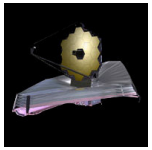

# 1863 - Confirming the First Low-Metallicity Wolf-Rayet Dust Factory

Cycle: 1, Proposal Category: GO

**INVESTIGATORS**

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|---|---|
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**OBSERVATIONS**

| *Folder* | *Observation* | *Label* | *Observing Template* | *Science Target* |
|---|---|---|---|---|
| SPIRITS19q | | | | |
| | 7 | NIRSPEC | NIRSpec IFU Spectroscopy | (4) SPIRITS19Q |

| *Folder* | *Observation* | *Label* | *Observing Template* | *Science Target* |
|---|---|---|---|---|
| | 8 | NIRSPEC-BKGD | NIRSpec IFU Spectroscopy | (5) SPIRITS19Q-BKGD |
| SPIRITS19q | | | | |
| | 9 | NIRSPEC | NIRSpec IFU Spectroscopy | (4) SPIRITS19Q |
| | 10 | NIRSPEC-BKGD | NIRSpec IFU Spectroscopy | (5) SPIRITS19Q-BKGD |

**ABSTRACT**

In our current understanding of dust-forming sources, we cannot account for the observed quantities of dust in local and high-redshift galaxies. Recent studies indicate that the answer to this long-standing mystery may include carbon-rich Wolf-Rayet (WC) stars. Theoretical models predict that WC stars can even be significant sources of dust at sub-solar metallicity, consistent with the lower metallicity environment of galaxies beyond the local Universe. However, there is a dearth of known dust-forming WC binaries at sub-solar metallicity to verify the model predictions.

New results from the Spitzer Space Telescope have identified an IR-luminous outburst named SPIRITS 19q, which exhibited highly efficient dust production likely linked to a dust-formation episode from an extragalactic WC system in the subsolar metallicity outskirts of the nearby galaxy NGC 2403. This tentative link between SPIRITS 19q and the WC star has not yet been confirmed due to the unresolved nature of the luminous stellar cluster coincident with 19q. In this proposal, we request 6.74 hours of spectroscopic imaging observations with the NIRSpec IFU between 0.6 - 5.3 microns at R ~ 100 in order to confirm dust formation from the WC star by spatially resolving and identifying the near-IR (1 - 2 micron) spectroscopic features associated with the WC star and the mid-IR (3 - 5 micron) emission associated with the SPIRITS 19q. Efficient dust-formation from just one WC system can have a significant impact on the ISM, and confirmation of efficient dust formation from this WC star would validate the theoretical models that demonstrate WC stars as significant sources of dust at sub-solar metallicity.

**OBSERVING DESCRIPTION**

We propose a total of 6.74 hours of JWST observations using NIRSpec IFU Spectroscopy with the low-resolution (R ~ 100) PRISM grating in order to detect and spatially resolve the position of the spectroscopically identified WC4 star and the newly formed dust associated with the SPIRITS 19q outburst. The 0.6-5.3 micron wavelength coverage from the NIRSpec PRISM observations is ideal for simultaneously detecting stellar emission from the WC4 star and the thermal dust emission from the SPIRITS~19q outburst. The NIRSpec 3 x 3" field of view is also well-suited for covering the region in NGC 2403 that hosts the WC4 star and SPIRITS~19q. There is a ~0.25" (~4 pc at 3.2 Mpc) offset between the mid-IR centroid of SPIRITS 19q and the bright near-IR core of the host cluster. With the 0.1 x 0.1" spatial element of the NIRSpec IFU, we therefore expect to resolve the position of SPIRITS 19q from the bright cluster core and identify the associated stellar counterpart.

Our requested NIRSpec IFU PRISM observations do not require target acquisition given the IFU FoV; however, we request a pointing verification image with the F110W filter, which will provide a valuable reference image for resolving stars in the IFU observations. The IFU observations will utilize a 4-point dither pattern to improve spatial sampling and mitigate detector/MSA effects such as open MSA shutters. As an additional precaution to correct for MSA leakage, we will take leakage exposures at each dither position with 25% of the science exposure time. Given the extended nature of SPIRITS 19q's host region, we also request a dedicated background observation at a nearby patch of blank sky to reliably measure and subtract the background signal. This background observation uses the exact same exposure parameters as the science observations including the 4-pt dither and the leakage calibration with 25% of the science exposure time.

