example_run_starlight_and_ifscube

October 30, 2025

1 Running Starlight and IFSCube

This notebook was created as a **step-by-step example** of how to run a full workflow using STARLIGHT and IFSCube.
The goal is to demonstrate, in a reproducible way, how to load input data, perform spectral fitting, and visualize the results.

The workflow covered here includes: 1. Preparing the input spectra. 2. Running STARLIGHT for stellar population synthesis and spectral fitting. 3. Processing the results with IFSCube. 4. Visualizing the results.

This notebook is intended both as a **hands-on tutorial** and as a **quick reference** for future projects.

```python
[1]: import os
import subprocess
import numpy as np
import pandas as pd
from pathlib import Path
from spectools import specutils,spectrum_io
import matplotlib.pyplot as plt


# Define your own figure configuration here
font = 12
plt.rcParams.update({
    'font.family': 'DejaVu Sans',  # ou Helvetica se estiver instalada
    'text.usetex': True,
    'font.size': font,
    'axes.titlesize': font,
    'axes.labelsize': font,
    'xtick.labelsize': font,
    'ytick.labelsize': font,
    'legend.fontsize': font,
    'figure.titlesize': font,
    'font.sans-serif': ['Helvetica']
})
```

Defining all the workflow directories:

```
[2]: base_dir = Path.cwd().parent    # pega o diretório onde o notebook está rodando
     data_dir = base_dir / "data/A194/"

     library_dir = base_dir / "data/STARLIGHTv04/CB19CSFBasesDir/"
     mask_dir = base_dir / "data/STARLIGHTv04/"
     starlight_dir = base_dir / "data/STARLIGHTv04/"
```

Generating a list of all spectra in '.txt' format in **data_dir** that will be processed with Starlight.

```
[3]: galaxies  = [f for f in os.listdir(data_dir) if '.txt' in f]
```

1.1 Creating the input file for Starlight fitting

Starlight only runs inside the STARLIGHTv04 directory, where the executable is located.

That's why the **data_directory** needs to be defined in that way. Inside the next step, where you actually run Starlight, the running occours inside the **starlight_dir** defined above.

```
[4]: conf_file = specutils.create_starlight_input_file(
         data_directory = './../A194/',
         list_galaxies = galaxies,
         n_files = 3,
         library = 'CB19_16x5')

     conf_path = mask_dir / "config.in"

     with open(conf_path, "w") as f:
         f.write(conf_file)
```

1.2 Running Starlight...

```
[5]: specutils.run_starlight(starlight_dir)
```


    **> Welcome to STARLIGHT (v04) & good luck with this run!

    **> Read config file: StCv04.C11.config
    **> Read data file: spec-1079-52621-0424.txt
        from dir = ./CB19CSFB
        Data goes from: 3734.0 -->   9049.0 Angs with N = 5316 pixels
    **> ATT: Defined error & flag spectra the old way! S/N =   11.145
      [ReadSpecWithHeader] BUG! N > Nl_max!! 14000
    ???
    OOPS! You have specified i_FastBC03_FLAG = 1 (in arq_config) but the file:
    ./CB19CSFBasesDir/cb19_xmilesi_z004_chab_CSF01.16.man.spec
    does NOT match the lambdas of BC03/STELIB!! Reverting to i_FastBC03_FLAG = 0!
    ???
      [ReadSpecWithHeader] BUG! N > Nl_max!! 14000
```

