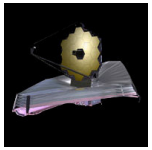

# 2209 - Preparing for planets: the impact of the extraordinary outburst of EX Lup on its circumstellar disk

Cycle: 1, Proposal Category: GO


**INVESTIGATORS**

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**OBSERVATIONS**

| *Folder* | *Observation* | *Label* | *Observing Template* | *Science Target* |
|---|---|---|---|---|
| EX Lup spectroscopy | | | | |
| | 1 | EXLup | MIRI Medium Resolution Spectroscopy | (1) HD-325367 |
| | 2 | EXLup | MIRI Medium Resolution Spectroscopy | (2) HD-325367-BACKGROUND |


**ABSTRACT**

The extraordinary outburst of the young eruptive star EX Lup in 2008 offers currently the best and only opportunity to study quantitatively the effect of a pre-main sequence outburst on the circumstellar disk. Mid-infrared spectroscopic observations during the burst revealed the formation of crystalline silicates, as well as drastic chemical changes in the abundances of gas-phase OH, H2O, and organic molecules. Observations suggest, and simulations make predictions for the outward transport of the fresh crystals and for the timescales and intensity of molecular changes. Here we propose to use JWST/MIRI in medium resolution spectroscopy mode to re-discover the lost crystalline grains 15 years after the outburst. We will

measure their mass, pinpoint the outward transport trajectory, and learn if the crystals could have reached the comet-forming zone behind the snowline, solving the mystery of the measured high crystallinity in solar-system comets. The spectra will also provide unique information on the time-dependent outburst-induced chemistry, and enables us to decide whether molecular reformation leads to long-term cumulative changes in the chemical content of the inner disk. EX Lup is the only target to answer these questions, because precise observations exist for pre-burst, burst, and - with JWST - the post-outburst phases. The project will close the investigation of the 2008 outburst, and provides a quantitative assessment of the effects of similar outbursts, which the proto-Sun also could have experienced, on the chemical and mineralogical inventory of the inner disk where terrestrial planets and comets form.

**OBSERVING DESCRIPTION**

The requested MIRI IFU medium resolution spectroscopy of the young outbursting star EX Lup will utilize all 4 channels, covering the whole available wavelength range between 5 and 28 micrometer. The source is expected to be in quiescent phase at the date of the JWST measurement, thus the pre-outburst high-resolution Spitzer spectrum could be used as input for ETC calculations. In most spectral ranges we require S/N > 300 on the continuum. This number was driven by the >= 3 sigma detectability of the broad forsterite silicate bands in the 20-28 micrometer range even at r>=5 au distance from the Sun (see Fig. 3 of the Science justification). This S/N will also allow us to measure all the key molecules and perform the planned quantitative comparison with the pre-burst and in-burst Spitzer spectra. According to the ETC, we will need 15 groups and 2 integrations per exposure in each Channel/Wavelength range. Three exposures, each of 333 sec, will be needed for a complete wavelength coverage. A 4-point dither pattern will be adopted. The lowest S/N will be 234 (@5 micrometer), the highest is 860 (@17 micrometer). Simultaneous imaging was included to help calibration.

**Fixed Targets**

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | HD-325367 | RA: 16 03 5.4778 (240.7728242d)<br>Dec: -40 18 25.78 (-40.30716d)<br>Equinox: J2000 | Proper Motion RA: -8.825216804433302E-4 sec of time/yr<br>Proper Motion Dec: -0.022536000074069307 arcsec/yr<br>Epoch of Position: 2015.5 | |
| *Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*<br>*Category=Star*<br>*Description=[M dwarfs, Pre-main sequence stars, Protoplanetary disks]*<br>*Extended=NO* | | | | |
| (2) | HD-325367-BACKGROUND | RA: 16 03 12.6281 (240.8026171d)<br>Dec: -40 15 30.42 (-40.25845d)<br>Equinox: J2000 | Epoch of Position: 2015.5 | |
| *Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*<br>*Category=Calibration*<br>*Description=[Telescope/sky background]*<br>*Extended=NO* | | | | |

## Observation

**Proposal 2209, Observation 1: EXLup** Tue Aug 09 13:00:27 GMT 2022

**Diagnostic Status: Warning**

Observing Template: MIRI Medium Resolution Spectroscopy

Background Observations:[EXLup (Obs 2)]

## Diagnostics

(EXLup (Obs 1)) Warning (Form): The science and background exposures are not consistent and may result in non-optimal science output.

