



3973 - Using planets to dynamically weigh a debris disc for the first time

Cycle: 2, 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>
NIRCam coronagraphy				
	1	HD53143 - science target	NIRCam Coronagraphic Imaging	(1) HD-53143
	8	HD53143 - science target	NIRCam Coronagraphic Imaging	(1) HD-53143
	3	HD37501 - PSF reference star	NIRCam Coronagraphic Imaging	(5) HD-37501
NIRCam non coronagraphic images				

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
	6	HD53143 roll one	NIRCam Imaging	(1) HD-53143
	7	HD53143 roll two	NIRCam Imaging	(1) HD-53143

ABSTRACT

Debris discs (like our Kuiper Belt) are a fundamental component of planetary systems, detected around 20 % of main-sequence stars. They yield powerful insights into planetary system architecture, formation and evolution, but a major issue limits their effectiveness as probes of planetary systems: debris-disc masses are unknown. We aim to dynamically measure an extrasolar debris disc's mass for the first time. We would use JWST to search for planets in the specific system HD 53143, which hosts a narrow debris disc that is the most eccentric known. This makes it highly sensitive to planet-debris interactions. There is considerable evidence that at least one planet is present, and constraining its parameters would let us dynamically measure the debris-disc mass (which must be high enough for self-gravity to maintain the disc shape in the face of planetary perturbations). We ask for NIRCam imaging of the system, which would be sensitive to planets down to sub-Jupiter mass. A planet detection, combined with our novel interaction theory, would constrain the debris disc to be at least 10 to 100 Earth masses (a major advance, since extrasolar debris-disc masses are currently only constrained to be between 0.1 and 1000 Earth masses). Even a non-detection would be beneficial, as it would be combined with existing proper-motion-anomaly, SPHERE and RV data to bound the planet properties and still constrain the disc mass. The result would greatly aid debris and system-formation science, and put our Solar System into context. In addition, this programme offers the opportunity to detect and characterise a ~1 Gyr old exoplanet for the first time.

OBSERVING DESCRIPTION

Our goal is to search for exoplanets below 2 Jupiter masses interior to the HD53143 debris disc; our images would also be sensitive to companions outside the disc.

We would observe HD53143 with the NIRCam coronagraph, using the dual-band imaging mode with the short-wavelength filter F200W, the long-wavelength filter F444W and the MASK335R coronagraph. We would also collect PSF reference images of HD37501 with the 5-point small grid dither technique. This allows the data to be reduced using reference differential imaging (RDI); we do not use angular differential imaging (ADI) in this case. HD37501 is ~0.6mag brighter than HD53143, has an on-sky separation from HD53143 of 10.2 degrees, and the two targets have well-matched spectral types for PSF subtraction, according to the JWST documentation.

We would also observe HD53143 without a coronagraph, using the same filters. In this case, we would collect data at two roll angles, with a PA offset between 8 to 14 degrees, to allow for angular differential imaging (ADI).

Our choice to use RDI vs ADI is based on the results of the JWST ERS program 1386, which found that RDI is significantly more effective at close separations, and ADI and RDI perform similarly further from the star. RDI+ADI was not found to offer significant improvement over RDI alone (Carter et al. 2023, Hinkley et al. 2023).

The coronagraphic science and reference images would be included in a non-interruptible sequence so as to minimize the time baseline between these images, and ensure a high-quality subtraction of the stellar PSF from the science data. Similarly, the two non-coronagraphic roll angles would be included in a non-interruptible sequence to ensure high-quality stellar PSF subtraction.

Our NGROUPS/INTEGRATION and NINTS/EXPOSURE are chosen based on the results of simulations with PanCAKE (for coronagraphic imaging) and pyNRC (for non-coronagraphic imaging). We designed our non-coronagraphic images to saturate at the stellar core, since the primary goal of these images is to probe to deep sensitivity beyond $\sim 3''$.

