CIGALE: A Python Code Investigating GALaxy Emission

Fitting Spectral Energy Distribution (SED) of Galaxies

What is CIGALE

- A Python code designed for fitting the spectral energy distribution (SED) of galaxies
- **Estimate physical properties** such as star formation rate, attenuation, dust luminosity, stellar mass, and more
- Based on an **energy balance principle**: energy absorbed by dust in UV-optical is re-emitted in mid- and far-infrared
- Utilizes a **Bayesian-like approach** for estimating physical properties by weighting all models based on their goodness-of-fit (likelihood distribution)

Installing CIGALE

- Follow steps from **https://cigale.lam.fr/documentation/**

How it works

1. **PDF analysis mode:**
    a. Used for fitting observed galaxy SEDs
    b. Estimates physical properties from the likelihood distribution
2. **Savefluxes mode:**
    a. Used for simulating model SEDs and saving outputs
    b. Acts as a model-generation tool

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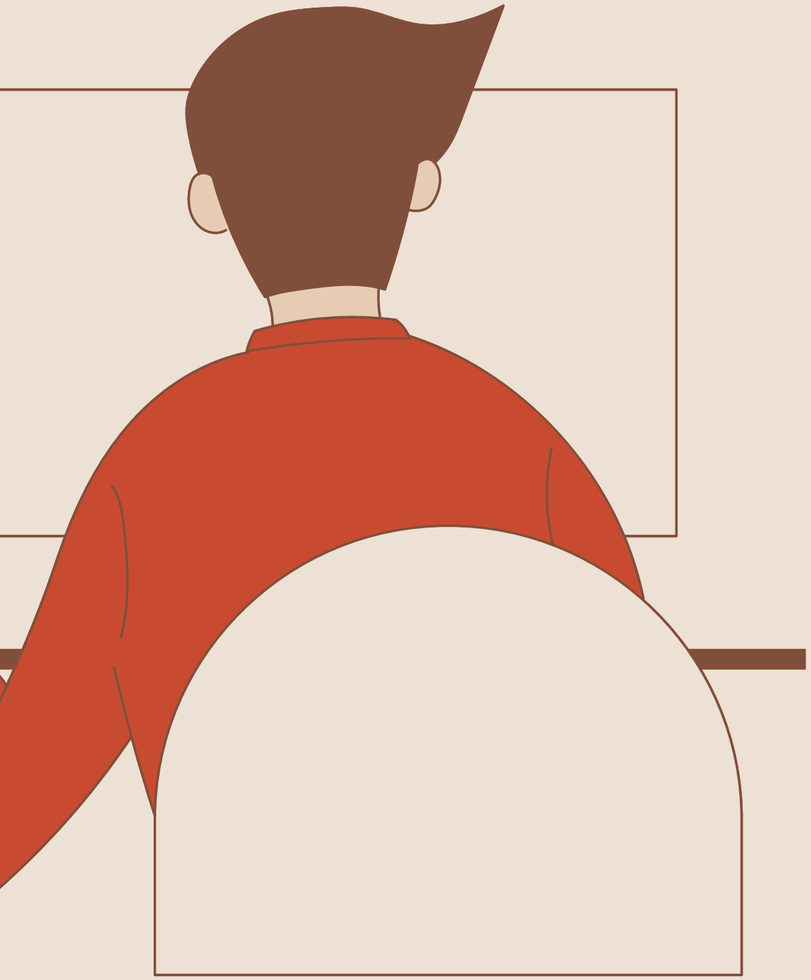
Data Preparation



Input Data Format: An ASCII table

- First Column: Source ID (name for each source)
- Second Column: Redshift information
  - Can be set to **negative** for photometric redshift search.
  - **0** assumes source is at 10 pc
- Optional Column: **"distance"** (in Mpc), inserted after redshift
- Following Columns: Fluxes and 1σ uncertainties
  - Units: **mJy** for photometry or **W m^{-2}** for emission lines
  - Filter names (e.g., "filter1", "filter2") must be in CIGALE database