```
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
```

```
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
[ReadSpecWithHeader] BUG! N > Nl_max!!  14000
```
***> Read base files: CBASE.PARSEC.chab.16x5.all   N_base = 80
    from dir = ./CB19CSFBasesDir/
***> Read masks file: mask_sdss.gm   N_masks = 24
    from dir = ./
***> Modeling spec-1079-52621-0424.txt   ==> spec-1079-52621-0424_CB19_16x5
    Sampling: 3569.0 ==> 9650.0 with dl =   1.0 Angs & fscale_chi2 = 1.000E+00
    dl_cushion (A) =   50.0
    Extinction Law = CCM
    Initial kinematical parameters: v0 =   0.0 & vd = 150.0 km/s
    We are going to FIT the spectrum of this galaxy
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@> BASE LIMITS WARNING <@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ Your base goes from lambda =   5.6 to   8750.6 Angs
@ but the fit will run from   3519.0 to   9700.0 Angs
@ (including a +/- 50.0 Angs cushion for the kinematical filter)
@ STARLIGHT will flag-out lambdas outside the   55.6 to   8700.6 Angs range!
@@@
    Number of components with different extinction =   0 (0.00 < YAV < 0.00)
    S/N   =   11.145   10.443   in S/N & norm. windows

4

```
    S/N_err =   11.145    10.443     in S/N & norm. windows
********************************************************************************
* STARTING FIRST FITS …
* N_loops  =   3
* N_chains =   7
* Temp     = 1.00E+02 ==> 1.00E+00
* GR-R     = 1.30E+00 ==> 1.30E+00  Method =  0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING RE-FIT AFTER CLIPING …
* Cliped    96 points with > 4.0 sigma residuals with method = NSIGMA
* N_loops =   1
* Temp     = 1.00E+00 ==> 1.00E+00
* GR-R     = 1.30E+00 ==> 1.30E+00  Method =  0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING FINAL BURN-IN LOOP…
* N_loops =   1
* Temp     = 1.00E+00 ==> 1.00E+00
* GR-R     = 1.20E+00 ==> 1.20E+00  Method =  0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING EX0s FITS …
* EX0_method      =   CUMUL
* EX0s_Threshold =   0.020
* EX0s_PopVector =     MIN
* N_loops =   5
* Temp     = 1.00E+00 ==> 1.00E-03
* GR-R     = 1.20E+00 ==> 1.00E+00  Method =  1  (0/1=Soft/Hard)
********************************************************************************

**> RESULTS for spec-1079-52621-0424_CB19_16x5
   N_tot chi2/Nl_eff    adev |    v0     vd | sum       A_V  Y_AV |    x_j…
[%], j = 1 … 80
 1049440 1.3307E+00   9.4883 |   91.9  75.0 | 101.376  0.28  0.00 |    0.00
32.09   0.00   2.21   0.00   0.00   0.00   6.47   0.00   0.00
                                                                     4.96
18.57  12.90   2.56   1.65   0.00   0.00   0.00   0.00   0.00
                                                                     0.00
 0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
                                                                     0.00
 0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
                                                                     0.00
 0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
                                                                     0.00
 0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
                                                                     0.00
 0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
```

```
                                                                 0.00
 0.00  14.88    5.06    0.00    0.00    0.00    0.00    0.00    0.00


                                                           Total chi2
 =    5.9946E+03  for Nl_eff =   4505 lambdas!


*CidTIME>  FF=        8   RF=        2   BI=        4   EX0=        1   ALL=
35   sec - fit = spec-1079-52621-0424_CB19_16x5
*TotTIME>  FF=     8.300   RF=     2.255   BI=     3.644   EX0=     1.155   ALL=
34.117   sec - fit = spec-1079-52621-0424_CB19_16x5
*UsrTIME>  FF=     8.296   RF=     2.255   BI=     3.643   EX0=     1.153   ALL=
34.087   sec - fit = spec-1079-52621-0424_CB19_16x5
*SysTIME>  FF=     0.004   RF=     0.000   BI=     0.001   EX0=     0.002   ALL=
0.030   sec - fit = spec-1079-52621-0424_CB19_16x5



