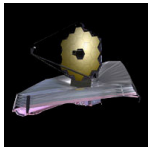

2969 - Distant Sparkles: Are We Seeing Ancient Globular Clusters at Cosmic Noon?

Cycle: 2, Proposal Category: GO

INVESTIGATORS

Name	***Institution***
Lamiya Mowla (PI)	**Wellesley College**
Prof. Roberto G. Abraham (CoI) (CSA Member)	University of Toronto
Kartheik Iyer (CoI) (CoPI) (US Admin CoI) (Contact)	Columbia University in the City of New York
Dr. Chris J. Willott (CoI) (CSA Member)	NRC Herzberg Institute of Astrophysics
Dr. Adam Muzzin (CoI) (CSA Member)	York University
Dr. Marcin Sawicki (CoI) (CSA Member)	St. Mary's University
Dr. Brian Welch (CoI)	University of Maryland
Dr. Dan Coe (CoI) (ESA Member)	Space Telescope Science Institute - ESA - JWST
Dr. Camilla Pacifici (CoI)	Space Telescope Science Institute
Prof. Erica Nelson (CoI)	University of Colorado at Boulder
Dr. Nicholas Martis (CoI)	University of Ljubljana, Dept. of Physics
Dr. Katherine E. Whitaker (CoI)	University of Massachusetts - Amherst
Mr. Obada Ojjeh (CoI) (CSA Member)	University of Toronto
Dr. Gael Noirot (CoI) (CSA Member)	St. Mary's University
Prof. Marusa Bradac (CoI)	University of Ljubljana, Dept. of Physics
Ghassan T Sarrouh (CoI) (CSA Member)	York University
Victoria Strait (CoI) (ESA Member)	University of Copenhagen, Niels Bohr Institute
Dr. Gabriel Brammer (CoI) (ESA Member)	University of Copenhagen, Niels Bohr Institute
Dr. Vicente Estrada-Carpenter (CoI) (CSA Member)	St. Mary's University
Mr. Yoshihisa Asada (CoI) (CSA Member)	St. Mary's University
Guillaume Desprez (CoI) (CSA Member)	St. Mary's University
Dr. Angela Adamo (CoI) (ESA Member)	Stockholm University
Dr. Rachel Bezanson (CoI)	University of Pittsburgh

Name	***Institution***
Dr. Kim McLeod (CoI)	Wellesley College
Dr. Adelaide Marie Claeyssens (CoI) (ESA Member)	Stockholm University
Ms. Leo Yvonne Alcorn (CoI)	Texas A & M University
Dr. Abdurro'uf Abdurro'uf (CoI)	The Johns Hopkins University
Dr. Guillaume Mahler (CoI) (ESA Member)	Universite de Liege
Prof. Massimo Ricotti (CoI)	University of Maryland
Dr. Swara Ravindranath (CoI)	Catholic University of America
Prof. Pieter van Dokkum (CoI)	Yale University
Prof. Karl Glazebrook (CoI)	Swinburne University of Technology
Prof. Eric Gawiser (CoI)	Rutgers the State University of New Jersey
Dr. Duncan A. Forbes (CoI)	Swinburne University of Technology
Prof. Aaron Romanowsky (CoI)	San Jose State Univ. Research Foundation

OBSERVATIONS

Folder	***Observation***	***Label***	***Observing Template***	***Science Target***
Observation Folder				
	1		NIRSpec IFU Spectroscopy	(1) SPARKLER

ABSTRACT

The Sparkler, discovered in Webb's First Deep Field, caught the world's attention with its bright resolved star clusters shining like fireworks. This galaxy at z_spec=1.38 (age of the Universe only 4.7 Gyr) with a magnification of 10-100, gives us a unique opportunity to perform detailed photometry and SED modelling on the resolved sparkles. Contrary to the expectation that these are young, star-forming clusters, detailed star formation history analysis indicates that the sparkles may have formed a scant 500Myr-1Gyr after the Big Bang (Mowla & Iyer et al. 2022, Claeyssens et al. 2022). While this hints that the sparkles may be ancient globular clusters (GCs) at z=1.38 (a use-case previously unimagined with JWST!), their high stellar surface density and metallicity, combined with the the large uncertainties on the sparkles from photometric constraints, make it difficult to rule out the scenario that they may be peculiar dusty young star clusters or ultra-compact satellites.

