronomy

OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	BACKGROUND-REF	MIRI Coronagraphic Imaging	(6) BACKGROUND-HD28343
	2	REF-GJ179-F1550C	MIRI Coronagraphic Imaging	(7) HD28343-F1550C
	3	REF-GJ179-F444W	NIRCam Coronagraphic Imaging	(2) HD28343-F444W
	4	GJ179-F444W	NIRCam Coronagraphic Imaging	(1) GJ179-F444W
	5	GJ179-F1550C	MIRI Coronagraphic Imaging	(3) GJ179-F1550C
	6	BACKGROUND-GJ179	MIRI Coronagraphic Imaging	(5) BACKGROUND-GJ179

ABSTRACT

We will directly detect a massive planet (>2MJ), or low-mass brown dwarf (<20MJ), orbiting the solar-age M dwarf GJ179. We will derive a luminosity and a dynamical mass, and perform a rare but important observational test of evolutionary models at old age and low mass. The detection will pave the way for detailed atmospheric characterization of a cold atmosphere, and JWST coronagraphic imaging is the only facility capable of detecting this object.

We will differentiate chemical equilibrium and non-equilibrium models of the target by combining NIRCam F444W and MIRI F1550C images, and differentiate true companions from backgrounds stars and galaxies with a high level of statistical certainty. The constraints on separation and apparent flux will also be crucial to design future spectroscopic campaigns using NIRSpec and the MIRI MRS. This will allow detailed atmospheric characterization campaigns - providing a rare opportunity to study the rich molecular chemistry of a cold atmosphere, and probe its formation and evolution.

GJ179 is an ideal target for this work. The system shows strong evidence of an outer planet, from a long-term RV trend and an astrometric acceleration. The host star is nearby (12pc), allowing for very deep absolute magnitudes to be reached; it is late-type (M3.5V), reducing the contrast between the star and a massive companion; it has a well-constrained age (5.0Gyr). Archival imaging with Keck/NIRC2 rules out companions >20MJ and hotter than 450K, but the RV trend confirms that the companion must be massive and widely separated, and detectable with JWST - paving the way to detailed atmospheric characterization of a cool, solar-age planet/brown dwarf.

OBSERVING DESCRIPTION

We will collect coronagraphic observations of GJ179 with both MIRI and NIRCam, so as to detect a massive companion seen in radial velocity and astrometric observations of the system.

For MIRI we will observe with filter F1550C and the FQPM coronagraph; for NIRCam we will observe in the dual-band mode, collecting both F200W and F444W observations with the 335R round mask in place. This provides the deepest sensitivity to planets, and a preliminary constraint on the companion atmospheric chemistry.

We will collect reference PSF observations for both the MIRI and NIRCam sequences. In both cases we chose HD28343 as a suitable reference star: it is ~2mag brighter than GJ179 (leading to efficient reference observations even with a dither pattern); is within 16 degrees of the science target; it appears to be single based on the literature and on Gaia noise statistics. We will collect these reference images with the 9pt dither pattern, to ensure

optimal PSF reconstruction. We will also collect background observations near the science and reference targets for the MIRI observations, so as to subtract out the scattered light "glowstick" feature. All observations are included in a SEQ NON INT, to minimize the time baseline between science, reference and background stars, and optimise the removal of the stellar PSF and scattered light.

We will integrate in each filter for ~3600s, to optimize between deep detection limits and an efficient campaign. Our groups/integration and integrations/exposure are chosen based on the results of simulations with PanCAKE, and for the reference star are designed to match the detector flux of the science observations at each dither position.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	GJ179-F444W	RA: 04 52 5.7321 (73.0238838d) Dec: +06 28 35.59 (6.47655d) Equinox: J2000	Proper Motion RA: 153.615 mas/yr Proper Motion Dec: -306.0460000369858 mas/yr Epoch of Position: 2000	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[M stars]*				
(2)	HD28343-F444W	RA: 04 29 0.1238 (67.2505158d) Dec: +21 55 21.72 (21.92270d) Equinox: J2000	Proper Motion RA: -67.017 mas/yr Proper Motion Dec: 174.627 mas/yr Epoch of Position: 2000	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[M stars]*				
(3)	GJ179-F1550C	RA: 04 52 5.7321 (73.0238838d) Dec: +06 28 35.59 (6.47655d) Equinox: J2000	Proper Motion RA: 153.615 mas/yr Proper Motion Dec: -306.0460000369858 mas/yr Epoch of Position: 2000	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[M stars]*				
(5)	BACKGROUND-GJ179	RA: 04 52 7.5400 (73.0314167d) Dec: +06 27 38.10 (6.46058d) Equinox: J2000		
Comments: The coordinates were generated by looking into a empty region close to the SCIENCE star by using the tool Aladin v8.1 and catalog WISE on the APT. *Category=Calibration* *Description=[Telescope/sky background]*				
(6)	BACKGROUND-HD28343	RA: 04 28 55.3900 (67.2307917d) Dec: +21 53 52.50 (21.89792d) Equinox: J2000		
Comments: The coordinates were generated by looking into a empty region close to the SCIENCE star by using the tool Aladin v8.1 and catalog WISE on the APT. *Category=Calibration* *Description=[Telescope/sky background]*				
(7)	HD28343-F1550C	RA: 04 29 0.1238 (67.2505158d) Dec: +21 55 21.72 (21.92270d) Equinox: J2000	Proper Motion RA: -67.017 mas/yr Proper Motion Dec: 174.627 mas/yr Epoch of Position: 2000	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Star* *Description=[M stars]*				

Observation

Proposal 5229, Observation 1: BACKGROUND-REF Mon Dec 23 22:00:09 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Coronagraphic Imaging