**> Welcome to STARLIGHT (v04) & good luck with this run!

**> Read config file: StCv04.C11.config
**> Read data file: spec-f2ace614-8708-11ef-b7bb-5
   from dir = ./CB19CSFB
   Data goes from:   3534.0  -->   9641.0 Angs with N =  6108 pixels
**> ATT: Defined error & flag spectra the old way! S/N =    6.397
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
????????????????????????????????????????????????????????????????????????????????
OOPS! You have specified i_FastBC03_FLAG = 1 (in arq_config) but the file:
./CB19CSFBasesDir/cb19_xmilesi_z004_chab_CSF01.16.man.spec
does NOT match the lambdas of BC03/STELIB!! Reverting to i_FastBC03_FLAG = 0!
????????????????????????????????????????????????????????????????????????????????
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
```

```
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
```

```
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
   [ReadSpecWithHeader] BUG! N > Nl_max!!   14000
**> Read base files: CBASE.PARSEC.chab.16x5.all                 N_base  =  80
    from dir = ./CB19CSFBasesDir/
**> Read masks file: mask_sdss.gm                               N_masks =  24
    from dir = ./
**> Modeling spec-f2ace614-8708-11ef-b7bb-5 ==>
spec-f2ace614-8708-11ef-b7bb-525400f334e1_CB19_16x5
    Sampling: 3569.0 ==> 9650.0  with dl =   1.0 Angs  & fscale_chi2 = 1.000E+00
    dl_cushion (A) =    50.0
    Extinction Law = CCM
    Initial kinematical parameters: v0 =    0.0 & vd =  150.0 km/s
    We are going to FIT the spectrum of this galaxy
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@> BASE LIMITS WARNING <@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ Your base goes from lambda =       5.6 to    8750.6 Angs
@ but the fit will run from       3519.0 to    9700.0 Angs
@ (including a +/- 50.0 Angs cushion for the kinematical filter)
@ STARLIGHT will flag-out lambdas outside the      55.6 to    8700.6 Angs range!
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
    Number of components with different extinction =   0  ( 0.00 < YAV <  0.00)
    S/N    =    6.397     6.380     in S/N & norm. windows
    S/N_err =    6.397     6.380     in S/N & norm. windows
********************************************************************************
* STARTING FIRST FITS …
* N_loops  =   3
* N_chains =   7
* Temp     = 1.00E+02 ==> 1.00E+00
* GR-R     = 1.30E+00 ==> 1.30E+00  Method =  0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING RE-FIT AFTER CLIPING …
* Cliped    71 points with > 4.0 sigma residuals with method = NSIGMA
* N_loops =   1
* Temp     = 1.00E+00 ==> 1.00E+00
* GR-R     = 1.30E+00 ==> 1.30E+00  Method =  0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING FINAL BURN-IN LOOP…
```

```
* N_loops =    1
* Temp    = 1.00E+00 ==> 1.00E+00
* GR-R    = 1.20E+00 ==> 1.20E+00  Method =  0   (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING EXOs FITS …
* EXO_method     =   CUMUL
* EXOs_Threshold =   0.020
* EXOs_PopVector =     MIN
* N_loops =    5
* Temp    = 1.00E+00 ==> 1.00E-03
* GR-R    = 1.20E+00 ==> 1.00E+00  Method =  1   (0/1=Soft/Hard)
********************************************************************************

**> RESULTS for spec-f2ace614-8708-11ef-b7bb-525400f334e1_CB19_16x5
   N_tot chi2/Nl_eff    adev |    v0    vd | sum      A_V  Y_AV |    x_j…
[%], j = 1 … 80
 1257340 9.6491E-01  11.9768 |   99.3  23.5 |  98.121  0.41  0.00 |    0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
                                                                     0.00
1.49    0.00    0.00    4.81    9.37    0.00    0.00    7.52    0.00
                                                                     0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
                                                                     0.00
0.00    0.00   26.69    0.00    0.00    0.00    0.00    0.00   36.00
                                                                     0.00
0.00    0.00    0.00    0.00    0.11    0.00    0.00    0.00    0.00
                                                                     0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    5.62
                                                                     0.00
0.06    0.01    0.00    1.34    0.00    0.00    0.00    0.00    0.00
                                                                     0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    5.08    0.00


                                                           Total chi2
=    4.5013E+03  for Nl_eff =   4665 lambdas!