Proposal 3973 - Targets - Using planets to dynamically weigh a debris disc for the first time

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	HD-53143	RA: 06 59 59.3064 (104.9971100d) Dec: -61 20 6.15 (-61.33504d) Equinox: J2000	Proper Motion RA: -0.022497032861942313 sec of time/yr Proper Motion Dec: 0.264836 arcsec/yr Epoch of Position: 2015.5	
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					
<i>Category=Star</i>					
<i>Description=[Debris disks, Exoplanet Systems]</i>					
(5)	HD-37501	RA: 05 34 57.4173 (83.7392387d) Dec: -61 10 34.19 (-61.17616d) Equinox: J2000	Proper Motion RA: -9.97404121877017E-4 sec of time/yr Proper Motion Dec: -0.0268360000973189 arcsec/yr Epoch of Position: 2015.5		
<i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					
<i>Category=Star</i>					
<i>Description=[G stars]</i>					

Proposal 3973 - Observation 1 - Using planets to dynamically weigh a debris disc for the first time

Tue Apr 16 22:00:11 GMT 2024

Observation	<p>Proposal 3973, Observation 1: HD53143 - science target</p> <p>Diagnostic Status: Error</p> <p>Observing Template: NIRCam Coronagraphic Imaging</p> <p><i>Comments: We are not requesting an ADI reference image. This is explained in the technical justification, and produces a warning here.</i></p>									
Diagnostics	<p>(HD53143 - science target (Obs 1)) Error (Form): Permission has not been granted for this program to use Special Requirement 'No Parallel Attachments'.</p> <p>(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(HD53143 - science target (Obs 1)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>									
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections			Miscellaneous		
	(1)	HD-53143	RA: 06 59 59.3064 (104.9971100d) Dec: -61 20 6.15 (-61.33504d) Equinox: J2000		Proper Motion RA: -0.022497032861942313 sec of time/yr Proper Motion Dec: 0.264836 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=[Debris disks, Exoplanet Systems]</i></p>									
Acquisition	#	Target	Filter	Target Brightness	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	1 HD-53143	F335M	BRIGHT (ND Square)	SHALLOW4	65	1	1	16.305	144996.13
Template	Module		Coronagraphic 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	9	15	1	15	2710.324	
PSF References	<p>HD37501 - PSF reference star (Obs 3) (PSF Reference; Filters [F200W/F444W])</p> <p>Additional Justification: false</p>									

Proposal 3973 - Observation 1 - Using planets to dynamically weigh a debris disc for the first time

Special Requirements

Offset -0.01 arcsec, 0.005 arcsec
No Parallel Attachments

Sequence Observations 1, 3, 8, Non-interruptible
Aperture PA Offset 8 from 1 by 8 to 14 Degrees (Same offsets in V3)

Proposal 3973 - Observation 8 - Using planets to dynamically weigh a debris disc for the first time

Tue Apr 16 22:00:11 GMT 2024

Observation	<p>Proposal 3973, Observation 8: HD53143 - science target</p> <p>Diagnostic Status: Error</p> <p>Observing Template: NIRCam Coronagraphic Imaging</p> <p><i>Comments: We are not requesting an ADI reference image. This is explained in the technical justification, and produces a warning here.</i></p>									
Diagnostics	<p>(HD53143 - science target (Obs 8)) Error (Form): Permission has not been granted for this program to use Special Requirement 'No Parallel Attachments'.</p> <p>(Visit 8:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(HD53143 - science target (Obs 8)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>									
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections			Miscellaneous		
	(1)	HD-53143	RA: 06 59 59.3064 (104.9971100d) Dec: -61 20 6.15 (-61.33504d) Equinox: J2000		Proper Motion RA: -0.022497032861942313 sec of time/yr Proper Motion Dec: 0.264836 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=[Debris disks, Exoplanet Systems]</i></p>									
Acquisition	#	Target	Filter	Target Brightness	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	1 HD-53143	F335M	BRIGHT (ND Square)	SHALLOW4	65	1	1	16.305	144996.13
Template	Module		Coronagraphic 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	9	15	1	15	2710.324	
PSF References	<p>HD37501 - PSF reference star (Obs 3) (PSF Reference; Filters [F200W/F444W])</p> <p>Additional Justification: false</p>									

Proposal 3973 - Observation 8 - Using planets to dynamically weigh a debris disc for the first time

Special Requirements

Offset -0.01 arcsec, 0.005 arcsec
No Parallel Attachments

Sequence Observations 1, 3, 8, Non-interruptible
Aperture PA Offset 8 from 1 by 8 to 14 Degrees (Same offsets in V3)

Proposal 3973 - Observation 3 - Using planets to dynamically weigh a debris disc for the first time

