Mock Spectra Generation - 2021

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i) Install the CIGALE-BPT version (https://gitlab.lam.fr/cigale/cigale/-/tree/cigale-BPT). This version has new parameters inside the nebular module as the gas-phase metallicity and electron density. The parameters can be set by the user.

ii) Install CIGALE with the high-resolution BC03 library. They can be activated when building the database by adding `--bc03res=hr` to the build command. In that case, the low-resolution models are not built. (Médéric Boquien)

iii) Once installed, objects can be analyzed in a regular way. The strategy is to divide the sample into redshift bins to be able to fit objects in a more efficient way as the SFH parameters can change a lot in the range z~0-1, while they are more similar for z>1.

iv) A first fit is needed to compute the physical parameters in particular the star-formation rate and the stellar mass which will be used along with the Curtis+2020 relation to obtaining the gas-phase metallicity. (see, https://ui.adsabs.harvard.edu/abs/2017MNRAS.465.1384C/abstract and https://ui.adsabs.harvard.edu/abs/2020MNRAS.491..944C/abstract)

v) The ionization parameter has to be also constrained as there is only photometry involved in the SED fitting process. The analytical relation of Carton+2017 can be used as it relates the ionization parameters to the gas-phase metallicity obtained in iv). However, a more robust estimation could be needed to perform for example using the diagram of Pérez-Montero+2014 (Fig. 3) performing a Monte-Carlo analysis and choosing the good ionization parameter for each object to be fitted with CIGALE. (see, https://ui.adsabs.harvard.edu/abs/2017MNRAS.468.2140C/abstract and https://ui.adsabs.harvard.edu/abs/2014MNRAS.441.2663P/abstract)

vi) The idea is to produce only continuum and continuum+lines spectra. The continuum is useful for some teams which will use them to put emission lines with outflows on top of the continuum emission using their own recipes. The continuum+lines is useful to test the different codes used for the redshift estimation, spectral line fitting, and abundance estimations. Continuum spectra are mostly used by the AGN teams and Alice Concas. She is the direct person to talk to for the modeling in case she needs something specific.

vii) Once the spectra are retrieved by CIGALE they need to be converted to 1D-spectra useful for the ETC, and the different MOONS simulators. A priori, we can distribute the “raw” spectra produced by CIGALE so anyone can use them and produce their own 1D-Spectra depending on the characteristics of different instruments. However, for the specific case of MOONS, I created some routines which are useful to do this work taking into account the file structure accepted by the ETC and the interpolation needed to put everything at the same level of resolution required by MOONS.

The routines can be found in: https://github.com/Jurgenvilla/MOONS. They have been distributed in different emails to Vivienne Wild and Myriam Rodrigues.

viii) The 1D-Spectra are distributed to the TG-WG7 which is the main group I was working with. The main people to contact are Vivienne Wild, Lucia Pozzetti, and Adam Carnall. I also worked with Myriam Rodrigues and Adam Carnall as part of the C-WG1. This was more for the ETC and the code itself, correcting bugs, coding, and specifying parameters to be set between the modeling with CIGALE and the actual structure of the MOONS ETC and simulators in general. The main person here is Myriam Rodrigues.

FMOS-COSMOS sample (2508 objects)

A smaller sample not including all the objects of the COSMOS2015 catalog of Laigle+2016 was used to test the performance of CIGALE in reproducing SFR and stellar mass. Some analysis is presented in my Ph.D. thesis manuscript (see, http://www.theses.fr/s210961).

The attenuation law used is Calzetti-like because we wanted to be as close as possible to the recipes used by the Laigle team and check that CIGALE can derive more robust estimations than what they obtained. I fitted the UV-to-MIR photometry and checked that indeed CIGALE performs well and that we can expand the results to a larger sample. The first mock spectra which can be provided to the group are based on this sample because it is easier to run in a specific redshift bin, so the only subdivision is in gas-phase metallicity. Also, because for most of the sources we have emission line information which can be useful to obtain the SFR and compare or even to fit along with the photometry as we did for my thesis.

COSMOS-field entire catalog (COSMOS2015 or COSMOS2021)

The idea of using COSMOS2021 new photometric data for the COSMOS field was ruled out by the team as some people made comparisons and found weird results for the passive galaxies. The complete and technical report can be found in the VLT-MOONS wiki.

