



7087 - A High Precision Disk Opacity Law from the Great Serpens Shadow

Cycle: 4, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1	NIRCam image	NIRCam Imaging	(1) GREAT-SERPENS-DISK-SHADOW
	2	MIRI image	MIRI Imaging	(1) GREAT-SERPENS-DISK-SHADOW

ABSTRACT

In a disk system, starlight penetrates the disk surface layers subject to the dust opacity as a function of wavelength. The relative dust opacity law is critical input for protoplanetary disk formation and evolution models, but has not yet been measured empirically. An observational measurement of the opacity in a disk will influence planet formation models, settling, and interpretation of surface tracers accessible to JWST, including molecular gas. However, the precision needed to measure the opacity law via direct methods cannot be achieved with existing facilities. We propose to observe, for the first time, the relative disk opacity law in a young disk through the magnifying effect of shadowing. The Herbig Ae/Be-like star HBC672 (EC82), embedded in the Serpens molecular cloud, is associated with a giant (17000 AU scale) disk shadow revealed through HST/WFC3IR imaging. In this edge-on circumstellar disk system, starlight is occulted by disk surface structures in the innermost few AU, creating a sharp conical shadow against the cloud background. The shadow is cast from the innermost AU region of the disk in this system, at least three orders of magnitude smaller than the shadow extent, magnifying the effect of disk opacity by at least three orders of magnitude against the Serpens cloud background.

JWST Proposal 7087 (Created: Tuesday, May 6, 2025, 3:00:09PM Eastern Standard Time) - Overview

Using JWST/NIRCam and MIRI imaging we will measure the relative disk opacity law in 13 bands from 0.9-18 microns by determining the shadow opening angle, translated to disk scale height, as a function of wavelength. Using this special geometric setup, this would be the first empirical measurement of the dust opacity law in a planet-forming disk.

OBSERVING DESCRIPTION

In order to decipher and measure the shadow opening angle (ie. the boundary between shadowed and illuminated cloud material), we must be able to detect the boundary; this requires sufficient sensitivity to detect the fainter of the shadow or illuminated cloud structure at all proposed wavelengths. At wavelengths less than 5 μm , we use pre-JWST data to estimate the flux density of material inside and outside of the shadow. At longer wavelengths where the shadow is not resolved (ie. by Spitzer), we measure the flux density near and more distantly from the central protostar EC82. Our observations will achieve S/N of 70 on the lowest value at each wavelength (ie. within the shadow, or nearby cloud emission). We used the JWST exposure time calculator for each of 17 bands spanning 0.7-28 μm , 8 (paired) bandpasses with NIRCam, and 5 bandpasses with MIRI.

We observe in four paired bandpasses with NIRCam: F090W/F250M, F115/F300M, F162M+F150W2, and F210M/F430M. Each uses the SHALLOW2 readout pattern and 5 groups per integration, and the INTRAMODULEX 6 point dither. The F162M filter is similar to F164N on HST/WFC3-IR, which will provide a cross-calibration anchor and provide the baseline shadow position angle for this dataset. The F300M will include water ice. Each of the four filter pairs requires 1030 seconds of exposure time, for a total exposure time of 4128 seconds, or 11024 seconds including overhead.

We observe in five bandpasses/filter settings with MIRI: F560W, F770W, F1000W, F1280W, and F1800W. Each uses a fast readout pattern and 40 groups per integration (with a single integration and exposure), except for F1800W in which only 30 groups per integration are required to achieve the S/N goal. We use a 6 point cycling dither pattern. The F1000W will include silicate dust emission. Each filter requires 666 seconds exposure time, except for F1800W which requires only 500 seconds, for a total exposure time of 3192 seconds, or 8249 seconds including overhead.

As indicated in the special requirements, all NIRCam and MIRI imaging for this program must be executed from start to finish within a 5 day time period to avoid potential variability in the shadow position angle, although the specific time period is not further constrained. We used a POSTARG to center the EC82 star in between detectors (mostly) in the NIRCam SW channel, centering in one of the LW detectors. This will reduce the confusion introduced by the EC82 star on the shadow angle. For most likely angles, the shadow will fall diagonally in the SW detectors.

