16914 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs
Cycle: 29, Proposal Category: GO
(UV Initiative)
(Availability Mode: SUPPORTED)

INVESTIGATORS

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>E-Mail</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Dr. Joseph M. Mazzarella (Col)</td>
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<tr>
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<td><a href="mailto:hanae@hiroshima-u.ac.jp">hanae@hiroshima-u.ac.jp</a></td>
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Proposal 16914 (STScI Edit Number: 2, Created: Friday, October 28, 2022 at 11:03:00 AM Eastern Standard Time) - Overview
We propose WFC3/UVIS F336W, F438W, and F814W observations for 8 Luminous Infrared Galaxies (LIRGs) in the Great Observatories All-Sky LIRG Survey (GOALS) scheduled for JWST Cycle 1 (GO1) observations. With a proprietary period of 0 days for 50% of the GO1 LIRGs, observations taken now will provide the concurrent WFC3/UVIS imaging necessary to reliably age-date the star clusters detected in these systems. In addition to our science goals these data will be made available for use by the community immediately, ensuring the maximum science return for the inaugural JWST Cycle. Recent HST observations provide evidence that the rate of cluster destruction in the nuclear regions of LIRGs is higher than that in their extranuclear regions, and higher than that observed in normal star-forming galaxies. The combination of HST and JWST NIRSPEC and MIRI IFU observations make possible a complete inventory of the properties of star clusters in the nuclear regions. The HST filters are needed to
break the age-reddening degeneracy, and the JWST IFU observations will detect hydrogen recombination and PAH emission associated with the most embedded nuclear clusters. We will measure key properties such as the fraction of star formation residing in clusters, the nuclear and extranuclear cluster destruction rates, and the cluster formation efficiency. No telescopes other than the combination of HST and JWST are capable of obtaining the deep, high-resolution data required for such a multi-wavelength study of star clusters in LIRGs.

OBSERVING DESCRIPTION

HST images will be obtained using the WFC3/UVIS in imaging mode with the broad-band F336W filter as well as the broad-band F438W and F814W filters for two galaxies (NGC 5135 and ESO 420-G013). For the remaining 6 galaxies the new F336W observations will be paired with our pre-existing ACS/WFC F435W and F814W observations. The ACS/WFC and WFC3/UVIS cameras have comparable fields of view (202"x202" and 162"x162", respectively), and cover sufficient area to enable observations of these LIRGs in a single pointing.

The clusters observed in this sample of LIRGs have $M_V$= -8 to -16 mag and apparent F435W (B) magnitudes typically in the range B ~ 21-25.5 mag. We have made use of instantaneous starburst models from Bruzual & Charlot (2003) to estimate the observed magnitudes in the F336W filter. For a 100 Myr starburst (F336W - F435W = -0.53 mag) and a conservative apparent magnitude of B=25.5 mag, we find that we can reach a signal-to-noise ratio, SNR, of approximately 10 with F336W, F438W, and F814W in roughly 2600, 1300, and 1300 seconds respectively. Note that if the clusters are younger, their spectral energy distributions peak even higher in bluer filters, and are therefore 1-2 magnitudes brighter than described above. Thus, in the absence of dust, the achieved SNR will be significantly higher.

We model our observing strategy based on other studies of star clusters in luminous infrared galaxies (GO 14066 and GO 15472) and use a custom 4-pt dither pattern for each source designed to (1) remove the gap between the chips (1.2 arcsec) (2) sub-sample the PSF (half pixel or a third of a pixel shift have been included if the pattern is a multiple of 2 or 3, respectively), and (3) to remove droplets (shift of 4 arcsec required). The 4-pointing pattern has the following coordinates in arcsec: (0,0), (-3.69,1.31), (-2.5, -2.44), (1.19,-3.75). For the F438W we modify the WFC3-UVIS-GAP-LINE patten to include a third pointing at (0,0). For the F814W we adopt the standard WFC3-UVIS-GAP-LINE pattern. Thus the patterns are (0,0), (-0.092, -1.203), (0.092, 1.203) and (-0.089, -1.203), (0.089, 1.203) respectively.

Further, the main body of the galaxy has been placed at the UVIS2-FIX location (which is more sensitive in the UV, and therefore, optimal to detect clusters), or at the UVIS-FIX location in order to fully map the galaxy if it has very extended tidal features. We use the latter aperture for VV340A, UGC5101, NGC5135, and Mrk 273. Finally, we observe in the ACCUM mode, and include a FLASH of 10 seconds with the CR_SPLIT=NO
The data reduction and calibration of new and archival data will be done using the standard HST pipeline. IRAF, IDL and python will be used for additional data reduction and photometry within metric apertures. The cluster analysis will be done by using Source Extractor to identify clusters and IDL routines to extract aperture measurements of clusters and calculate luminosities. Similar analysis has been done on other F336W, F435W, and F814W datasets (Linden et al. 2017, 2021). Folding in the analysis data at other wavelengths from the Great Observatories All-Sky LIRG Survey (GOALS) will complete the interpretation of the HST dataset.
Proposal 16914 - Visit 01 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

Visit
Proposal 16914, Visit 01, failed
Diagnostic Status: No Diagnostics
Scientific Instruments: WFC3/UVIS
Special Requirements: (none)

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Comments:
Category=GALAXY
Description=INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL

Exposures

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Orbit Structure

Orbit 1

Server Version: 20220630
Proposal 16914 - HOPR1 (Z1) - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

Visit
Proposal 16914, HOPR1 (Z1), completed
Diagnostic Status: No Diagnostics
Scientific Instruments: WFC3/UVIS
Special Requirements: (none)

