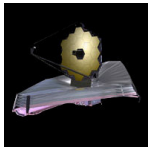

1240 - De-Mystifying SPRITEs with JWST

Cycle: 1, Proposal Category: GTO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
AT2019ABN				
	1	LRS	MIRI Low Resolution Spectroscopy	(8) AT2019ABN-MIRI-COORDS
	2	NIRSPEC-FS	NIRSpec Fixed Slit Spectroscopy	(1) AT2019ABN-NIRSPEC-COORDS
WISETRANSIENT				
	3	LRS	MIRI Low Resolution Spectroscopy	(2) WISETRANSIENT
	4	NIRSPEC-FS	NIRSpec Fixed Slit Spectroscopy	(2) WISETRANSIENT
SPIRITS18NU				
	5	LRS	MIRI Low Resolution Spectroscopy	(3) SPIRITS18NU
	6	NIRSPEC	NIRSpec IFU Spectroscopy	(3) SPIRITS18NU

ABSTRACT

We will perform three non-disurptive ToO follow-up observations with MIRI and NIRSpec of unusual IR-luminous transients detected by Spitzer in our Spitzer Infrared Intensive Transients Survey (SPIRITS). Our focus is on characterizing the origins of the SPIRITS-discovered SPRITEs:

eSPecially Red Intermediate-luminosity Transient Events. These IR-luminous transients are exceptionally red and show only very weak or short-lived optical counterparts, if any. The diversity of their mid-IR light curves implies that SPRITEs represent a mix of different physical origins including luminous blue variable outbursts, stellar mergers, and obscured supernovae (Kasliwal et al. 2017; Jencson et al. 2019).

This proposal has ToO status.

The 3 ToOs in this program will be selected using the following criteria (all magnitudes are on the Vega system):

• Target detected in the SPIRITS program with at least two positive detections.
Rationale: The SPIRITS program operated from 2014 until the end of the Spitzer mission in Jan 2020. We require at least two epochs of positive detections to provide a temporal baseline to extrapolate and predict the expected mid-IR brightness at the time of JWST follow-up.

• Peak absolute magnitude at 3.6 or 4.5 μm brighter than -11, OR with a light curve duration > 1 yr.
Rationale: This requirement is necessary to distinguish SPRITEs from classical novae. The brightness indicated is the highest absolute magnitude in the mid-IR that can be achieved by dusty classical novae without exceeding their Eddington limit. Since novae fade within ~ 6 months, the light curve duration adds another constraint to exclude novae.

• Predicted 4.5 μm magnitude brighter than 18 (10 μJy) at time of trigger.
Rationale: In order to obtain a robust >= 10 sigma detection with our requested exposure times and observing modes, we require the SPRITE to exhibit a 4.5 μm flux of >= 10 μJy. The SPRITE flux/magnitude will be predicted based on extrapolations of the evolution of the mid-IR light curve.

Target Prioritization: High priority SPRITEs for ToO triggering will exhibit red [3.6]-[4.5] colors and high luminosities. Priority will also be given to targets with pre- or post-explosion counterpart imaging from the Hubble Space Telescope.

OBSERVING DESCRIPTION

The dynamic infrared (IR) sky has been explored extensively by the Spitzer Space Telescope. By searching 200 nearby galaxies, the Spitzer Infrared Intensive Transient Survey (SPIRITS) found 37 unusual infrared transients, with no optical counterparts whatsoever, dubbed SPRITEs (eSPecially Red Intermediate Luminosity Red Transients, Kasliwal et al., 2017). SPRITEs are much redder than both novae (e.g. Nova Cygni 1975; Gallagher & Ney 1976) and supernovae (e.g. SN2011dh and SN2014J; Johansson et al. 2017; Helou et al. 2013), while the optical upper limits may make them

comparable to late-stage Luminous Red Novae (LRNs; e.g. M101OT; Blagorod-nova et al. 2017) and Intermediate-Luminosity Red Transients (ILRTs; e.g. SN2008S; Adams et al. 2016). With infrared luminosities between novae and supernovae, SPRITEs are found to occur in grand spiral galaxies. These transients cannot be classical novae as their infrared luminosities are much higher than Eddington. SPRITEs may represent diverse physical origins including 1) the birth of massive binaries that drive shocks in their molecular cloud (Kasliwal et al., 2017), 2) stellar mergers with dusty winds (Smith et al., 2016; Blagorodnova et al., 2017; Pejcha et al., 2016), 3) 8–10 Msun stars experiencing e-capture induced collapse in their cores (Kochanek et al., 2014; Prieto et al., 2008), or 4) birth of stellar mass black holes (Adams et al., 2016; Lovegrove & Woosley, 2013). SPIRITS revealed that the infrared sky is not only as dynamic as the optical sky; it also provided access to unique and complementary signatures of stellar astrophysics.

