

2757 - Understanding the origin of Boyajian's Star occultations

Cycle: 2, Proposal Category: GTO

INVESTIGATORS

| Name | Institution |
|----------------------------|--|
| Dr. Massimo Stiavelli (PI) | Space Telescope Science Institute |
| Dr. Tabetha Boyajian (CoI) | Louisiana State University and A & M College |
| Dr. Thomas G. Beatty (CoI) | University of Wisconsin - Madison |
| Dr. Jason T Wright (CoI) | The Pennsylvania State University |

OBSERVATIONS

| Folder | Observation | Label | Observing Template | Science Target | | |
|---------|--------------|--------------|----------------------------------|---------------------|--|--|
| Observa | ation Folder | | | | | |
| | 2 NIRSpec | | NIRSpec Fixed Slit Spectroscopy | (1) GSC-03162-00665 | | |
| | 3 | MIRI LRS | MIRI Low Resolution Spectroscopy | (1) GSC-03162-00665 | | |
| | 4 | MIRI Imaging | MIRI Imaging | (1) GSC-03162-00665 | | |

ABSTRACT

KIC 8462852 (Boyajian's Star) displays an extraordinary light curve, showing both deep "dipping" events and long-term changes. We propose observations of this object in the wavelength range 1.7 to 25 microns in order to measure the thermal emission from the circumstellar material causing the observed light curve variations. We will obtain spectra in the 1.66-11 microns wavelength range, and imaging at 15, 18, 20, and 25 microns with orders of magnitude better sensitivity than existing observations. The first goal of these observations is to distinguish among competing models for the star's behavior: a detection would confirm the circumstellar nature of the occulting material; a non-detection would be highly constraining, and motivate further development of alternative models for the star's light curve, such as dense knots of material in the interstellar medium, or an intervening cold disk of a dark object such as a black hole. The second goal of these observations, in the event of a detection, is to determine the temperature and luminosity of the circumstellar dust to better understand this extraordinary object. These observations will be sensitive to any debris disk in the 10th percentile of those around similar old stars. These observations also have a chance of measuring the emission spectrum

JWST Proposal 2757 (Created: Monday, May 8, 2023 at 10:00:27 AM Eastern Standard Time) - Overview

of warm dust during the close passage of the occulting material, allowing it to be conclusively identified and studied via its silicate features. We waive the exclusive access period for these observations.

OBSERVING DESCRIPTION

We will measure the spectral energy distribution (SED) of Boyajian's Star using a combination of NIRSpec and MIRI spectroscopy, and MIRI imaging. For the NIRSpec observations, we will use the S200A1 fixed slit spectroscopic mode on the SUB200A1 subarray with the G235M and G395M dispersers to collect two spectra, covering 1.66um to 5.1um. We will take a sequence of dithered integrations with both dispersers, using a combined set of two primary nods and the ``spectral'' sub-pixel pattern to give the cleanest possible results. For the G235M data we will use two groups per integration and two integrations per exposure, with six total dithered exposures. For the G395M data we will use four groups per integration, and again two integrations per exposure with six dithered exposures.

For the MIRI imaging observations we will take a set of dithered images using the F2100W and F2550W filters and the FULL subarray. Again, the goal with these images is to have the SNR of the stellar flux measurement exceed SNR=100. At F2100W we will use twelve groups per integration and a single integration per exposure. The F2550W images use the less sensitive Channel 4 detector, and so require 18 groups per integration and 20 integrations per exposure to match the F2100W SNR. In both filters we will use a single 4-point dither -- starting at Set 5 to place the images near the center of the subarray -- giving us four dithered exposures in each filter.

Unlike NIRSpec, it is possible for MIRI to acquire the target directly for the spectroscopic observations. We will use the F1000W filter on the full subarray with the FAST readout mode and 4 groups per integration. This will give the TA image a SNR of 380. For the MIRI imaging observations, no target acquisition is necessary, since the blind point of the telescope is sufficient to place Boyajian's Star in the field of view.