*CidTIME>  FF=        7   RF=        4   BI=        3   EXO=        2   ALL=
35    sec - fit = spec-f2ace614-8708-11ef-b7bb-525400f334e1_CB19_16x5
*TotTIME>  FF=    7.446   RF=    3.351   BI=    3.286   EXO=    2.076   ALL=
34.696   sec - fit = spec-f2ace614-8708-11ef-b7bb-525400f334e1_CB19_16x5
*UsrTIME>  FF=    7.436   RF=    3.346   BI=    3.285   EXO=    2.076   ALL=
34.656   sec - fit = spec-f2ace614-8708-11ef-b7bb-525400f334e1_CB19_16x5
*SysTIME>  FF=    0.010   RF=    0.005   BI=    0.001   EXO=    0.000   ALL=
0.040   sec - fit = spec-f2ace614-8708-11ef-b7bb-525400f334e1_CB19_16x5


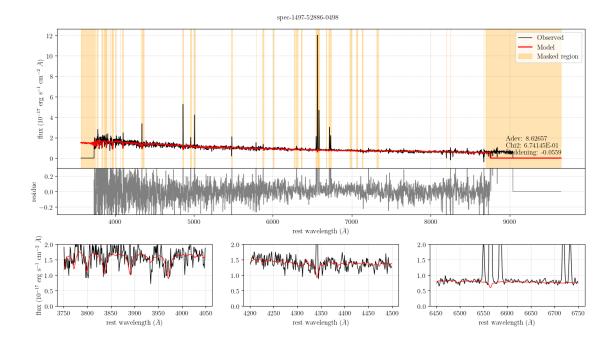**> Welcome to STARLIGHT (v04) & good luck with this run!
```

```
**> Read config file: StCv04.C11.config
**> Read data file: spec-1497-52886-0498.txt
    from dir = ./CB19CSFB
    Data goes from:   3736.0  -->   9041.0 Angs with N =  5306 pixels
**> ATT: Defined error & flag spectra the old way! S/N =    8.809
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
?????????????????????????????????????????????????????????????????????????????????????
OOPS! You have specified i_FastBC03_FLAG = 1 (in arq_config) but the file:
./CB19CSFBasesDir/cb19_xmilesi_z004_chab_CSF01.16.man.spec
does NOT match the lambdas of BC03/STELIB!! Reverting to i_FastBC03_FLAG = 0!
?????????????????????????????????????????????????????????????????????????????????????
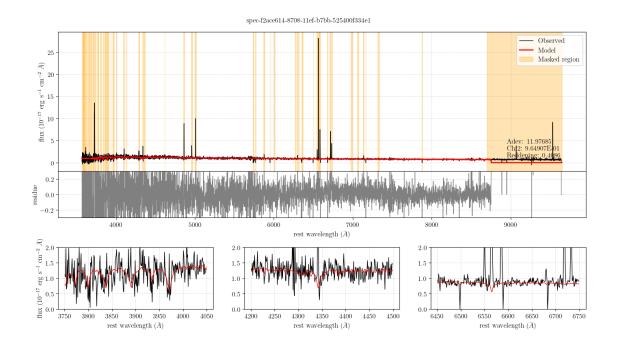  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
  [ReadSpecWithHeader] BUG! N > Nl_max!!  14000
```

