



3449 - Direct Detection of Molecular Gas in the Extremely Metal-Poor Galaxy Leo P

Cycle: 2, Proposal Category: GO

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Dr. Grace Telford (PI)	Rutgers the State University of New Jersey
Dr. Karin Marie Sandstrom (CoI)	University of California - San Diego
Dr. Kristen B W McQuinn (CoI)	Rutgers the State University of New Jersey
Dr. Simon Glover (CoI) (ESA Member)	Universitat Heidelberg
Mr. Ryan Rickards Vaught (CoI)	University of California - San Diego
Prof. Alberto Bolatto (CoI)	University of Maryland

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Leo P				
	1	MIRI MRS Mosaic	MIRI Medium Resolution Spectroscopy	(1) LEO-P
	2	MIRI MRS Background	MIRI Medium Resolution Spectroscopy	(2) LEO-P-OFF

ABSTRACT

Star formation impacts virtually all areas of astrophysics, and yet remains remarkably poorly understood at the low metallicities typical of early galaxies. Observations show that star formation proceeds in molecular gas (largely in undetectable cold H₂) in higher-metallicity galaxies. But the usual tracer of this ISM phase, CO emission, becomes inefficient in metal-poor gas, leaving us without empirical evidence that molecular gas is the dominant fuel for star formation at very low metallicity. Some models predict that stars can form directly from cold HI in these environments, which would profoundly change the trajectory of stellar mass assembly at high redshift.

We propose MIRI MRS observations of the closest extremely metal-poor, star-forming galaxy, Leo P (1.6 Mpc, 3% Z_{sun}) to search for rotationally

excited emission from warm H₂. This 100-1000 K material is typically ~10% of the total H₂ mass in star-forming galaxies, so its detection would imply the presence of cold molecular gas. The combination of Leo P's proximity and MIRI's unprecedented spatial resolution and sensitivity in the MIR uniquely enables robust detection of (or a stringent upper limit on) the compact, warm H₂ clouds expected in the metal-poor ISM. Simultaneously, these observations will be sensitive to PAH emission, dust continuum, and fine-structure nebular lines from the galaxy's only HII region, all of which will provide new insight into the impacts of radiation field hardness and intensity in metal-poor environments. This proposal will fundamentally shape our understanding of star-formation physics in metal-poor galaxies, both locally and at high redshift.

OBSERVING DESCRIPTION

We will observe Leo P with MIRI MRS with a primary goal of detecting rotationally excited transitions of warm molecular hydrogen. To cover the full region of the galaxy where the emission is expected requires a 2x2 mosaic. We select Channel 3 as the primary for mosaic construction (with 10% overlap in the Channel 3 field of view) to maximize the extent of the mosaic while ensuring complete spatial coverage for the S(1) line at 17 micron, which is expected to give the most sensitive limit. The lines of interest span all three grating settings (ABC), so we require three observations of the mosaic, one at each grating setting. We request MIRI simultaneous imaging as recommended for astrometric alignment and select the F560W, F770W filters for their high spatial resolution, as well as the F2100W filter for its sensitivity to dust continuum and dust-producing, evolved stars. APT gives an Imager Filter overlap warning for the F2100W filter, but this will not impact our science goals. The SLOWR1 readout pattern is necessary to stay within the data volume limits. We adopt the 4-pt dither pattern optimized for extended sources to improve PSF sampling and obtain a background observation for each grating setting at an offset of -50 arcsec in both the X and Y directions from the science target to ensure that the MIRI simultaneous imaging covers Leo P while the offset field is observed with MRS. As recommended in JDOX, we require that the backgrounds are observed in a non-interruptible sequence with the science observations. These observations do not require target acquisition. We adopt 12 groups/int in the JWST ETC v2 to stay below the 300s limit recommended to mitigate the impacts of cosmic rays. To reach achieve S/N=5 at the surface brightness limit of the S(1) line required by our science goals requires 2 integrations (x the 4 exposures in the dither pattern) for a total time request of 15.4 hours from the APT.

Proposal 3449 - Targets - Direct Detection of Molecular Gas in the Extremely Metal-Poor Galaxy Leo P

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	LEO-P	RA: 10 21 45.0725 (155.4378021d) Dec: +18 05 21.38 (18.08927d) Equinox: J2000	Epoch of Position: 2015.5	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>Category=Galaxy</i></p> <p><i>Description=[Dwarf galaxies, Dwarf irregular galaxies, Low Surface Brightness galaxies, Primordial galaxies]</i></p> <p><i>Extended=YES</i></p>
(2)	LEO-P-OFF	RA: 10 21 45.0725 (155.4378021d) Dec: +18 05 21.38 (18.08927d) Equinox: J2000	Epoch of Position: 2015.5	<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>This target is identical to LEO-P but we will observe at an offset of 50 arcsec in the X and Y directions from this target to obtain the required background observation for the main target of the proposal.</i></p> <p><i>Category=Galaxy</i></p> <p><i>Description=[Dwarf galaxies, Dwarf irregular galaxies, Low Surface Brightness galaxies, Primordial galaxies]</i></p> <p><i>Extended=YES</i></p>	