# Proposal 1863 - Targets - Confirming the First Low-Metallicity Wolf-Rayet Dust Factory

**Fixed Targets**

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (4) | SPIRITS19Q | RA: 07 37 18.2100 (114.3258750d)<br>Dec: +65 33 49.00 (65.56361d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Category=Star*<br>*Description=[Circumstellar dust, WC stars]* | | | | |
| (5) | SPIRITS19Q-BKGD | RA: 07 37 57.6943 (114.4903929d)<br>Dec: +65 38 49.22 (65.64701d)<br>Equinox: J2000 | | |
| *Comments:*<br>*Category=Calibration*<br>*Description=[Telescope/sky background]* | | | | |

## Observation

**Proposal 1863, Observation 7: NIRSPEC** Sat Mar 23 21:00:33 GMT 2024

**Diagnostic Status: Warning**

Observing Template: NIRSpec IFU Spectroscopy

Background Observations:[NIRSPEC-BKGD (Obs 8)]

## Diagnostics

(NIRSPEC (Obs 7)) Warning (Form): A verification image of the target in the IFU using the TA broad-band filter will be acquired. Please note that an image of the target in the science filter can be constructed from the IFU data cube itself, so verification imaging may not be necessary. If neither MSA nor IFU verification imaging is needed, select TA Method = None to omit this imaging.

(NIRSPEC (Obs 7)) Warning (Form): WATA may be a better choice for more accurate placement in the IFU for point-like acquisition targets with positional uncertainty of 0.1 arcsec or less.

(Visit 7:1) Warning (Form): Data Excess over lower threshold

(Visit 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (4) | SPIRITS19Q | RA: 07 37 18.2100 (114.3258750d)<br>Dec: +65 33 49.00 (65.56361d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Star*
*Description=[Circumstellar dust, WC stars]*

## Template

| TA Method |
|---|
| VERIFY_ONLY |

## Dithers

| # | Dither Type | Size | Starting Point | Number of Points | Points |
|---|---|---|---|---|---|
| 1 | 4-POINT-DITHER | | | | |

## Pointing Verification

| # | PV MSA Configuration | Filter | PV Readout Pattern | PV Groups/Int | PV Integrations/Exp | PV Total Dithers | PV Total Integrations | PV Total Exposure Time |
|---|---|---|---|---|---|---|---|---|
| 1 | ALLCLOSED | F110W | NRSIRS2RAPID | 10 | 1 | 1 | 1 | 160.478 |

## 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 | PRISM/CLEAR | NRSIRS2RAPID | 100 | 1 | false | true | NONE | 4 | 4 | 5893.912 | |
| 2 | PRISM/CLEAR | NRSIRS2RAPID | 57 | 1 | true | true | NONE | 4 | 4 | 3384.622 | |

| Special Requirements | |
|---|---|
| | Aperture PA Range 158.97164917 to 288.97164917 Degrees (V3 20.0 to 150.0)<br><br>Sequence Observations 7, 8, Non-interruptible |

## Observation

**Proposal 1863, Observation 8: NIRSPEC-BKGD** Sat Mar 23 21:00:33 GMT 2024

**Diagnostic Status: Warning**

Observing Template: NIRSpec IFU Spectroscopy

Background Observation For: [NIRSPEC (Obs 7)]

## Diagnostics

(NIRSPEC-BKGD (Obs 8)) Warning (Form): A verification image of the target in the IFU using the TA broad-band filter will be acquired. Please note that an image of the target in the science filter can be constructed from the IFU data cube itself, so verification imaging may not be necessary. If neither MSA nor IFU verification imaging is needed, select TA Method = None to omit this imaging.

(NIRSPEC-BKGD (Obs 8)) Warning (Form): WATA may be a better choice for more accurate placement in the IFU for point-like acquisition targets with positional uncertainty of 0.1 arcsec or less.

(Visit 8:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (5) | SPIRITS19Q-BKGD | RA: 07 37 57.6943 (114.4903929d)<br>Dec: +65 38 49.22 (65.64701d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Calibration*
*Description=[Telescope/sky background]*

## Template

| TA Method |
|---|
| VERIFY_ONLY |

## Dithers

| # | Dither Type | Size | Starting Point | Number of Points | Points |
|---|---|---|---|---|---|
| 1 | 4-POINT-DITHER | | | | |

## Pointing Verification

| # | PV MSA Configuration | Filter | PV Readout Pattern | PV Groups/Int | PV Integrations/Exp | PV Total Dithers | PV Total Integrations | PV Total Exposure Time |
|---|---|---|---|---|---|---|---|---|
| 1 | ALLCLOSED | F110W | NRSIRS2RAPID | 10 | 1 | 1 | 1 | 160.478 |