Tue Apr 16 22:00:11 GMT 2024

Observation	<p>Proposal 3973, Observation 3: HD37501 - PSF reference star</p> <p>Diagnostic Status: Error</p> <p>Observing Template: NIRCam Coronagraphic Imaging</p>									
Diagnostics	<p>(HD37501 - PSF reference star (Obs 3)) Error (Form): Permission has not been granted for this program to use Special Requirement 'No Parallel Attachments'.</p> <p>(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>									
Fixed Targets	#	Name	Target Coordinates		Targ. Coord. Corrections			Miscellaneous		
	(5)	HD-37501	RA: 05 34 57.4173 (83.7392387d) Dec: -61 10 34.19 (-61.17616d) Equinox: J2000		Proper Motion RA: -9.97404121877017E-4 sec of time/yr Proper Motion Dec: -0.0268360000973189 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=[G stars]</i></p>									
Acquisition	#	Target	Filter	Target Brightness	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
	1	5 HD-37501	F335M	BRIGHT (ND Square)	SHALLOW4	33	1	1	8.279	144996.8
Template	Module		Coronagraphic Mask		Obtain Astrometric Confirmation Images?		Subarray		Dither Pattern	
	A		MASK335R		false		SUB320A335R		5-POINT-BOX	
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	5	12	5	60	5709.902	
PSF References	<p>PSF Reference: true</p>									

Proposal 3973 - Observation 3 - Using planets to dynamically weigh a debris disc for the first time

Special Requirements

Offset -0.01 arcsec, 0.005 arcsec
No Parallel Attachments

Sequence Observations 1, 3, 8, Non-interruptible

Proposal 3973 - Observation 6 - Using planets to dynamically weigh a debris disc for the first time

Tue Apr 16 22:00:11 GMT 2024

Observation	<p>Proposal 3973, Observation 6: HD53143 roll one</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRCam Imaging</p>									
Diagnostics	<p>(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(HD53143 roll one (Obs 6)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>									
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous	
	(1)	HD-53143	RA: 06 59 59.3064 (104.9971100d) Dec: -61 20 6.15 (-61.33504d) Equinox: J2000			Proper Motion RA: -0.022497032861942313 sec of time/yr Proper Motion Dec: 0.264836 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=[Debris disks, Exoplanet Systems]</i></p>									
Template	Module		Subarray				Target Placement			
	B		FULL				Module Gap			
Dithers	#	Primary Dither Type		Primary Dithers		Subpixel Dither Type		Dither Size	Subpixel Positions	
	1	NONE				STANDARD			5	
Spectral Elements	#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
	1	F200W	F444W	RAPID	3	10	50	5	2093.67	
Special Requirements	<p>Offset 4.5 arcsec, 4.5 arcsec</p> <p>Sequence Observations 6, 7, Non-interruptible</p> <p>Aperture PA Offset 7 from 6 by 8 to 14 Degrees (Same offsets in V3)</p>									

Proposal 3973 - Observation 7 - Using planets to dynamically weigh a debris disc for the first time

Tue Apr 16 22:00:11 GMT 2024

Observation	<p>Proposal 3973, Observation 7: HD53143 roll two</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRCam Imaging</p>									
Diagnostics	<p>(Visit 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p> <p>(HD53143 roll two (Obs 7)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.</p>									
Fixed Targets	#	Name	Target Coordinates			Targ. Coord. Corrections			Miscellaneous	
	(1)	HD-53143	RA: 06 59 59.3064 (104.9971100d) Dec: -61 20 6.15 (-61.33504d) Equinox: J2000			Proper Motion RA: -0.022497032861942313 sec of time/yr Proper Motion Dec: 0.264836 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=[Debris disks, Exoplanet Systems]</i></p>									
Template	Module		Subarray				Target Placement			
	B		FULL				Module Gap			
Dithers	#	Primary Dither Type		Primary Dithers		Subpixel Dither Type		Dither Size	Subpixel Positions	
	1	NONE				STANDARD			5	
Spectral Elements	#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
	1	F200W	F444W	RAPID	3	10	50	5	2093.67	
Special Requirements	<p>Offset 4.5 arcsec, 4.5 arcsec</p> <p>Sequence Observations 6, 7, Non-interruptible</p> <p>Aperture PA Offset 7 from 6 by 8 to 14 Degrees (Same offsets in V3)</p>									