Finally, we note that there is a faint companion star to Boyajian's star located approximately 2" away. For the NIRSpec observations this is far enough away that the companion will be outside the S200A1 slit, even if it were aligned exactly along the position angle of the companion. For MIRI imaging we expect the FWHM of the images in both filters to be approximately 0".7 to 0".8, which will allow the two stars to be well separated. The MIRI LRS slit is large enough to also include the companion if it were oriented towards the companion, so for the LRS observations we have included mild orient constraints to ensure this does not happen. These constraints remove approximately three weeks from the seven month visibility window for Boyajian's Star.

We waive the exclusive access period for these observations.

Proposal 2757 - Targets - Understanding the origin of Boyajian's Star occultations

| | # Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous | | | | | |
|-------|---|----------------------------------|--------------------------------------|---------------|--|--|--|--|--|
| | (1) GSC-03162-00665 | RA: 20 06 15.4371 (301.5643212d) | Proper Motion RA: -0.00103748 mas/yr | | | | | | |
| | | Dec: +44 27 24.63 (44.45684d) | Proper Motion Dec: -0.0102731 mas/yr | | | | | | |
|)ts | | Equinox: J2000 | Epoch of Position: 2016.0 | | | | | | |
| Targe | Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. updated RA, DEC, and proper motion from GAIA DR3. Category=Star Description= $[F dwarfs]$ | | | | | | | | |
| ed | (2) 20061592+4427494 | RA: 20 06 15.9237 (301.5663487d) | Proper Motion RA: 0.8728 mas/yr | | | | | | |
| Ě | | Dec: +44 27 49.39 (44.46372d) | Proper Motion Dec: -2.2050 mas/yr | | | | | | |
| _ | | Equinox: J2000 | Epoch of Position: 2016.0 | | | | | | |
| | Comments: This object was generated by the targetselector and retrieved from the 2MASS database. updated coordinates to GAIA DR 3 and added proper motions. Category=Star Description=[M stars] | | | | | | | | |

Proposal 2757 - Observation 2 - Understanding the origin of Boyajian's Star occultations

