# Report on Internship

**Title:** SED fitting the Sparkler galaxy using Bagpipes

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**Institution:** Jashore University of Science and Technology

**Internship Period:** [15.07.2025 – 15.10.2025]

**Supervisor:** Lamiya Mowla

## Introduction:

During this internship, I worked on the **Sparkler Galaxy**, a gravitationally lensed system located behind the massive galaxy cluster SMACS 0723 and observed in the **JWST UNCOVER Survey**.

The main objective was to process multi-filter JWST imaging data, extract photometric measurements, and model the **Spectral Energy Distribution (SED)** using **BAGPIPES** to infer the galaxy's physical properties.

## Work Progress:

### a) Cutout Creation from FITS Files:

I began by downloading **JWST FITS files** in **seven** filters: F090W, F115W, F150W, F200W, F277W, F356W, and F444W. Using Astropy's **Cutout2D** function, I extracted image regions centered on the Sparkler Galaxy from each band. The cutouts were aligned using the World Coordinate System (WCS) to ensure consistency in size and orientation. This step allowed me to isolate the target galaxy from the full survey field, which is essential for precise multi-band analysis.

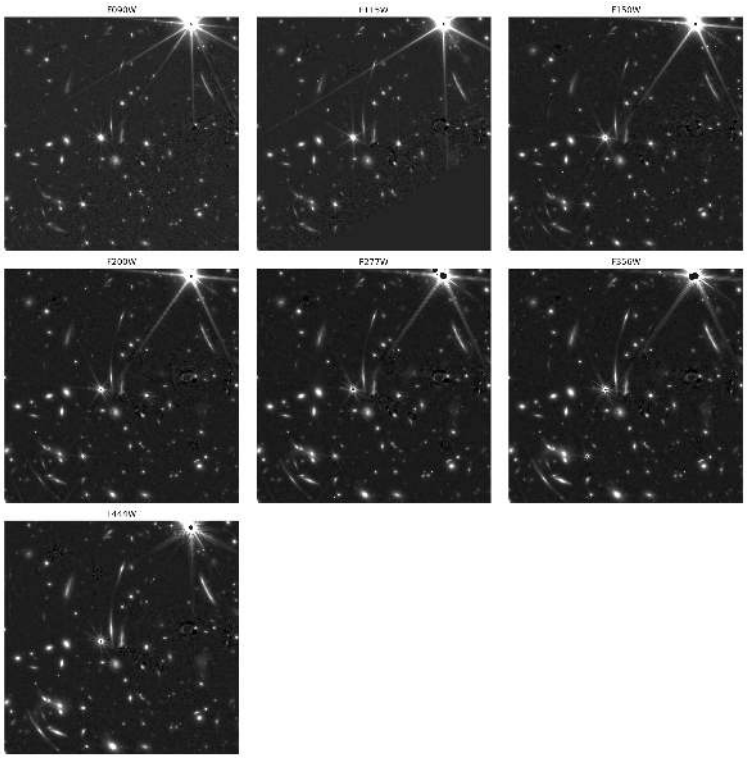

**Fig.1:** Original Fits FIle

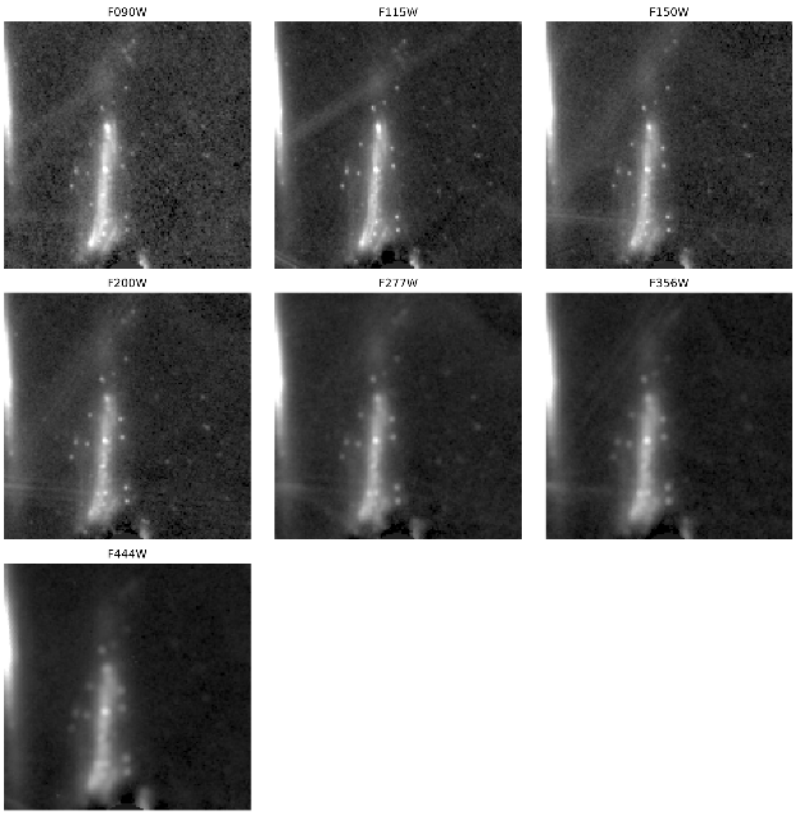


**Fig.2**: Sparkler Cutout

## b) RGB Image Construction:

To visualize the Sparkler Galaxy's structure and color distribution, I created two **RGB composite images** using different wavelength ranges:

- **RGB 1 (Shorter Wavelengths):**
  - R = F200W
  - G = F150W
  - B = F090W

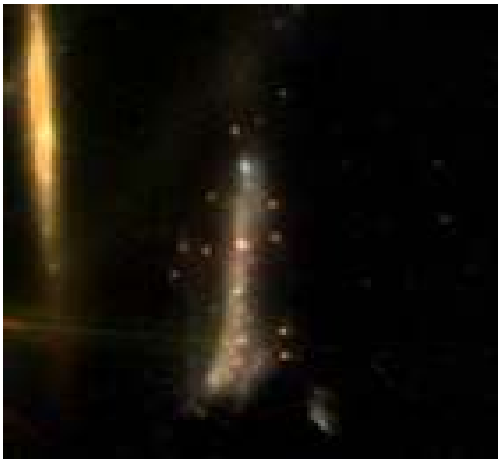

**Fig.3** : RGB 1

- **RGB 2 (Longer Wavelengths):**
  - R = F444W
  - G = F356W
  - B = F277W

**Fig.4**: RGB 2

Each composite was generated using **matplotlib** with the help of **simple_norm** for contrast normalization.

## c) Segmentation and Photometry:

After visualizing the region, I used **Photutils** to perform **segmentation**, identifying the Sparkler Galaxy and its compact neighboring sources.
The **segmentation map** helped separate the main galaxy from surrounding light contamination.
Following this, I conducted **aperture photometry** using **elliptical apertures** positioned on the identified sources.
This step provided **flux measurements** for each JWST filter, forming the dataset necessary for SED modeling.