```
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
[ReadSpecWithHeader] BUG! N > Nl_max!!   14000
**> Read base files: CBASE.PARSEC.chab.16x5.all                    N_base  =  80
    from dir = ./CB19CSFBasesDir/
**> Read masks file: mask_sdss.gm                                  N_masks =  24
    from dir = ./
**> Modeling spec-1497-52886-0498.txt       ==> spec-1497-52886-0498_CB19_16x5
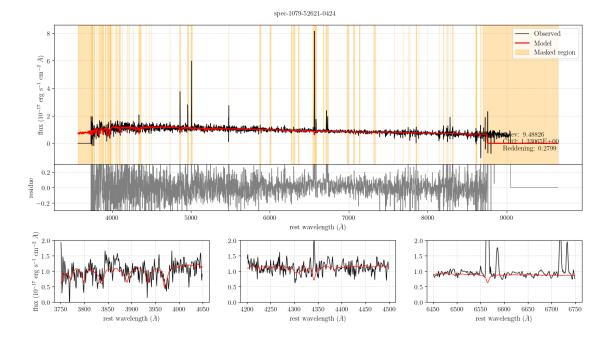```

```
     Sampling: 3569.0 ==> 9650.0  with dl =    1.0 Angs  & fscale_chi2 = 1.000E+00
     dl_cushion (A) =    50.0
     Extinction Law = CCM
     Initial kinematical parameters: v0 =    0.0 & vd =  150.0 km/s
     We are going to FIT the spectrum of this galaxy
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@> BASE LIMITS WARNING <@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ Your base goes from lambda =        5.6 to    8750.6 Angs
@ but the fit will run from        3519.0 to    9700.0 Angs
@ (including a +/- 50.0 Angs cushion for the kinematical filter)
@ STARLIGHT will flag-out lambdas outside the      55.6 to    8700.6 Angs range!
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
     Number of components with different extinction =   0  ( 0.00 < YAV <  0.00)
     S/N      =     8.809     7.979     in S/N & norm. windows
     S/N_err =     8.809     7.979     in S/N & norm. windows
********************************************************************************
* STARTING FIRST FITS …
* N_loops  =    3
* N_chains =    7
* Temp     = 1.00E+02 ==> 1.00E+00
* GR-R     = 1.30E+00 ==> 1.30E+00  Method =   0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING RE-FIT AFTER CLIPING …
* Cliped    25 points with > 4.0 sigma residuals with method = NSIGMA
* N_loops =    1
* Temp     = 1.00E+00 ==> 1.00E+00
* GR-R     = 1.30E+00 ==> 1.30E+00  Method =   0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING FINAL BURN-IN LOOP…
* N_loops =    1
* Temp     = 1.00E+00 ==> 1.00E+00
* GR-R     = 1.20E+00 ==> 1.20E+00  Method =   0  (0/1=Soft/Hard)
********************************************************************************
********************************************************************************
* STARTING EXOs FITS …
* EXO_method      =    CUMUL
* EXOs_Threshold =    0.020
* EXOs_PopVector =      MIN
* N_loops =    5
* Temp     = 1.00E+00 ==> 1.00E-03
* GR-R     = 1.20E+00 ==> 1.00E+00  Method =   1  (0/1=Soft/Hard)
********************************************************************************

**> RESULTS for spec-1497-52886-0498_CB19_16x5
   N_tot chi2/Nl_eff    adev |     v0    vd | sum        A_V  Y_AV |     x_j…
[%], j = 1 … 80
 1532650 6.7415E-01    8.6266 |   58.6  69.0 |  96.078 -0.06  0.00 |     5.78
```

```
0.00    2.93    1.59    0.00    0.00    0.00    0.00    0.00    0.00
                                                                        0.02
4.70    5.86    6.28    8.66    0.00    3.30    0.00   15.55    1.77
                                                                        0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
                                                                        0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
                                                                        0.00
0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
                                                                        0.00
1.97    8.35    0.00    0.00    0.00    0.00    0.00    0.00    0.00
                                                                        0.00
0.00    0.00    0.00    8.71    0.00    0.00    0.00    0.01    0.00
                                                                        0.00
0.00    0.00    0.00    0.00    0.00    0.00    6.76    0.00   13.86

                                                                 Total chi2
  =    3.0876E+03   for Nl_eff =   4580 lambdas!

*CidTIME>  FF=        8   RF=         2   BI=         3   EX0=         2   ALL=
35   sec - fit = spec-1497-52886-0498_CB19_16x5
*TotTIME>  FF=    7.618   RF=     2.490   BI=     2.959   EX0=     2.372   ALL=
34.842    sec - fit = spec-1497-52886-0498_CB19_16x5
*UsrTIME>  FF=    7.617   RF=     2.490   BI=     2.959   EX0=     2.371   ALL=
34.827    sec - fit = spec-1497-52886-0498_CB19_16x5
*SysTIME>  FF=    0.001   RF=     0.000   BI=     0.000   EX0=     0.001   ALL=
0.015    sec - fit = spec-1497-52886-0498_CB19_16x5
```