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| ving Template: NIRSpec Fixe | ed Slit Spectroscop | У | | | | Diagnostic Status: Warning | | | | | | | | | |
| | | | Observing Template: NIRSpec Fixed Slit Spectroscopy | | | | | | | | | | | | |
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| G395M/F290LP | S200A1 | NRSRAPID | 4 | 5 | 2 | NONE | 3 | 15 | 117.157 | 58204 | | | | | |
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| | 2:1) Warning (Form): Overh | Name Targe GSC-03162-00665 RA: 20 Dec: + Equinor corry=Star Equinor iption=[F dwarfs] TA Method 2 20061592+44274 94 WATA A1 Grating/Filter Slit G235M/F170LP S200A1 G395M/F290LP | Name Target Coordinates GSC-03162-00665 RA: 20 06 15.4371 (30) Dec: +44 27 24.63 (44.4) Equinox: J2000 vents: This object was generated by the targetselector and retrieve ory=Star iption=[F dwarfs] 2 WATA Subarray 2 WATA SUB32 20061592+44274 WATA SUB32 N1 Grating/Filter Slit Readout Readout Pattern G235M/F170LP S200A1 NRSRAPID G395M/F290LP S200A1 NRSRAPID NRSRAPID | Name Target Coordinates GSC-03162-00665 RA: 20 06 15.4371 (301.5643212d) Dec: +44 27 24.63 (44.45684d) Equinox: J2000 rents: This object was generated by the targetselector and retrieved from the SIMB: ory=Star piton=[F dwarfs] Target TA Method Subarray Filter 2 WATA SUB32 F110W 20061592+44274 WATA SUB32 F110W 94 94 3 A1 | Name Target Coordinates 7 GSC-03162-00665 RA: 20 06 15.4371 (301.5643212d) I Dec: +44 27 24.63 (44.45684d) I Equinox: J2000 I ents: This object was generated by the targetselector and retrieved from the SIMBAD database. updatory=Star primary Edwarfs1 Target TA Method Subarray Filter Readout 2 WATA SUB32 F110W NRSRAI 21 2 WATA SUB32 F110W NRSRAI 20 Subarray Filter Readout Primary Dither Positions 3 3 3 3 3 | Name Target Coordinates Targ. Coordinates GSC-03162-00665 RA: 20 06 15.4371 (301.5643212d) Proper Mo Dec: +44 27 24.63 (44.45684d) Proper Mo Equinox: J2000 Epoch of P eents: This object was generated by the targetselector and retrieved from the SIMBAD database. updated RA, DI ory=Star ption=[F dwarfs] Target TA Method Subarray Filter Readout Pattern 2 WATA 20061592+44274 WATA SUB32 F110W NRSRAPID 2 Grating/Filter SUBs20 3 Grating/Filter S200A1 NRSRAPID 2 4 4 5 2 200A1 NRSRAPID 4 3 5 | Name Target Coordinates Targ. Coord. Corrections GSC-03162-00665 RA: 20 06 15.4371 (301.56432124) Proper Motion RA: -0.001037. Dec: +44 27 24.63 (44.45684d) Proper Motion RA: -0.001037. Equinox: 12000 Epoch of Position: 2016.0 ents: This object was generated by the targetselector and retrieved from the SIMBAD database. updated RA. DEC, and proper motiony=Star Target TA Method Subarray Filter Readout Pattern Groups/Int 2 WATA SUB32 F110W NRSRAPID 3 2 WATA SUB32 F110W NRSRAPID 3 41 SUBS200A1 SUBS200A1 SUBS200A1 | Name Target Coordinates Targ. Coord. Corrections GSC-03162-00665 RA: 20 06 15.4371 (301.5643212d) Proper Motion RA: -0.00103748 mas/yr Dec: +44 27 24.63 (44.45684d) Proper Motion Dec: -0.0102731 mas/yr Equinox: 12000 Epoch of Position: 2016.0 ents: This object was generated by the targetselector and retrieved from the SIMBAD database. updated RA, DEC, and proper motion from GAIA DR3. prp=3ker prp=7ker pinon: 12000 Epoch of Position: 2016.0 ents: This object was generated by the targetselector and retrieved from the SIMBAD database. updated RA, DEC, and proper motion from GAIA DR3. prp=3ker prp=7ker 20001592+44274 WATA SUB32 F110W NRSRAPID 3 1 20001592+44274 WATA SUB32 F110W NRSRAPID 3 1 94 SUBS200A1 SUBS200A1 SUBS200A1 SUBS200A1 Frimary Dither Positions Sub-Pixel P 3 NONE Gata Mathematical Subarray Primary Dither Positions Sub-Pixel P Gata Mathematical Subarray Gata Mathematical Sub | Name Target Coordinates Targ. Coord. Corrections Miscellaneon GSC-03162-00665 RA: 20 06 15.4371 (301.5643212d) Dec: 44 27 24.63 (44.45684d) Proper Motion RA: -0.00103748 mas/yr Eputon 20100 Epote Motion Dec: -0.0102731 mas/yr Eputon 20100 Epote Motion Dec: -0.0102731 mas/yr ents: This object was generated by the targetselector and retrieved from the SIMBAD database. updated RA, DEC, and proper motion from GAIA DR3. ryr=Star Target TA Method Subarray Filter Readout Pattern Groups/Int Integrations/Ex Total Integrations 2 0061592-44274 WATA SUB32 F110W NRSRAPID 3 1 1 2 0061592-44274 WATA SUB32 F110W NRSRAPID 3 1 1 1 SUBS200A1 SUBS200A1 Sub-Pixel Pattern 3 1 1 2 0355M/F170LP S200A1 NRSRAPID 2 4 1 NONE 3 12 3 S035M/F170LP S200A1 NRSRAPID 4 5 2 NONE 3 12 | Name Target Coordinates Targ. Coord. Corrections Miscellaneous GSC-03162-00665 R.: 20.06 15.4371 (201.5643212d) Proper Motion RA: -0.00103748 mas/yr Dec: +44 27 24.63 (44.45684d) Dec: +44 27 24.63 (44.45684d) Proper Motion RA: -0.00103748 mas/yr Equinos: 12: 000 Equinos: 12: 000 Equinos: 12: 000 Equinos: 12: 000 Target TA Method Subarray Filter Readout Pattern Groups/Int Integrations/Exp Total Exposure 2 00615921:44274 WATA SUB32 F110W NRSRAPID 3 1 1 0.08 2 200615921:44274 WATA SUB32 F110W NRSRAPID 3 1 1 0.08 3 Subarray Subarray Filter Readout Pattern Groups/Int Integrations/Exp Total Exposure 1 SUB32 F110W NRSRAPID 3 1 1 0.08 2 200615921:44274 WATA SUB32 F110W SUBS200A1 1 1 0.08 3 Subarray Subarray Subarray Subarray Subarray Subarray Subarray 1 1 0.08 | | | | | |