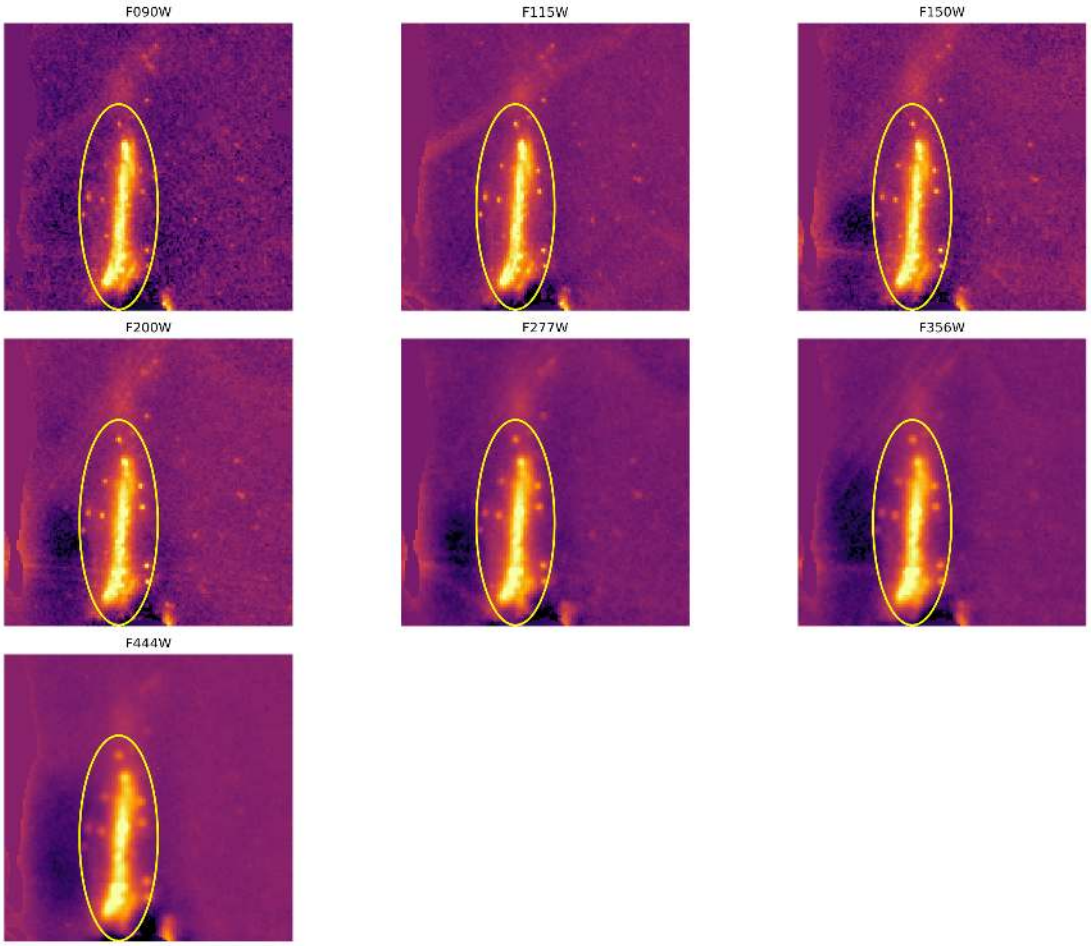


**Fig.5:** Aperture Photometry

## d) SED Fitting with BAGPIPES:

The measured fluxes were then input into **BAGPIPES**, a Bayesian SED fitting code designed to infer galaxy properties.
By modeling the observed photometry, I estimated several key **physical parameters** of the Sparkler Galaxy.

The best-fit model from BAGPIPES showed excellent agreement between the observed and modeled fluxes, validating the accuracy of the photometric data.