Managing Filters in CIGALE

List existing filters: Run $ pcigale-filters list

2mass

Filter name	Description	Wavelength
2mass.J	2MASS J	1.24 µm
2mass.H	2MASS H	1.65 µm
2mass.Ks	2MASS Ks	2.16 µm

akari

Filter name	Description	Wavelength
akari.fis.N60	AKARI FIS N60	65.37 µm
akari.fis.WIDE-S	AKARI FIS WIDE-S	85.12 µm
akari.fis.WIDE-L	AKARI FIS WIDE-L	146.43 µm
akari.fis.N160	AKARI FIS N160	161.67 µm
akari.irc.N2	AKARI IRC N2	2.36 µm
akari.irc.N3	AKARI IRC N3	3.22 µm
akari.irc.N4	AKARI IRC N4	4.38 µm
akari.irc.S7	AKARI IRC S7	7.18 µm
akari.irc.S9W	AKARI IRC S9W	8.85 µm
akari.irc.S11	AKARI IRC S11	10.64 µm
akari.irc.L15	AKARI IRC L15	15.80 µm
akari.irc.L18W	AKARI IRC L18W	18.92 µm
akari.irc.L24	AKARI IRC L24	23.12 µm

astrosat

Filter name	Description	Wavelength
astrosat.uvit.F148Wa	Astrosat UVIT F148Wa	149.70 nm
astrosat.uvit.F148W	Astrosat UVIT F148W	149.92 nm
astrosat.uvit.F154W	Astrosat UVIT F154W	155.21 nm
astrosat.uvit.F169M	Astrosat UVIT F169M	160.09 nm
astrosat.uvit.F172M	Astrosat UVIT F172M	171.83 nm
astrosat.uvit.N219M	Astrosat UVIT N219M	219.30 nm
astrosat.uvit.N242W	Astrosat UVIT N242W	241.44 nm
astrosat.uvit.N245M	Astrosat UVIT N245M	244.75 nm
astrosat.uvit.N263M	Astrosat UVIT N263M	263.59 nm
astrosat.uvit.N279N	Astrosat UVIT N279N	279.21 nm
astrosat.uvit.VIS1	Astrosat UVIT VIS1	347.46 nm
astrosat.uvit.VIS2	Astrosat UVIT VIS2	390.58 nm
astrosat.uvit.BK7	Astrosat UVIT BK7	426.49 nm
astrosat.uvit.ND1	Astrosat UVIT ND1	448.85 nm
astrosat.uvit.VIS3	Astrosat UVIT VIS3	457.43 nm

If your filter is not in the database, create your filter.

- ASCII file format: filter name, filter type ("energy" or "photon"), comments, then "wavelength (Å)" and "transmission"
  - https://svo2.cab.inta-csic.es/svo/theory/fps/index.php?id=Misc/Atlas.orange
- Run $ pcigale-filters add filter file

```
# filter_name # photon /energy
9720.00 -0.0018
9726.43 -0.0001
9732.86 0.0016
9739.30 0.0033
9745.73 0.0034
9752.16 0.0034
9758.59 0.0034
```

Handling Fluxes and Errors

Errors:

- Normal data (error > 0, flux is finite)
- Upper-limit data (error < 0)