Proposal 2757 - Observation 3 - Understanding the origin of Boyajian's Star occultations

| Ľ | Proposal 2757, Observation 3: MIRI LRS | | | | | | | Mon May | 08 15:00:27 GMT 2023 | | |
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| Ĕ | Diagnostic Status: Warning | | | | | | | | | | |
| Ž | Observing Template: MIRI Low Resolution Spectroscopy | | | | | | | | | | |
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| ar | | Dec: +44 27 24.63 (44. | 45684d) | | Proper Motion Dec: | -0.0102731 mas/yr | r | | | | |
| | | Equinox: J2000 | | | Epoch of Position: 2 | 016.0 | | | | | |
| ĕ | Comments: This object was generated by the t | argetselector and retriev | ed from the SIMBA | AD database. upo | lated RA, DEC, and p | roper motion from | GAIA DR3. | | | | |
| iî. | Category=Star Description=IF_dwarfs1 | | | | | | | | | | |
| 2 | # Target | Filter | Readout Patter | n Groups | Int Integ | rations/Exp | Fotal Integrations | Total Exposure Time | ETC Wkbk.Calc ID | | |
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| <u>Prc</u> | <u>posal 2757 - (</u> | Observation 3 · | - Understanding | <u>a the origin of E</u> | <u> Boyajian's Star</u> | occultations | | | |
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| ts | # | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Exposures/Dith | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
| Spectral Elemen | 1 | FASTR1 | 11 | 10 | 20 | 1 | 2 | 660.46 | 58204 |
| Special Requirements | Aperture PA Range 1 Aperture PA Range 29 | 12 to 262 Degrees (V3 1 92 to 82 Degrees (V3 28 | 07.24203 to 257.24203) 7.24203 to 77.24203) | | | | | | |

Proposal 2757 - Observation 4 - Understanding the origin of Boyajian's Star occultations Observation Proposal 2757, Observation 4: MIRI Imaging Mon May 08 15:00:27 GMT 2023 Diagnostic Status: Warning Observing Template: MIRI Imaging Diagnostics Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. Name **Target Coordinates** Targ. Coord. Corrections Miscellaneous **Fixed Targets** GSC-03162-00665 (1)RA: 20 06 15.4371 (301.5643212d) Proper Motion RA: -0.00103748 mas/yr Dec: +44 27 24.63 (44.45684d) Proper Motion Dec: -0.0102731 mas/yr Equinox: J2000 Epoch of Position: 2016.0 Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. updated RA, DEC, and proper motion from GAIA DR3. Category=Star Description=[F dwarfs] Template Subarray FULL Dithers Number of Points Points **Dither Type Starting Point Starting Set** Number of Sets **Optimized For** Direction Pattern Size 2-Point 3 DEFAULT 1 CYCLING 1 4 5 1 DEFAULT Spectral Elements # Filter Readout Pattern Groups/Int Integrations/Exp Exposures/Dith Dither **Total Dithers** Total Total Exposure ETC Wkbk.Calc Integrations ID Time 5 F1500W FASTR1 1 1 Dither 2 4 55.501 58204 4 2 F1800W FASTR1 10 1 1 Dither 2 4 4 111.002 58204 F2100W FASTR1 12 1 1 Dither 2 4 133.202 58204 3 4 F2550W FASTR1 18 20 1 Dither 2 4 80 4206.961 58204