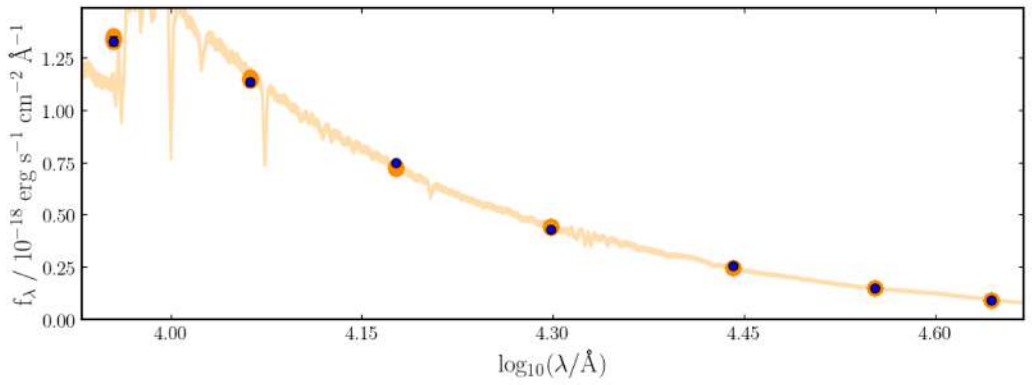


**Fig.6:** Spectrum Posterior (z=1.4)

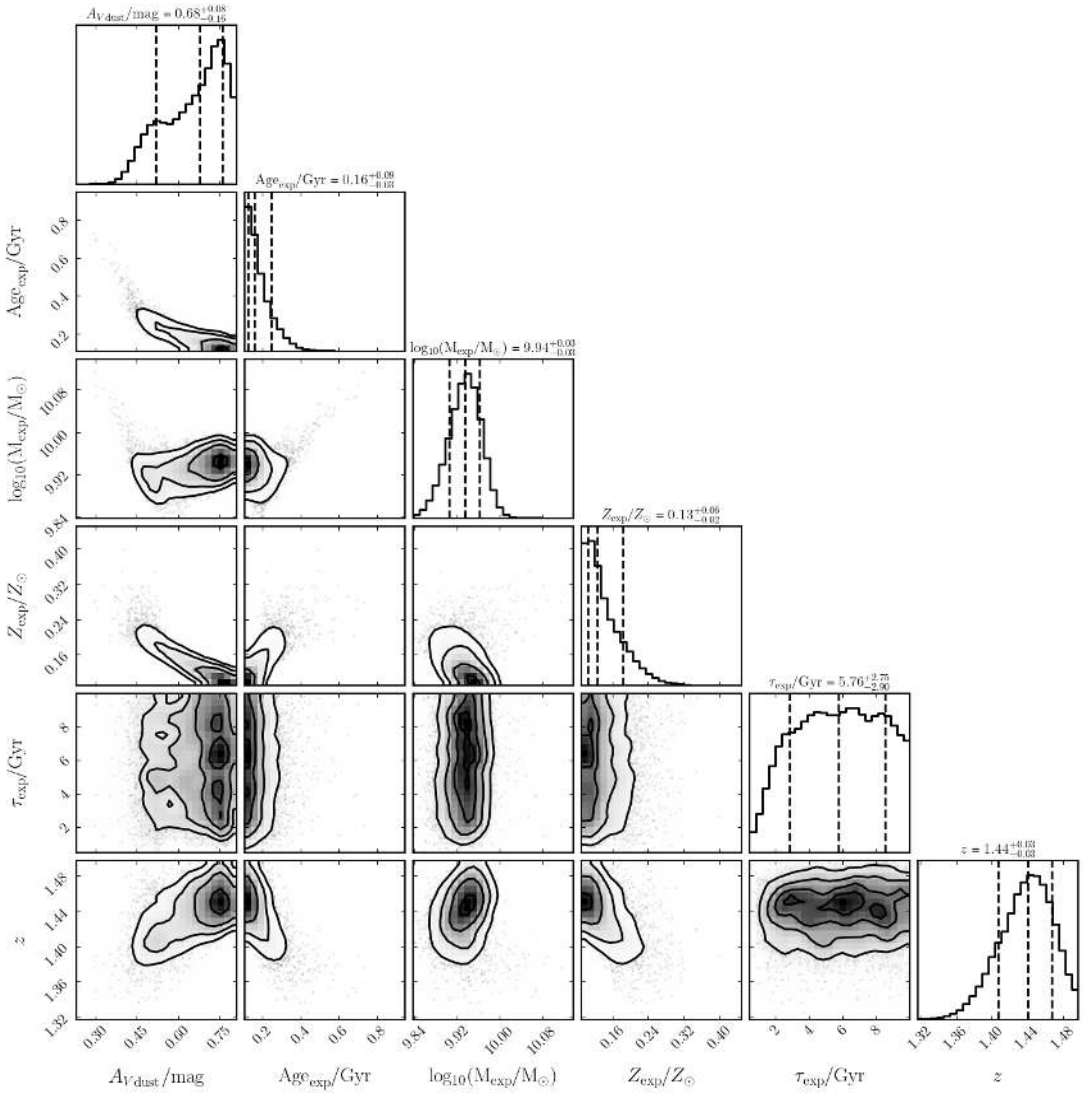


**Fig.7:** Corner Plot (z=1.4)

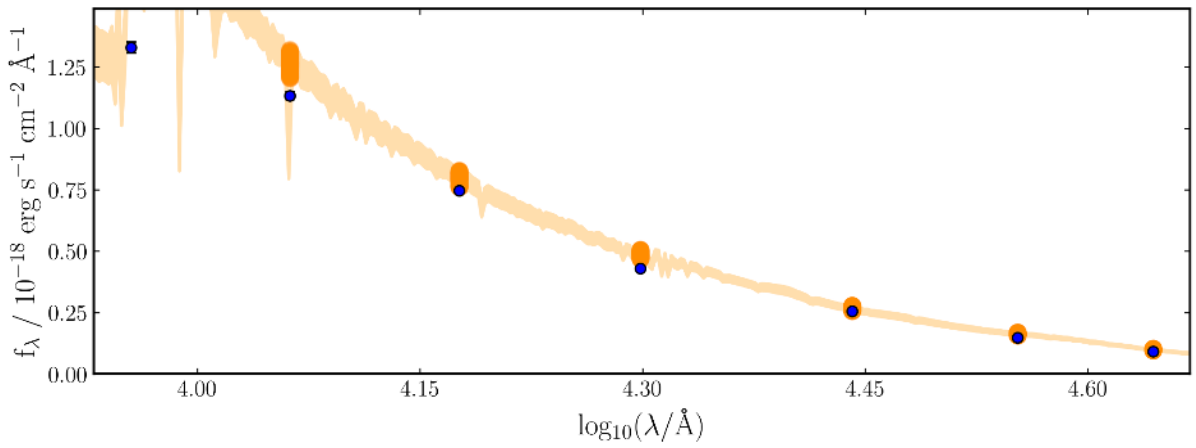


**Fig.8**: Spectrum Posterior (z=1.37)

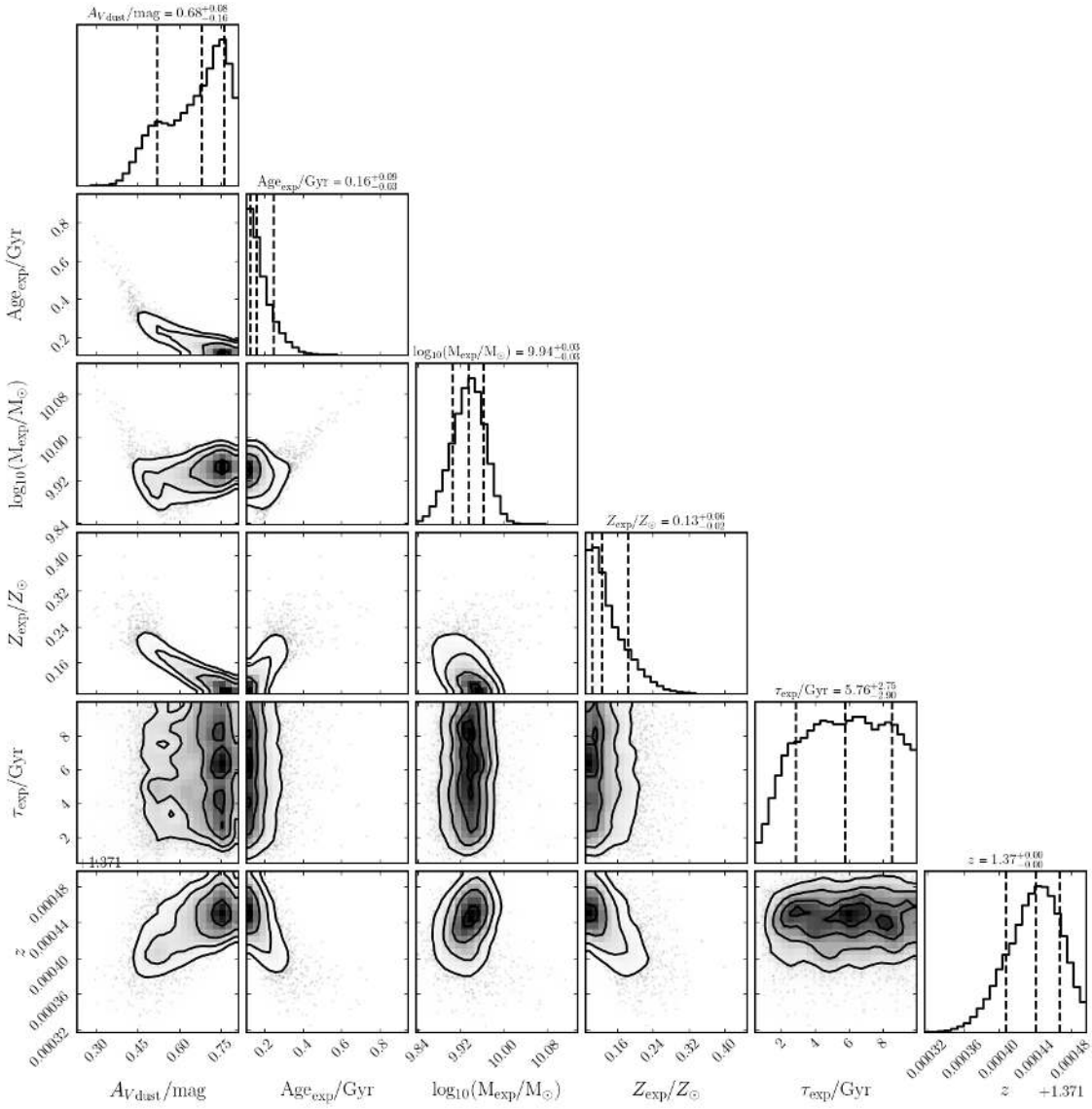


**Fig.9:** Corner Plot (z=1.37)

Figures 7 and 9 show that refining the redshift range from **0–10** to **1.37–1.38** changed the best-fit value from **z = 1.4 ± 0.03** to **z = 1.37 ± 0.00**, while the corner plot remained identical except for the redshift. Both fits yield consistent galaxy properties, close to the literature value **z = 1.378 (https://niriss.github.io/sparkler.html)**, confirming that the **photometry is reliable** and the **stellar parameters are robust.**

## Results and Achievements:

- Successfully generated **cutouts** for the Sparkler Galaxy across seven JWST filters.
- Created **two RGB composite images**, each emphasizing different wavelength ranges.
- Performed **segmentation** to isolate the Sparkler and its nearby star clusters.
- Conducted **multi-band aperture photometry** to measure fluxes accurately.
- Executed **SED fitting using BAGPIPES**, deriving the galaxy's fundamental properties.

