



9177 - Unmasking a Potential Recoiling Black Hole or Hyperluminous Blue Variable

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>
Observations				
	5	SDSS1133-NIRSpec	NIRSpec IFU Spectroscopy	(1) SDSS1133

ABSTRACT

The coalescence of SMBHs during galaxy mergers produces strong gravitational waves, which can cause a merged black hole to recoil with velocities up to 5000 km/s. Such recoiling black holes, if displaced from the center of their host galaxy, may retain an active accretion disk and broad emission lines, creating a spatially or kinematically offset AGN. Despite their theoretical importance in black hole-galaxy coevolution models, confirmed cases of recoiling black holes are exceedingly rare.

We propose JWST/NIRSPEC observations of SDSS1133, an enigmatic persistent broad line object offset 800 pc a nearby (30 Mpc) dwarf galaxy. SDSS1133 has displayed AGN-like broad emission lines and significant variability 63 years, yet also shows rare P Cygni absorption and narrow Fe II and [Ca II] emission which have led to interpretations as a hyperluminous massive) blue variable undergoing eruptions. However, further, AO

imaging has failed to reveal star forming regions around SDSS1133, challenging the idea of a massive LBV ($M > 100 M_{\text{sun}}$) in a quiescent dwarf galaxy. SDSS1133's X-ray emission is also 4 orders of magnitude brighter than typical LBVs.

We propose JWST/NIRSPEC to search for extended emission or star-forming regions around SDSS1133, associated with a massive LBV star. Alternatively, a lack of extended features would favor the interpretation of SDSS1133 as a recoiling black hole. Either scenario would be groundbreaking and likely common given the small volume SDSS 11133 was found. SDSS1133 could represent an extreme LBV, or a previously undetected population of recoiling SMBHs in dwarf galaxies, with profound implications for future gravitational wave detectors like eLISA.

OBSERVING DESCRIPTION

We propose observations with the NIRSpec IFU. We chose a 4-point dither pattern to obtain sub-pixel sampling to best recover the undersampled PSF for both NIRSPEC. To reduce the chance of contamination of the IFU data by nearby bright sources, we request leakcal observations for both NIRSpec IFU observations of our targets.

We propose observations with the NIRSpec IFU using the high-resolution gratings to cover the 1.66-3.17 μm range and 2.87-5.27 μm . Each of the gratings contains crucial regions to study the recoil. Brackett alpha 4.0 μm (G395, redshifted to 4.43 μm) will enable narrow line measurements in a wavelength regime with even less extinction, though the emission is 4 times weaker than Paschen alpha in Case B recombination. The CO band heads at 2.3-2.5 μm redshifted to the G235 coverage and 2.51-2.73 μm (G235) trace stellar emission. Warm and dense gas around the potential recoil nuclei are traced by warm molecular hydrogen emission (G235, G395). PAH emission is at 3.28 μm (G395). Finally, high-ionization coronal lines (e.g., [Si VI] and [Si IX]) are in both gratings (G235, G395).

We use the NRSIRS2RAPID readout mode, which improves NIRSpec detector noise performance by interspersing reference pixel reads with science pixels and facilitates rejection of cosmic rays as it provides all frames. The 4-point dither will minimize the influence of any open MSA shutters, and the overall leakage signal through the MSA.

Proposal 9177 - Targets - Unmasking a Potential Recoiling Black Hole or Hyperluminous Blue Variable

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	SDSS1133	RA: 11 33 23.9700 (173.3498750d) Dec: +55 04 15.80 (55.07106d) Equinox: J2000		
<i>Comments: We set the pointing based off HST/gaia positions.</i>					
<i>Category=Galaxy</i>					
<i>Description=[Active galactic nuclei, Amorphous Irregular Galaxies, Dwarf galaxies, Markarian galaxies]</i>					

Proposal 9177 - Observation 5 - Unmasking a Potential Recoiling Black Hole or Hyperluminous Blue Variable

Tue Mar 11 23:08:34 GMT 2025

Observation	Proposal 9177, Observation 5: SDSS1133-NIRSpec Diagnostic Status: Warning Observing Template: NIRSpec IFU 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			
	(1)	SDSS1133	RA: 11 33 23.9700 (173.3498750d) Dec: +55 04 15.80 (55.07106d) Equinox: J2000									
	<i>Comments: We set the pointing based off HST/gaia positions.</i> <i>Category=Galaxy</i> <i>Description=[Active galactic nuclei, Amorphous Irregular Galaxies, Dwarf galaxies, Markarian galaxies]</i>											
Template	TA Method						HFF Readout Mode					
	NONE						false					
Dithers	#	Dither Type		Size	Starting Point			Number of Points	Points			
	1	4-POINT-DITHER										
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	G235H/F170LP	NRSIRS2RAPI D	20	1	false	true	NONE	4	4	1225.467	227822
	2	G235H/F170LP	NRSIRS2RAPI D	20	1	true	true	NONE	4	4	1225.467	
	3	G395H/F290LP	NRSIRS2RAPI D	10	1	false	true	NONE	4	4	641.911	227822
	4	G395H/F290LP	NRSIRS2RAPI D	10	1	true	true	NONE	4	4	641.911	