The key to disentangling the various possible physical origins of the new discoveries and deciphering the astrophysics and astrochemistry is IR spectroscopy. Due to the sensitivity limitations imposed by Earth's atmosphere, SPRITEs have been too faint to detect from ground-based IR observatories. We therefore require the unprecedented IR sensitivity of MIRI and NIRSPEC on JWST to obtain the first detections and IR spectra at wavelengths > 4.5 μm of these mysterious transients. In addition to detecting diagnostic IR emission and absorption lines, the spectra would reveal: 1) the composition of the emitting dust (e.g., silicate or carbonaceous grains), 2) the total emitting dust mass, and thus the overall mass of the circumstellar medium, and 3) the integrated IR luminosity, and thus the luminosity of the heating source.

References:

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Pejcha, O., Metzger, B. D., & Tomida, K. 2016, MNRAS, 455, 4351
Prieto, J. L., Kistler, M. D., Thompson, T. A., et al. 2008, ApJL, 681, L9
Smith, N., Andrews, J. E., Van Dyk, S. D., et al. 2016, MNRAS, 458, 950

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	AT2019ABN-NIRSPEC-COORDS	RA: 13 29 42.3903 (202.4266262d) Dec: +47 11 16.64 (47.18796d) Equinox: J2000	Epoch of Position: 2012	
Comments: AT2019ABN (Coordinates for NIRSpec FS based on 2012 HST F110W image) *Category=Star* *Description=[Eruptive variables]* *Extended=NO*				
(2)	WISETRANSIENT	RA: 19 09 39.7825 (287.4157604d) Dec: +05 35 4.27 (5.58452d) Equinox: J2000	Epoch of Position: 2015.5	
Comments: IR transient discovered by WISE and ZTF *Category=Star* *Description=[Eruptive variables]*				
(3)	SPIRITS18NU	RA: 03 46 45.6034 (56.6900142d) Dec: +68 03 26.88 (68.05747d) Equinox: J2000	Epoch of Position: 2015.5	
Comments: SPIRITS18nu *Category=Star* *Description=[Eruptive variables]*				
(4)	LRS-OFFSET-SPIRITS18NU	RA: 03 46 45.0789 (56.6878287d) Dec: +68 03 43.68 (68.06213d) Equinox: J2000	Epoch of Position: 2015.5	
Comments: Offset star for SPIRITS 18NU LRS Observation *Category=Calibration* *Description=[Target acquisition test]* *Extended=NO*				
(5)	LRS-OFFSET-WISETRANSIENT	RA: 19 09 39.9938 (287.4166408d) Dec: +05 35 8.03 (5.58556d) Equinox: J2000	Epoch of Position: 2015.5	
Comments: Wise Transient bright TA offset star *Category=Calibration* *Description=[Target acquisition test]*				
(6)	NIRSPEC-FS-OFFSET-AT2019ABN	RA: 13 29 40.4987 (202.4187446d) Dec: +47 11 10.15 (47.18615d) Equinox: J2000	Epoch of Position: 2012	
Comments: AT2019abn TA offset star for NIRSpec FS observations *Category=Calibration* *Description=[Target acquisition test]* *Extended=NO*				
(7)	LRS-OFFSET-AT2019ABN	RA: 13 29 41.6073 (202.4233637d) Dec: +47 11 52.61 (47.19795d) Equinox: J2000	Proper Motion RA: 9.666 mas/yr Proper Motion Dec: -12.479 mas/yr Epoch of Position: 2019	
Comments: Offset star for AT2019abn LRS Observation *Category=Calibration* *Description=[Target acquisition test]* *Extended=NO*				

	(8)	AT2019ABN-MIRI-COORDS	RA: 13 29 42.3301 (202.4263754d) Dec: +47 11 16.92 (47.18803d) Equinox: J2000	Epoch of Position: 2019

Comments: AT2019ABN (Coordinates for MIRI LRS based on 2019 Spitzer image)
Category=Star
Description=[Eruptive variables]
Extended=NO

Observation

Proposal 1240, Observation 1: LRS

Thu Dec 01 03:00:32 GMT 2022

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution 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
(8)	AT2019ABN-MIRI-COORDS	RA: 13 29 42.3301 (202.4263754d) Dec: +47 11 16.92 (47.18803d) Equinox: J2000	Epoch of Position: 2019	

Comments: AT2019ABN (Coordinates for MIRI LRS based on 2019 Spitzer image)
Category=Star
Description=[Eruptive variables]
Extended=NO

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	7 LRS-OFFSET-AT2019ABN	F560W	FAST	10	1	1	27.75	131329.13

Template

Subarray	Obtain Verification Image?
FULL	true

Dithers

#	Dither Type	No. Spectral Steps	Spectral Step Offset	No. Spatial Steps	Spatial Step Offset
1	ALONG SLIT NOD				

Pointing Verification

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	FAST	10	1	1	27.75	131329.13

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	140	1	2	1	2	777.011	131329.5

Special Requirements

Target Of Opportunity response time 14 Days

Sequence Observations 1, 2, Non-interruptible

Observation

Proposal 1240, Observation 2: NIRSPEC-FS Thu Dec 01 03:00:32 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRSpec Fixed Slit Spectroscopy