# Research Reading:

During this internship, I also explored several **research papers** to better understand the **astrophysical** context of my work.

These readings provided valuable insights into the interpretation of the Sparkler system and how similar studies are conducted using JWST data.

# Reflections:

This project gave me hands-on experience with real JWST data and a complete understanding of the **galaxy analysis pipeline**, from image processing to physical interpretation.
It improved my proficiency in **Astropy**, **Photutils**, and **BAGPIPES**, while deepening my appreciation for how observational data connects to theoretical astrophysics.

Reading research papers alongside practical work helped me understand not just the *how* but also the *why* behind each step — connecting image analysis with physical cosmology.

Overall, the project strengthened my foundation for pursuing **research in observational astrophysics and galaxy evolution**.

## Conclusion:

This internship has been an essential step in developing my research and technical skills in **observational astrophysics**.

By working on the Sparkler galaxy using JWST data, I learned how to collect, analyze, and understand astronomical data.

The project improved my technical skills and gave me a clearer idea of how galaxies form and change over time.

It also made me more confident and motivated to continue studying **galaxy evolution** and **observational astronomy** in the future.

## References:


1. Mowla Astro Group : https://www.mowlaastrogroup.com/
2. Photutils Documentation: https://photutils.readthedocs.io/en/stable/
3. BAGPIPES Documentation: https://bagpipes.readthedocs.io/en/latest/
4. UNCOVER JWST Data Release: https://jwst-uncover.github.io/
5. Astropy: https://learn.astropy.org/

# Approval

The internship report titled “SED fitting the Sparkler galaxy using Bagpipes” submitted by Joyeeta Kundu Aishi, a participant of the ICTP PWF: Physics for Bangladesh Online Summer Internship, has been found satisfactory in partial fulfillment of the requirements of the internship program. The internship was conducted under the supervision of **Lamiya Mowla** during the period **15 July 2025** to **15 October 2025**.

**Supervisor**

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Lamiya Mowla

Wellesley College, MA, USA.