Background Observation For: [REF-GJ179-F1550C (Obs 2)]

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
(6)	BACKGROUND-HD28343	RA: 04 28 55.3900 (67.2307917d) Dec: +21 53 52.50 (21.89792d) Equinox: J2000		

Comments: The coordinates were generated by looking into a empty region close to the SCIENCE star by using the tool Aladin v8.1 and catalog WISE on the APT.
Category=Calibration
Description=[Telescope/sky background]

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	1007	3	1	2	6	1449.105	

PSF References

Additional Justification: false

Special Requirements	
	No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, Non-interruptible

Observation

Proposal 5229, Observation 2: REF-GJ179-F1550C Mon Dec 23 22:00:09 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Coronagraphic Imaging

Background Observations:[BACKGROUND-REF (Obs 1)]

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
(7)	HD28343-F1550C	RA: 04 29 0.1238 (67.2505158d)	Proper Motion RA: -67.017 mas/yr	
		Dec: +21 55 21.72 (21.92270d)	Proper Motion Dec: 174.627 mas/yr	
		Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[M stars]

Acquisition

#	Target	Filter	Quadrant	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	FND	1	FAST	4	1	1	0.959	174823.9

Template

Repeat observation
NO

Dithers

#	Dither Type
1	9-POINT-SMALL-GRID

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	1007	3	1	9	27	6520.974	174823.8

PSF References

PSF Reference: true

Special Requirements	
	No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, Non-interruptible

Observation

Proposal 5229, Observation 3: REF-GJ179-F444W Mon Dec 23 22:00:09 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRCam Coronagraphic Imaging

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
(2)	HD28343-F444W	RA: 04 29 0.1238 (67.2505158d)	Proper Motion RA: -67.017 mas/yr	
		Dec: +21 55 21.72 (21.92270d)	Proper Motion Dec: 174.627 mas/yr	
		Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[M stars]

Acquisition

#	Target	Filter	Target Brightness	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	2 HD28343-F444W	F335M	BRIGHT (ND Square)	SHALLOW4	33	1	1	8.279	234615.15

Template

Module	Occulting Mask	Obtain Astrometric Confirmation Images?	Subarray	Dither Pattern
A	MASK335R	false	SUB320A335R	9-POINT-CIRCLE

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	F200W	F444W	DEEP8	7	4	9	36	4965.359	174823.12

PSF References

PSF Reference: true

Special Requirements	
	Offset -0.01 arcsec, -0.015 arcsec Sequence Observations 1, 2, 3, 4, 5, 6, Non-interruptible

Observation

Proposal 5229, Observation 4: GJ179-F444W

Mon Dec 23 22:00:09 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRCam Coronagraphic Imaging

Diagnostics

(GJ179-F444W (Obs 4)) 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 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	GJ179-F444W	RA: 04 52 5.7321 (73.0238838d)	Proper Motion RA: 153.615 mas/yr	
		Dec: +06 28 35.59 (6.47655d)	Proper Motion Dec: -306.0460000369858 mas/yr	
		Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[M stars]

Acquisition

#	Target	Filter	Target Brightness	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	1 GJ179-F444W	F335M	FAINT	RAPID	9	1	1	0.504	234615.13

Template

Module	Occulting Mask	Obtain Astrometric Confirmation Images?	Subarray	Dither Pattern
A	MASK335R	false	SUB320A335R	NONE

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	F200W	F444W	DEEP8	15	17	1	17	5252.542	174823.11

PSF References

REF-GJ179-F444W (Obs 3) (PSF Reference; Filters [F200W/F444W])

Additional Justification: false

Special Requirements	
	Offset -0.01 arcsec, -0.015 arcsec Sequence Observations 1, 2, 3, 4, 5, 6, Non-interruptible

Observation

Proposal 5229, Observation 5: GJ179-F1550C Mon Dec 23 22:00:09 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Coronagraphic Imaging

Background Observations:[BACKGROUND-GJ179 (Obs 6)]

Diagnostics

(GJ179-F1550C (Obs 5)) 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 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(3)	GJ179-F1550C	RA: 04 52 5.7321 (73.0238838d)	Proper Motion RA: 153.615 mas/yr	
		Dec: +06 28 35.59 (6.47655d)	Proper Motion Dec: -306.0460000369858 mas/yr	
		Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Star
Description=[M stars]

Acquisition

#	Target	Filter	Quadrant	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	FND	1	FAST	36	1	1	8.628	174823.3

Template

Repeat observation
NO

Dithers

#	Dither Type
1	NONE

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	1251	12	1	1	12	3600.713	174823.5

PSF References

REF-GJ179-F1550C (Obs 2) (PSF Reference; Filters [F1550C])

Additional Justification: false

Special Requirements	
	No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, Non-interruptible

Observation

Proposal 5229, Observation 6: BACKGROUND-GJ179 Mon Dec 23 22:00:09 GMT 2024

Diagnostic Status: Warning

Observing Template: MIRI Coronagraphic Imaging

Background Observation For: [GJ179-F1550C (Obs 5)]

Diagnostics

(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(5)	BACKGROUND-GJ179	RA: 04 52 7.5400 (73.0314167d) Dec: +06 27 38.10 (6.46058d) Equinox: J2000		

Comments: The coordinates were generated by looking into a empty region close to the SCIENCE star by using the tool Aladin v8.1 and catalog WISE on the APT.
Category=Calibration
Description=[Telescope/sky background]

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	1251	12	1	2	24	7201.425	

PSF References

Additional Justification: false

Special Requirements	
	No Parallel Attachments Sequence Observations 1, 2, 3, 4, 5, 6, Non-interruptible