We propose detailed follow-up observations using NIRSpec IFU PRISM+G140M that are designed to:

(i) confirm that the sparkles are indeed old star clusters,

(ii) precisely determine their physical properties and place them in the context of GC scaling relations, and

(iii) analyze the properties of the host galaxy to determine what makes the Sparkler so unique.

This proof-of-concept will serve as a pathfinder for other high-redshift GC studies that leverage JWST's incredible angular resolution combined with the magnification from massive galaxy clusters.

OBSERVING DESCRIPTION

We propose performing NIRSpec/IFU spectroscopy of the Sparkler galaxy using a combination of CLEAR/PRISM and the G140M/F070LP disperser-filter. We request 3.3 hr in PRISM/CLEAR and 16.3 hr in G140M/F070LP for a total of 19.6 hr of science exposure (24.75 hr with overhead). We will utilize the NRSIRS2 readout pattern as it significantly reduces the correlated 1/f noise, important for obtaining the sky background. For PRISM we will observe with 10 groups of single integration while for G140M we will do 25 groups of 2 integrations. We are utilizing a 16-point MEDIUM CYCLING Dither pattern to have enough dithers to build robust background sky spectra excluding regions containing the main galaxy and sparkles. Most of the galaxy and the sparkles fit inside the IFU FoV, hence we will require a single pointing only. The MEDIUM CYCLING Dither pattern also ensures that all the sparkles have uniform coverage during dithering. To prevent significant leakage through the MSA from bright objects in the field, we are requesting a constraint in the position angle between 140-180 degree. This ensures that the brightest stars and cluster galaxies are behind the solid metal plates of the MSA rather than on the shutter quadrants. We will utilize blind pointing target acquisition which is good to 0.1", good enough to land the galaxy close to the center of the 3"x3" FoV.

The NIRSpec IFU observations will be fit with the public Dense Basis and Bagpipes SED fitting codes to robustly recover their physical properties (stellar mass, star formation rate, dust and metallicity). If their properties are found to be consistent with GC populations observed in the local universe, they will be additionally fit with single stellar population (SSP) models in FSPS to recover their ages. We will leverage the higher S/N continuum obtained from the NIRSpec PRISM (8-20 per resolution element in the rest-optical) to constrain the continuum shape in the lower S/N G140M spectra and gain additional information about the absorption line strengths. This is facilitated by the NRSIRS2 readout pattern, which reduces correlated noise in the spectrum.

SNR estimates for PRISM/CLEAR and G140M/F070LP are computed using the ETC, and are then used to create realistic noisy spectra that are input to the SED fitters to estimate full Bayesian posteriors for the physical properties. We test the effects of fitting just the PRISM and G140M separately, and find that the lower S/N G140M on its own does poorly, although combined with the PRISM it helps break age-metallicity degeneracies to better constrain these properties. In addition, calibrating the continuum of G140M using PRISM will allow for a detailed study of the Ca H-K and Balmer

absorption lines, which is not possible with the low-resolution PRISM alone. Compared to the reported uncertainties in literature from photometry alone, we find that the combination of PRISM+G140M drives posteriors that provide a factor of 2-10x tighter constraints on the physical properties, which is necessary to determine if the sparkles really are GCs, and if they follow the same scaling relations seen in the local universe.

Proposal 2969 - Targets - Distant Sparkles: Are We Seeing Ancient Globular Clusters at Cosmic Noon?

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SPARKLER	RA: 07 23 21.7840 (110.8407667d) Dec: -73 27 18.87 (-73.45524d) Equinox: J2000	Epoch of Position: 2000	

Comments:
Category=Galaxy
Description=[Galaxy disks]
Extended=YES

Observation

Proposal 2969, Observation 1

Thu May 09 18:00:22 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Comments: v3 PA of 140 added for guide stars (vetting done at this PA). old PA range was v3=140-180

Diagnostics

(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)	SPARKLER	RA: 07 23 21.7840 (110.8407667d) Dec: -73 27 18.87 (-73.45524d) Equinox: J2000	Epoch of Position: 2000	

Comments:
Category=Galaxy
Description=[Galaxy disks]
Extended=YES

Template

TA Method
NONE

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	MEDIUM	1	16	

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	G140M/F070LP	NRSIRS2	25	2	false	true	NONE	16	32	58822.404	139813
2	PRISM/CLEAR	NRSIRS2	10	1	false	true	NONE	16	16	11904.534	139813

Special Requirements

Aperture PA Range 278.97164917 to 278.97164917 Degrees (V3 140.0 to 140.0)