Fluxes

- All in mJy

```
# id redshift jwst.nircam.F115W jwst.nircam.F150W jwst.nircam.F200W jwst.nircam.F277W jwst.nircam.F356W jwst.nircam.F444W
jwst.nircam.F115W_err jwst.nircam.F150W_err jwst.nircam.F200W_err jwst.nircam.F277W_err jwst.nircam.F356W_err jwst.nircam.F444W_err
DSFG 4.5 4.374253038264284e-05 7.589482370023663e-05 0.00013988261985275083 0.0003831573401101504 0.000601443057963482
0.0006857610312742817 4.317936237040474e-05 2.7421899677590904e-05 2.397274208669328e-05 1.0233291303884342e-05
7.0031416053929555e-06 1.1165237143733084e-05
O3N1 4.5 1.7778200569693207e-05 5.118906869766822e-05 8.328118653013783e-05 0.00018969445015978032 0.0002618099449567084
0.000299176022687462 8 3.713741533090594e-05 2.3584842887516297e-05 2.0618314644322344e-05 8.801380300487715e-06
6.023214891169496e-06 9.602922005144627e-06
O3S1 4.5 0.00031189160777612084 0.00029716665060479624 0.00029908382334424533 0.000417034387644465 0.0003260482402296819
0.00024411779741500295 4.2658661953985865e-05 2.709121868099275e-05 2.3683654520272914e-05 1.0109887928967431e-05
6.9186906420163436e-06 1.1030595423452794e-05
O3S2 4.5 0.0002309151747937967 0.00023907789258181288 0.00021024498777226662 0.000310067325037359 0.0002565698752134810 6
0.00015887542773032916 5.3959413483905714e-05 3.4267982248655855e-05 2.9957716640241952e-05 1.2788109097831865e-05
8.751528341945721e-06 1.3952722194376133e-05
O3N2 4.5 4.925736125162935e-05 2.040540735945251 4e-05 2.1709162283489576e-05 7.514165057604021e-05 7.068190519829848e-05
4.042255964196901e-05 4.280807979133921e-05 2.7186109404732442e-05 2.3766609781337128e-05 1.0145299203513747e-05
6.942924308655069e-06 1.1069231602774824e-05
O3S3 4.5 5.285587607016261e-05 8.46915263985466e-05 0.00012472996878374338 0.0004255508745516 6044 0.0001961760276598916 3
6.13844138317255e-05 4.280807979133921e-05 2.7186109404732442e-05 2.3766609781337128e-05 1.0145299203513747e-05
6.942924308655069e-06 1.1069231602774824e-05
O3S4 4.5 5.69229823510091e-05 7.369145336642597e-05 7.681467242296398e-05 0.0001559666630882828 0.0002170629572160301 4
0.0002220939662990219 4.273343617781108e-05 2.7138705516176083e-05 2.3725168407558177e-05 1.0127609043231724e-05
6.930818066997502e-06 1.104993039959453e-05
O3N3 4.5 2.5627373046097482e-05 2.939347923999513e-05 3.723885918339912e-05 8.642720763771108e-05 8.135913596883862e-05
3.9893641147838806e-05 4.2882593476610954e-05 2.7233430779805126e-05 2.380797902027181e-05 1.0162958571453701e-05
6.95500947760734e-06 1.108849920935446e-05
O3N4 4.5 3.458565865576932e-05 2.2854761774870484e-05 1.574337453588918e-05 0.00010079786457423187 8.950900162132899e-05
3.585451307744144e-05 4.3105361694992345e-05 2.7374904099475938e-05 2.393165766560608e-05 1.0215753516696026e-05
6.991139640093834e-06 1.1146102190264151e-05
O3N5 4.5 0.00013714054383611376 0.00018140077100954407 0.00030452656319043055 0.0009226434065895858 0.000646842895583914
0.0003751644316903824 3.609108038223382e-05 2.292034738743198e-05 2.0037400140637995e-05 8.553404190063825e-06
```

Running CIGALE

First Step:

$pcigale init

This creates a file in which you must complete some parameters

data_file = file_name.txt

sed_modules = desired modules (full list in file), example: sfhdelayed, bc03, nebular, dale2014

analysis_method = pdf_analysis (Used for fitting observed galaxy SEDs)/savefluxes (Used for simulating model SEDs)

cores = Number of CPU cores to use in parallel

Running CIGALE

Second Step:

$pcigale genconf

pcigale.init file changes

[sed_modules_params] : change according to observed galaxies

save_best_sed = True

save_chi2 = 'all'/'none'/'properties'/'fluxes'

Third Step:

$pcigale run

Outputs

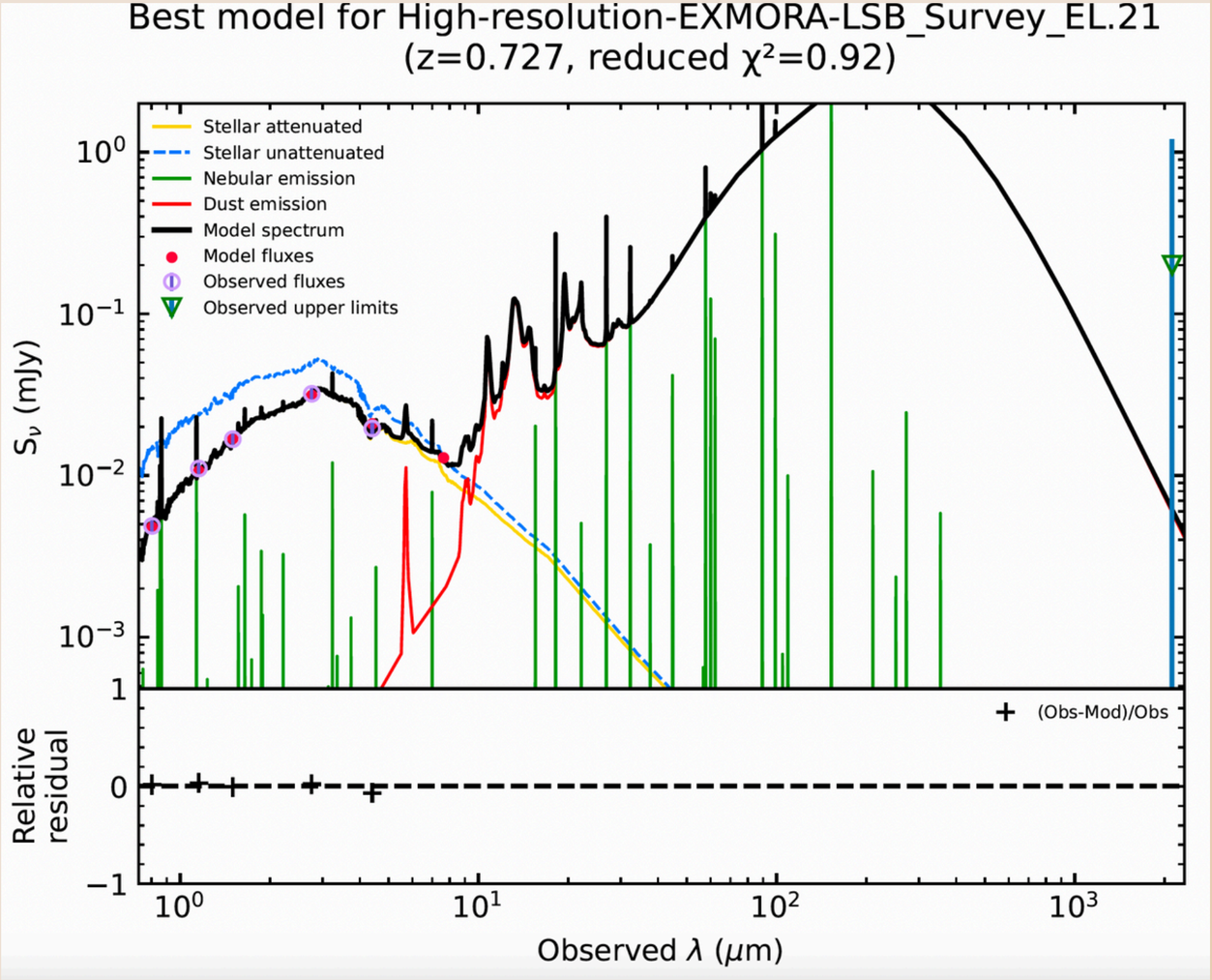
An output folder (out) will be created it will contain

- Results.fits : parameters
- objectXX_best_model.fits

To obtain PDF images of the posteriors and SEDs run:

$ pcigale-plots sed –nologo

$ pcigale-plots pdf



Thank you for listening!