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

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | HD-325367 | RA: 16 03 5.4778 (240.7728242d)<br>Dec: -40 18 25.78 (-40.30716d)<br>Equinox: J2000 | Proper Motion RA: -8.825216804433302E-4 sec of time/yr<br>Proper Motion Dec: -0.022536000074069307 arcsec/yr<br>Epoch of Position: 2015.5 | |

*Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*
*Category=Star*
*Description=[M dwarfs, Pre-main sequence stars, Protoplanetary disks]*
*Extended=NO*

## Acquisition

| # | Target |
|---|---|
| 1 | NONE |

## Template

| AcqFilter | Primary Channel | Simultaneous Imaging | Imager Subarray |
|---|---|---|---|
| F1000W | ALL | YES | FULL |

## Dithers

| # | Dither Type | Optimized For | Direction |
|---|---|---|---|
| 1 | 4-Point | POINT SOURCE | NEGATIVE |

## Spectral Elements

| # | Wavelength Range | Detector | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Exposures/Dith | Dither | Total Dithers | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | IMAGER | F1130W | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 1 | SHORT(A) | MRSLONG | | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 1 | SHORT(A) | MRSSHORT | | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 2 | | IMAGER | F1130W | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 2 | MEDIUM(B) | MRSLONG | | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 2 | MEDIUM(B) | MRSSHORT | | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 3 | | IMAGER | F1130W | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 3 | LONG(C) | MRSLONG | | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |
| 3 | LONG(C) | MRSSHORT | | FASTR1 | 15 | 2 | 1 | Dither 1 | 4 | 8 | 344.105 | |

| | |
|---|---|
| **Special Requirements** | Sequence Observations 1, 2, Non-interruptible |

## Observation

**Proposal 2209, Observation 2: EXLup** Tue Aug 09 13:00:27 GMT 2022

**Diagnostic Status: Warning**

Observing Template: MIRI Medium Resolution Spectroscopy

Background Observation For: [EXLup (Obs 1)]

## 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 |
|---|---|---|---|---|
| (2) | HD-325367-BACKGROUND | RA: 16 03 12.6281 (240.8026171d)<br>Dec: -40 15 30.42 (-40.25845d)<br>Equinox: J2000 | Epoch of Position: 2015.5 | |

*Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*
*Category=Calibration*
*Description=[Telescope/sky background]*
*Extended=NO*

## Acquisition

| # | Target |
|---|---|
| 1 | NONE |

## Template

| AcqFilter | Primary Channel | Simultaneous Imaging | Imager Subarray |
|---|---|---|---|
| F1000W | ALL | NO | FULL |

## Spectral Elements

| # | Wavelength Range | Detector | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Exposures/Dith | Dither | Total Dithers | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SHORT(A) | MRSLONG | | FASTR1 | 15 | 1 | 1 | None | 1 | 1 | 41.626 | |
| 1 | SHORT(A) | MRSSHORT | | FASTR1 | 15 | 1 | 1 | None | 1 | 1 | 41.626 | |
| 2 | MEDIUM(B) | MRSLONG | | FASTR1 | 15 | 1 | 1 | None | 1 | 1 | 41.626 | |
| 2 | MEDIUM(B) | MRSSHORT | | FASTR1 | 15 | 1 | 1 | None | 1 | 1 | 41.626 | |
| 3 | LONG(C) | MRSLONG | | FASTR1 | 15 | 1 | 1 | None | 1 | 1 | 41.626 | |
| 3 | LONG(C) | MRSSHORT | | FASTR1 | 15 | 1 | 1 | None | 1 | 1 | 41.626 | |

## Special Requirements

Sequence Observations 1, 2, Non-interruptible