Proposal 3449 - Observation 1 - Direct Detection of Molecular Gas in the Extremely Metal-Poor Galaxy Leo P

Thu May 11 01:06:20 GMT 2023

Observation	Proposal 3449, Observation 1: MIRI MRS Mosaic Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy Background Observations:[MIRI MRS Background (Obs 2)]												
	(MIRI MRS Mosaic (Obs 1)) Warning (Form): Imager Filter overlap. (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)	LEO-P	RA: 10 21 45.0725 (155.4378021d) Dec: +18 05 21.38 (18.08927d) Equinox: J2000				Epoch of Position: 2015.5						
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>Category=Galaxy</i> <i>Description=[Dwarf galaxies, Dwarf irregular galaxies, Low Surface Brightness galaxies, Primordial galaxies]</i> <i>Extended=YES</i>													
Acquisition	#											Target	
	1											NONE	
Template	AcqFilter	Primary Channel				Simultaneous Imaging			Imager Subarray				
		CHANNEL3				YES			FULL				
Mosaic	Rows	Columns	Row Overlap %	Column Overlap %	Row shift	Column shift	Tile Order						
	2	2	10.0	10.0	0.0	0.0	DEFAULT						
Dithers	#	Dither Type				Optimized For			Direction				
	1	4-Point				EXTENDED 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	F560W	SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	1	SHORT(A)	MRSLONG		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	1	SHORT(A)	MRSSHORT		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	2		IMAGER	F770W	SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	2	MEDIUM(B)	MRSLONG		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	2	MEDIUM(B)	MRSSHORT		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	3		IMAGER	F2100W	SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	3	LONG(C)	MRSLONG		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	3	LONG(C)	MRSSHORT		SLOWR1	12	2	1	Dither 1	4	8	2388.992	

Proposal 3449 - Observation 1 - Direct Detection of Molecular Gas in the Extremely Metal-Poor Galaxy Leo P

Special Requirements

Sequence Observations 1, 2, Non-interruptible

Proposal 3449 - Observation 2 - Direct Detection of Molecular Gas in the Extremely Metal-Poor Galaxy Leo P

Thu May 11 01:06:20 GMT 2023

Observation	Proposal 3449, Observation 2: MIRI MRS Background Diagnostic Status: Warning Observing Template: MIRI Medium Resolution Spectroscopy Background Observation For: [MIRI MRS Mosaic (Obs 1)]												
	(MIRI MRS Background (Obs 2)) Warning (Form): Imager Filter overlap. (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)	LEO-P-OFF	RA: 10 21 45.0725 (155.4378021d) Dec: +18 05 21.38 (18.08927d) Equinox: J2000				Epoch of Position: 2015.5						
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> <i>This target is identical to LEO-P but we will observe at an offset of 50 arcsec in the X and Y directions from this target to obtain the required background observation for the main target of the proposal.</i> Category=Galaxy Description=[Dwarf galaxies, Dwarf irregular galaxies, Low Surface Brightness galaxies, Primordial galaxies] Extended=YES													
Acquisition	#	Target											
	1	NONE											
Template	AcqFilter	Primary Channel				Simultaneous Imaging			Imager Subarray				
		CHANNEL3				YES			FULL				
Dithers	#	Dither Type				Optimized For			Direction				
	1	4-Point				EXTENDED SOURCE			NEGATIVE				
Spectral Elements	#	Wavelength Range	Detector	Filter	Readout Pattern	Groups/Int	Integrations/E xp	Exposures/Dit h	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1		IMAGER	F560W	SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	1	SHORT(A)	MRSLONG		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	1	SHORT(A)	MRSSHORT		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	2		IMAGER	F770W	SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	2	MEDIUM(B)	MRSLONG		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	2	MEDIUM(B)	MRSSHORT		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	3		IMAGER	F2100W	SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	3	LONG(C)	MRSLONG		SLOWR1	12	2	1	Dither 1	4	8	2388.992	
	3	LONG(C)	MRSSHORT		SLOWR1	12	2	1	Dither 1	4	8	2388.992	

Proposal 3449 - Observation 2 - Direct Detection of Molecular Gas in the Extremely Metal-Poor Galaxy Leo P

Special Requirements

Offset -50.0 arcsec, -50.0 arcsec

Sequence Observations 1, 2, Non-interruptible