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)	AT2019ABN-NIRSPEC-COORDS	RA: 13 29 42.3903 (202.4266262d) Dec: +47 11 16.64 (47.18796d) Equinox: J2000	Epoch of Position: 2012	

Comments: AT2019ABN (Coordinates for NIRSpec FS based on 2012 HST F110W image)
Category=Star
Description=[Eruptive variables]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	6 NIRSPEC-FS-OFFSET-AT2019ABN	WATA	SUB2048	F110W	NRSRAPIDD6	3	1	1	14.452	131329.12

Template

Slit	Subarray
S200A1	FULL

Dithers

#	Primary Dither Positions	Sub-Pixel Pattern
1	2	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	G395M/F290LP	S200A1	NRSIRS2RAPID	34	1	1	NONE	2	2	1021.222	131329.3

Special Requirements	
	No Parallel Attachments Target Of Opportunity response time 14 Days Sequence Observations 1, 2, Non-interruptible

Observation

Proposal 1240, Observation 3: LRS

Thu Dec 01 03:00:32 GMT 2022

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

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)	WISETRANSIENT	RA: 19 09 39.7825 (287.4157604d) Dec: +05 35 4.27 (5.58452d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: IR transient discovered by WISE and ZTF
Category=Star
Description=[Eruptive variables]

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	5 LRS-OFFSET-WISETRANSIENT	F560W	FAST	4	1	1	11.1	109558.5

Template

Subarray	Obtain Verification Image?
FULL	true

Dithers

#	Dither Type	No. Spectral Steps	Spectral Step Offset	No. Spatial Steps	Spatial Step Offset
1	ALONG SLIT NOD				

Pointing Verification

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	FAST	4	1	1	11.1	109558.5

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	140	1	2	1	2	777.011	

Special Requirements

Target Of Opportunity response time 14 Days

Sequence Observations 3, 4, Non-interruptible

Observation

Proposal 1240, Observation 4: NIRSPEC-FS Thu Dec 01 03:00:32 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRSpec Fixed Slit Spectroscopy

Comments: Special requirement of non-interruptible sequence (Obs 3-4) included to ensure NIRSPEC and MIRI observations are done close in time in case the transient evolves signficantly

Diagnostics

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

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(2)	WISETRANSIENT	RA: 19 09 39.7825 (287.4157604d) Dec: +05 35 4.27 (5.58452d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: IR transient discovered by WISE and ZTF
Category=Star
Description=[Eruptive variables]

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	SAME	WATA	SUB2048	F140X	NRSRAPID	3	1	1	3.628	109558.12

Template

Slit	Subarray
S200A1	FULL

Dithers

#	Primary Dither Positions	Sub-Pixel Pattern
1	2	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	G395H/F290LP	S200A1	NRSIRS2RAPID	28	1	1	NONE	2	2	846.156	

Special Requirements	
	No Parallel Attachments Target Of Opportunity response time 14 Days Sequence Observations 3, 4, Non-interruptible

Observation

Proposal 1240, Observation 5: LRS Thu Dec 01 03:00:32 GMT 2022

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Diagnostics

(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)	SPIRITS18NU	RA: 03 46 45.6034 (56.6900142d) Dec: +68 03 26.88 (68.05747d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: SPIRITS18nu
Category=Star
Description=[Eruptive variables]

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	4 LRS-OFFSET-SPIRITS18NU	F560W	FASTGRPAVG	10	1	1	111.002	109558.13

Template

Subarray	Obtain Verification Image?
FULL	false

Dithers

#	Dither Type	No. Spectral Steps	Spectral Step Offset	No. Spatial Steps	Spatial Step Offset
1	ALONG SLIT NOD				

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	FASTR1	140	1	2	1	2	777.011	

Special Requirements	Target Of Opportunity response time 14 Days Sequence Observations 5, 6, Non-interruptible

Observation

Proposal 1240, Observation 6: NIRSPEC Thu Dec 01 03:00:32 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Comments: Special requirement of non-interruptible sequence (Obs 5-6) included to ensure NIRSPEC and MIRI observations are done close in time in case the transient evolves signficantly

PA restriction range applied such that the NIRSpec MSA Field of View does not fall on the bright nucleus of the host galaxy to cause issues with leakage. The 14 day response may not fall in the restricted PA range, so we would therefore request the observations to be taken when the PA falls within the specified range. Based on the GTVT, this should fall around Sept 9, 2022.

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
(3)	SPIRITS18NU	RA: 03 46 45.6034 (56.6900142d) Dec: +68 03 26.88 (68.05747d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: SPIRITS18nu
Category=Star
Description=[Eruptive variables]

Template

TA Method
NONE

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	LARGE	1	4	

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G395M/F290LP	NRSIRS2RAPID	23	1	false	true	NONE	4	4	1400.533	

Special Requirements

Aperture PA Range 198.97253418 to 28.97253418 Degrees (V3 60.0 to 250.0)
No Parallel Attachments
Target Of Opportunity response time 14 Days

Sequence Observations 5, 6, Non-interruptible