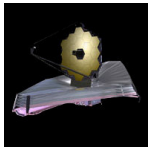

1936 - Nebular Spectroscopy of a Kilonova with JWST

Cycle: 1, Proposal Category: GO

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	Epoch 0	NIRCam Imaging	(1) KILONOVA
	2	Epoch 1	NIRSpec Fixed Slit Spectroscopy	(1) KILONOVA
	3	Epoch 2	NIRSpec Fixed Slit Spectroscopy	(1) KILONOVA
	4	Epoch 3	NIRSpec Fixed Slit Spectroscopy	(1) KILONOVA

ABSTRACT

Gravitational wave and optical/infrared detections of the binary neutron star merger GW170817/AT2017gfo revealed the astrophysical site of heavy element production via rapid neutron capture (the r-process). Emission from a "kilonova" powered by the radioactive decaay of these elements was used to infer the bulk abundances of r-process species and a handful of lighter elements in its outer layers, but we still have no "smoking gun" evidence that any specific heavy elements, especially lanthanides (Z>57), were produced in the ejecta. Moreover, our observations were confined to the earliest stages of kilonova evolution when most of the ejecta were optically thick, obscuring any emission from the inner layers. With only a single well-studied kilonova, there is significant progress to be made once the LIGO/Virgo/KAGRA gravitational wave detectors begin finding new neutron star mergers during their Observing Run 4. Here we propose to use the unique sensitivity and mid-infrared capabilities of JWST/NIRSpec to observe one kilonova at >30 days post-merger over three epochs with non-disruptive triggers. Detailed observations of even a single kilonova would lend new insight into the r-process, enabling us to isolate emission features from specific r-process species (especially Nd) in the "nebular" phase of kilonova evolution when they are mostly transparent to mid-infrared radiation. From these measurements, we will begin to probe the unique physical

conditions and variations in kilonova abundance patterns, taking the next step forward in our understanding of the r-process.

OBSERVING DESCRIPTION

This proposal aims to obtain JWST/NIRSpec spectra of a single kilonova localized from a LIGO/Virgo/Kagra gravitational wave signal during their Observing Run 4, which will start after June, 2022 and last for at least 1 year. We expect there to be 1 target within 150 Mpc and localized within 1 week post-merger. If the target is localized with deep or high-resolution imaging such that we can derive acquisition star offsets to NIRSpec tolerance (100 mas), we will immediately trigger our NIRSpec program. Otherwise, we will trigger a single NIRCam epoch to obtain such imaging and subsequently trigger our NIRSpec program at 3 weeks post-merger. The first epoch is scheduled to begin approximately 5 weeks (30-35 days) post-merger, with two subsequent epochs at 7 weeks (45-55 days) and 11 weeks (75-85 days) post-merger in order to constrain the presence and evolution of any emission features associated with r-process elements.

The main technical limitation is obtaining sufficiently high S/N for faint objects with uncertain background emission to achieve our science goals. We will use the PRISM/CLEAR setup for R~100 spectra (sufficient to isolate emission features at v~0.1c) and FULL+NRSIRS2RAPID readout mode to maximize our S/N. In order to isolate and model any background emission, we will use 3 primary spatial dithers. Our exposure times were chosen to obtain S/N~7-20 per resolution element over the spectrum based on the epoch of observation, our distance threshold, and the range of expected kilonova ejecta masses and composition.

Proposal 1936 - Targets - Nebular Spectroscopy of a Kilonova with JWST

Generic Targets

#	Name	Criteria	Description
(1)	KILONOVA	LIGO/Virgo/Kagra-targeted kilonova discovered <1 week post-merger	
(2)	BRIGHT-STAR	Bright offset star for Target 1	

Observation

Proposal 1936, Observation 1: Epoch 0

Fri Sep 10 19:00:33 GMT 2021

Diagnostic Status: Warning

Observing Template: NIRCam Imaging

Diagnostics

(Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.
(Visit 1:2) Warning (Form): Overheads are provisional until the Visit Planner has been run.
(Visit 1:3) Warning (Form): Overheads are provisional until the Visit Planner has been run.
(Visit 1:4) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Generic Targets