Proposal 7087 - Targets - A High Precision Disk Opacity Law from the Great Serpens Shadow

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	GREAT-SERPENS-DISK-SHADOW	RA: 18 29 56.8878 (277.4870325d) Dec: +01 14 46.17 (1.24616d) Equinox: J2000	Proper Motion RA: 3.208092086326899E-4 sec of time/yr Proper Motion Dec: -0.011072000097556156 arcsec/yr Epoch of Position: 2015.5	
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=Star Description=[Protoplanetary disks]					

Proposal 7087 - Observation 1 - A High Precision Disk Opacity Law from the Great Serpens Shadow

Tue May 06 20:00:09 GMT 2025

Observation	<p>Proposal 7087, Observation 1: NIRCam image</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRCam Imaging</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		
	(1)	GREAT-SERPENS-DISK-SHADOW	RA: 18 29 56.8878 (277.4870325d) Dec: +01 14 46.17 (1.24616d) Equinox: J2000		Proper Motion RA: 3.208092086326899E-4 sec of time/yr Proper Motion Dec: -0.011072000097556156 arcsec/yr 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=Star</i></p> <p><i>Description=[Protoplanetary disks]</i></p>									
Template	Module		Subarray			Target Placement				
	ALL		FULL			Module Gap				
Dithers	#	Primary Dither Type		Primary Dithers	Subpixel Dither Type		Dither Size	Subpixel Positions		
	1	INTRAMODULEX		6	STANDARD			1		
Spectral Elements	#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
	1	F090W	F250M	SHALLOW2	5	1	6	6	1417.254	
	2	F115W	F300M	SHALLOW2	5	1	6	6	1417.254	
	3	F162M+F150W2	F360M	SHALLOW2	5	1	6	6	1417.254	
	4	F210M	F430M	SHALLOW2	5	1	6	6	1417.254	
Special Requirements	<p>Aperture PA Range 95.92542306 to 105.92542306 Degrees (V3 96.0 to 106.0)</p> <p>Offset 90.75236285136371 arcsec, -1.5405882538578473 arcsec</p> <p>Group Observations 1, 2 within 5 Days</p>									

Proposal 7087 - Observation 2 - A High Precision Disk Opacity Law from the Great Serpens Shadow

Tue May 06 20:00:09 GMT 2025

Observation	<p>Proposal 7087, Observation 2: MIRI image</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: MIRI Imaging</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		
	(1)	GREAT-SERPENS-DISK-SHADOW	RA: 18 29 56.8878 (277.4870325d) Dec: +01 14 46.17 (1.24616d) Equinox: J2000			Proper Motion RA: 3.208092086326899E-4 sec of time/yr Proper Motion Dec: -0.011072000097556156 arcsec/yr Epoch of Position: 2015.5					
	<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i> Category=Star Description=[Protoplanetary disks]										
Template	<p>Subarray</p> <p>FULL</p>										
Dithers	#	Dither Type	Starting Point	Number of Points	Points	Starting Set	Number of Sets	Optimized For	Direction	Pattern Size	
	1	CYCLING	1	6						DEFAULT	
Spectral Elements	#	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Dither	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	F560W	FASTR1	40	1	1	Dither 1	6	6	666.01	
	2	F770W	FASTR1	40	1	1	Dither 1	6	6	666.01	
	3	F1000W	FASTR1	40	1	1	Dither 1	6	6	666.01	
	4	F1280W	FASTR1	40	1	1	Dither 1	6	6	666.01	
	5	F1800W	FASTR1	30	1	1	Dither 1	6	6	499.507	
Special Requirements	<p>Aperture PA Range 100.83544897 to 110.83544897 Degrees (V3 96.0 to 106.0)</p> <p>Group Observations 1, 2 within 5 Days</p>										