Fri Oct 28 16:03:00 GMT 2022

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Comments:
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Description=INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL

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### Orbit Structure

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Server Version: 20220630

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Exp. 2
Overhead Pointing Maneuver
Exp. 3
Overhead Pointing Maneuver
Exp. 4
Occultation
Overhead
Unused Orbital Visibility = 0
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**Comments:**

**Category:** GALAXY

**Description:** [INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

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### Exposures

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**Orbit Structure**

![Orbit Structure Diagram](image-url)
### Visit 03 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

**Proposal 16914, Visit 03, completed**

**Diagnostic Status:** No Diagnostics

**Scientific Instruments:** WFC3/UVIS

**Special Requirements:** (none)

#### Fixed Targets

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**Comments:**

Category=GALAXY  
Description=INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL

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**Orbit Structure**

- [GS Aces](#) Exp. 1
- [Overhead](#) Exp. 2
- [Overhead](#) Exp. 3
- [Overhead](#) Exp. 4
- [Occultation](#) Unused Orbital Visibility = 0

**Server Version:** 20220630
Proposal 16914 - Visit 04 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

- **Visit:** Proposal 16914, Visit 04, completed
- **Diagnostic Status:** No Diagnostics
- **Scientific Instruments:** WFC3/UVIS
- **Special Requirements:** (none)

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**Comments:**
- **Category:** GALAXY
- **Description:** [INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

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**Proposal 16914 - Visit 05 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs**

**Visit**
- Proposal 16914, Visit 05, completed
- Diagnostic Status: No Diagnostics
- Scientific Instruments: WFC3/UVIS
- Special Requirements: (none)

**Fixed Targets**

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**Comments:**
- Category=GALAXY
- Description=[INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

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**Orbit Structure**

- Orbit 1
- Overhead Pointing Maneuver
- Unused Orbital Visibility = 0
- Overhead Occultation

**Server Version: 20220630**
Visit 06 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

### Fixed Targets

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- Description=[INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

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**Orbit Structure**

- GS Acq
- Exp. 1
- Exp. 2
- Exp. 3
- Exp. 4
- Overhead
- Pointing Maneuver
- Occultation
- Unused Orbital Visibility = 0

**Server Version:** 20220630
**Proposal 16914 - HOPR 06 (Z6) - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs**

**Visit**
- Proposal 16914, HOPR_06 (Z6)
- Diagnostic Status: No Diagnostics
- Scientific Instruments: WFC3/UVIS
- Special Requirements: (none)

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- Description=[INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

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**Orbit Structure**

[Orbit Diagram]

**Server Version:** 20220630
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- Description=[INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

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**Orbit Structure**

- **Orbit 1**
  - Overhead Pointing Maneuver
  - Unused Orbital Visibility = 0
  - Overhead Pointing Maneuver
  - Unused Orbital Visibility = 0
  - Occultation

---

**Server Version:** 20220630
Proposal 16914 - Visit 08 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

Visit
Proposal 16914 - Visit 08, completed
Diagnostic Status: No Diagnostics
Scientific Instruments: WFC3/UVIS
Special Requirements: (none)

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Description=[INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

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Orbit Structure

Orbit 1

Server Version: 20220630
**Proposal 16914 - Visit 09 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs**

Visit

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Fri Oct 28 16:03:01 GMT 2022

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**Comments:**

*Category=GALAXY  
Description=INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL*

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Proposal 16914 - Visit 09 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

Orbit Structure

Experiment 1
Overhead
Pointing Maneuver
Experiment 2
Overhead
Pointing Maneuver
Experiment 3
Overhead
Pointing Maneuver
Experiment 4
Overhead
Pointing Maneuver
Experiment 5
Occultation
Overhead
Unused Orbital Visibility = 0

Server Version: 20220630
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- **Name:** NGC5135
- **RA:** 13 25 44.0600 (201.4335833d)
- **Dec:** -29 50 1.20 (-29.83367d)
- **Equinox:** J2000

**Comments:**
- **Category:** GALAXY
- **Description:** INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL

**Scientific Instruments:** WFC3/UVIS

**Special Requirements:** (none)

**Diagnostic Status:** No Diagnostics

---

**Proposal 16914 - HOPR9 (Z9) - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs**

- Fri Oct 28 16:03:01 GMT 2022
Proposal 16914 - HOPR9 (Z9) - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs
Proposal 16914 - Visit 10 - In the Belly of the Beast: Star Cluster Formation and Evolution in the Centers of local LIRGs

Visit
Proposal 16914, Visit 10, completed
Diagnostic Status: No Diagnostics
Scientific Instruments: WFC3/UVIS
Special Requirements: (none)

Fixed Targets

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<th>#</th>
<th>Name</th>
<th>Target Coordinates</th>
<th>Targ. Coord. Corrections</th>
<th>Fluxes</th>
<th>Miscellaneous</th>
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Comments:
Category=GALAXY
Description=[INTERACTING GALAXY, STARBURST, ULTRALUMINOUS IR GAL]

Exposures

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<td>ESO420-G013</td>
<td>WFC3/UVIS, ACCUM, UVIS-FIX</td>
<td>F438W</td>
<td>FLASH=20; CR-SPLIT=NO</td>
<td>POS TARG 0.0,0.0</td>
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<td>[==436.0 Secs ]</td>
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<td>F438W</td>
<td>FLASH=20; CR-SPLIT=NO</td>
<td>POS TARG -0.092,-1.203</td>
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