#	Name	Criteria	Description
(1)	KILONOVA	LIGO/Virgo/Kagra-targeted kilonova discovered <1 week post-merger	

Template

Module	Subarray
ALL	FULL

Dithers

#	Primary Dither Type	Primary Dithers	Subpixel Dither Type	Dither Size	Subpixel Positions
1	FULLBOX	8NIRSPEC	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	F200W	F444W	BRIGHT1	9	1	8	8	1460.201	63594.1

Special Requirements

Sequence Visits within 1 Days
Visits Same PA
On Hold On hold for LIGO/Virgo/KAGRA-targeted kilonova target-of-opportunity trigger at 3 weeks post-merger
Target Of Opportunity response time 21 Days

2 After 1 by 14 Days to 21 Days

Observation

Proposal 1936, Observation 2: Epoch 1

Fri Sep 10 19:00:33 GMT 2021

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.

Generic Targets

#	Name	Criteria	Description
(1)	KILONOVA	LIGO/Virgo/Kagra-targeted kilonova discovered <1 week post-merger	

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	2 BRIGHT-STAR	WATA	FULL	CLEAR	NRSRAPID	3	1	1	42.947	61929.6

Template

Slit	Subarray
S200A1	FULL

Dithers

#	Primary Dither Positions	Sub-Pixel Pattern
1	3	SPATIAL

Spectral Elements

#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp	#	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	PRISM/CLEAR	S200A1	NRSIRS2RAPID	40	1	1	NONE	6	6	3588.867	

Special Requirements	
	On Hold On hold for LIGO/Virgo/Kagra-targeted kilonova target-of-opportunity trigger at 5 weeks post-merger 2 After 1 by 14 Days to 21 Days 3 After 2 by 14 Days to 21 Days

Observation

Proposal 1936, Observation 3: Epoch 2

Fri Sep 10 19:00:33 GMT 2021

Diagnostic Status: Warning

Observing Template: NIRSpec Fixed Slit Spectroscopy

Diagnostics

(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Generic Targets

#	Name	Criteria	Description
(1)	KILONOVA	LIGO/Virgo/Kagra-targeted kilonova discovered <1 week post-merger	

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	2 BRIGHT-STAR	WATA	FULL	CLEAR	NRSRAPID	3	1	1	42.947	61929.6

Template

Slit	Subarray
S200A1	FULL

Dithers

#	Primary Dither Positions	Sub-Pixel Pattern
1	3	SPATIAL

Spectral Elements

#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp	#	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	PRISM/CLEAR	S200A1	NRSIRS2RAPID	36	2	1	NONE	6	12	6477.467	

Special Requirements	
	On Hold On hold for LIGO/Virgo/Kagra-targeted kilonova target-of-opportunity trigger at 7 weeks post-merger 3 After 2 by 14 Days to 21 Days 4 After 3 by 28 Days to 35 Days

Observation

Proposal 1936, Observation 4: Epoch 3

Fri Sep 10 19:00:33 GMT 2021

Diagnostic Status: Warning

Observing Template: NIRSpec Fixed Slit Spectroscopy

Diagnostics

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

Generic Targets

#	Name	Criteria	Description
(1)	KILONOVA	LIGO/Virgo/Kagra-targeted kilonova discovered <1 week post-merger	

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	2 BRIGHT-STAR	WATA	FULL	CLEAR	NRSRAPID	3	1	1	42.947	61929.6

Template

Slit	Subarray
S200A1	FULL

Dithers

#	Primary Dither Positions	Sub-Pixel Pattern
1	3	SPATIAL

Spectral Elements

#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp	#	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	PRISM/CLEAR	S200A1	NRSIRS2	8	5	1	NONE	6	30	17944.335	

Special Requirements	
	On Hold On hold for LIGO/Virgo/Kagra-targeted kilonova target-of-opportunity trigger at 11 weeks post-merger 4 After 3 by 28 Days to 35 Days