## 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 | PRISM/CLEAR | NRSIRS2RAPID | 100 | 1 | false | true | NONE | 4 | 4 | 5893.912 | |

| Special Requirements | |
|---|---|
| | Aperture PA Range 158.97164917 to 288.97164917 Degrees (V3 20.0 to 150.0)<br><br>Sequence Observations 7, 8, Non-interruptible |

## Observation

**Proposal 1863, Observation 9: NIRSPEC** Sat Mar 23 21:00:34 GMT 2024

**Diagnostic Status: Warning**

Observing Template: NIRSpec IFU Spectroscopy

Background Observations:[NIRSPEC-BKGD (Obs 10)]

## Diagnostics

(NIRSPEC (Obs 9)) Warning (Form): Verification imaging with an ALLOPEN MSA configuration may cause persistence from bright sources in the field of view.

(NIRSPEC (Obs 9)) Warning (Form): WATA may be a better choice for more accurate placement in the IFU for point-like acquisition targets with positional uncertainty of 0.1 arcsec or less.

(Visit 9:1) Warning (Form): Data Excess over lower threshold

(Visit 9:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (4) | SPIRITS19Q | RA: 07 37 18.2100 (114.3258750d)<br>Dec: +65 33 49.00 (65.56361d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Star*
*Description=[Circumstellar dust, WC stars]*

## Template

| TA Method |
|---|
| VERIFY_ONLY |

## Dithers

| # | Dither Type | Size | Starting Point | Number of Points | Points |
|---|---|---|---|---|---|
| 1 | 4-POINT-DITHER | | | | |

## Pointing Verification

| # | PV MSA Configuration | Filter | PV Readout Pattern | PV Groups/Int | PV Integrations/Exp | PV Total Dithers | PV Total Integrations | PV Total Exposure Time |
|---|---|---|---|---|---|---|---|---|
| 1 | ALLOPEN | F110W | NRSIRS2RAPID | 10 | 1 | 1 | 1 | 160.478 |

## 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 | PRISM/CLEAR | NRSIRS2RAPID | 100 | 1 | false | true | NONE | 4 | 4 | 5893.912 | |
| 2 | PRISM/CLEAR | NRSIRS2RAPID | 57 | 1 | true | true | NONE | 4 | 4 | 3384.622 | |

| Special Requirements | |
|---|---|
| | Aperture PA Range 236.97164917 to 236.97164917 Degrees (V3 98.0 to 98.0)<br>Guide Star in Guider 2<br><br>Sequence Observations 9, 10, Non-interruptible |

## Observation

**Proposal 1863, Observation 10: NIRSPEC-BKGD** Sat Mar 23 21:00:34 GMT 2024

**Diagnostic Status: Warning**

Observing Template: NIRSpec IFU Spectroscopy

Background Observation For: [NIRSPEC (Obs 9)]

## Diagnostics

(NIRSPEC-BKGD (Obs 10)) Warning (Form): Verification imaging with an ALLOPEN MSA configuration may cause persistence from bright sources in the field of view.

(NIRSPEC-BKGD (Obs 10)) Warning (Form): WATA may be a better choice for more accurate placement in the IFU for point-like acquisition targets with positional uncertainty of 0.1 arcsec or less.

(Visit 10:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (5) | SPIRITS19Q-BKGD | RA: 07 37 57.6943 (114.4903929d)<br>Dec: +65 38 49.22 (65.64701d)<br>Equinox: J2000 | | |

*Comments:*
*Category=Calibration*
*Description=[Telescope/sky background]*

## Template

| TA Method |
|---|
| VERIFY_ONLY |

## Dithers

| # | Dither Type | Size | Starting Point | Number of Points | Points |
|---|---|---|---|---|---|
| 1 | 4-POINT-DITHER | | | | |

## Pointing Verification

| # | PV MSA Configuration | Filter | PV Readout Pattern | PV Groups/Int | PV Integrations/Exp | PV Total Dithers | PV Total Integrations | PV Total Exposure Time |
|---|---|---|---|---|---|---|---|---|
| 1 | ALLOPEN | F110W | NRSIRS2RAPID | 10 | 1 | 1 | 1 | 160.478 |

## 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 | PRISM/CLEAR | NRSIRS2RAPID | 100 | 1 | false | true | NONE | 4 | 4 | 5893.912 | |

| Special Requirements | |
|---|---|
| | Aperture PA Range 236.97164917 to 236.97164917 Degrees (V3 98.0 to 98.0)<br><br>Sequence Observations 9, 10, Non-interruptible |