To fit the COSMOS2015 field in its totality:

i) Divide the sample into redshift bins
ii) Set the parameters for the SFH according to the redshift bins and fit the photometry
iii) Once the SFR and stellar mass are estimated, use them to compute either the gas-phase metallicity or the gas-phase metallicity and the ionization parameter.
iv) Re-fit again the photometry setting the electron density, the gas-phase metallicity, and the ionization parameter in the nebular module.
v) In step iv) either create only continuum or continuum+lines spectra. These are the files distributed in the database.

Extra-steps for MOONS:
vi) Each redshift bin file needs to be passed through the 1D-Spectra code. It takes time because the files need to be interpolated to have a homogeneous resolution across a large wavelength range. The wavelength range can be reduced as well as the number of points inside CIGALE to create the emission lines. This was set to 400 points but must be reduced to 20. In the regular version of CIGALE, this is set to 5 points.

vii) These files are distributed to the MOONS teams to test simulators and ETC.

Notes

The attenuation law used for the first models was only to test the same setup as in Laigle+2016. However, to be consistent with my thesis work, and taking into account that in the FMOS-COSMOS sample emission lines are detected we prefer to use the Charlot & Fall+2000 recipe which is more flexible and in case of using emission-lines inside CIGALe will retrieve more accurate results than a simplified Calzetti+2000-like curve.

Along with the photometry, the emission lines need to be included inside the file to be passed to CIGALE. There is a code that I use to include these lines. Names need to match the name of each line inside the nebular module. The error also needs to be included. As they are to be retrieved by CIGALE they won't be fitted as a -9999.99 is included in each column. There is a fake galaxy which is a duplicate of an object at the end of the file with values different from -9999.99 to allow CIGALE to use the line emission information, which is fake but to be able to retrieve values in the output file.

At my home directory on VULCAIN

cigale_bpt → Is the CIGALE directory to install CIGALE with the new updated models of Patrice. Use it to fit data. Remember to install the High-Resolution BC03 models. It should also have the sampling of 31 points for the emission lines and the vacuum correction for the continuum to match the wavelengths of the emission lines.

cigale_bpt_moons → It was used to create models with CIGALE not based on observations. It was fake modeling. I cutted the models of Patrice to include only 26 emission lines useful for the modeling otherwise you get all the info from the database.
It's better to always use the version from above as this one is created to match all the requirements of MOONS and to fit real data and produce spectra in the good shape for the general catalog and for the MOONS project.

I leave some data in /mnt/pdg-space/jvilla for Kasia and Patrice.
The COSMOS2015_mocks is for Kasia and the MOONS_mocks is for Patrice. All the data to fit with CIGALE is inside as well as the notebook and README files. The same information is found on the Github repository.

IMPORTANT: Remember that to convert the SSP models to vacuum we used inside CIGALE the Ciddor+96 strategy.

In cigale/database_builder/___init___.py we included the modification at the beginning

```
# Wavelengths above 2000A are transformed from Air to Vacuum.
wvl_l_vac = wavelength[wavelength < 2000]
wvl_u_air = wavelength[wavelength >= 2000]

# Constants in [(10-6 m)**-2] from Ciddor 1996,
# Applied Optics, Vol. 35, Issue 9, pp. 1566-1573.
k0 = 238.0185
k1 = 5792105.0
k2 = 57.362
k3 = 167917.0

sigma2 = (1.0e4/wvl_u_air)**2
nas    = (k1/(k0 - sigma2) + k3/(k2 - sigma2)) / 1.0e8 + 1.0

wvl_u_vac = wvl_u_air * nas

wavelength = np.concatenate([wvl_l_vac, wvl_u_vac])
```

This is not included in cigale_bpt which is the version I use for my paper to be consistent with the last release of CIGALE. This is included in cigale_bpt_moons. Always use cigale_bpt_moons to fit the COSMOS data because it is the version tailor-made for them.

The cigale_moons version was only created to reduce the number of lines and be able to crate fake data but this is not needed as the idea is to fit real data so one just needs to create a file with columns for the lines one wants to fit. The files I created have these 26 emission lines. Check the notebooks for their generation.