Once Starlight has run, we need to create the ".fits" file for IFSCube fitting and generate output spectra images to inspect the quality of the fit.

```python
[6]: # After running Starlight, read the output files and saving into a list
     files = [f for f in os.listdir(data_dir) if os.path.isfile(os.path.
      ↪join(data_dir, f)) and '.' not in f]
     starlight_output = specutils.read_starlight_output(files,
      ↪filepath=str(data_dir) + '/')

     for galaxy, data in starlight_output.items():
         fig = specutils.plot_starlight_spectrum(data)
         fig.suptitle(f'{galaxy}')
         fig.tight_layout()
         fig.savefig(data_dir / f"{galaxy}_starlight.png")
         plt.show(fig)
         plt.close(fig)

         new_fits = specutils.create_new_fits_from_starlight(data)
         new_fits.writeto(data_dir / f'{galaxy}_starlight.fits', overwrite=True)
```

spec-1497-52886-0498

Adev: 8.62657
Chi2: 6.74145E-01
Reddening: -0.0559

spec-f2ace614-8708-11ef-b7bb-525400f334e1

Adev: 11.97685
Chi2: 9.64907E-01
Reddening: 0.4086

spec-1079-52621-0424

1.3 Defining IFSCube inputs

If you want to add more emission lines in the fit, you need to add them at the "lines_config" dictionary.

```python
[10]: ifscube_config_file = base_dir / 'data/ifscube_config.cfg'
      stdout_ifscube = {} # to save the output log of ifscube runs
      velocity = '0, +- 300'
      velocity_broad = '0, +- 300'
      sigma = '100, 40:400'
      sigma_broad = '120, 50:200'
      lines_config = {
          "OII_3726": spectrum_io.make_line(3726.032, velocity, sigma),
          "OII_3729": spectrum_io.make_line(3728.815, velocity, sigma),
          "OIII_4363": spectrum_io.make_line(4363.210, velocity, sigma),
          "Hb_4861": spectrum_io.make_line(4861.325, velocity, sigma),
          "OIII_5007": spectrum_io.make_line(5006.84, velocity, sigma, k_group=0),
          "OIII_4959": spectrum_io.make_line(4958.91, velocity, sigma,
                                amplitude="peak, 0:, OIII_5007.amplitude / 2.98",␣
      ↪k_group=0),
          "OI_6300": spectrum_io.make_line(6300.304, velocity, sigma),
          "Ha_6563": spectrum_io.make_line(6562.80, velocity, sigma),
          "NII_6583": spectrum_io.make_line(6583.46, velocity, sigma, k_group=12),
          "NII_6548": spectrum_io.make_line(6548.04,
                                amplitude="peak, 0:, NII_6583.amplitude / 3.06",␣
      ↪k_group=12),
```

```
    "SII_6716": spectrum_io.make_line(6716.44, velocity, sigma, k_group=13),
    "SII_6731": spectrum_io.make_line(6730.82, amplitude="peak, 0:",␣
  ↪k_group=13),
}
```

1.4 Running IFSCube

Before running IFSCube, we check if the galaxy has emission lines detected.

-> How we do that?

We define as detected the emission line that has the amplitude greater than 3 times the standard desviation of the continuum next to the line.

```
[12]: ifscube_output_files = [f for f in os.listdir(data_dir) if f.
      ↪endswith('_starlight.fits')]


      for file in ifscube_output_files:
          galaxy = os.path.splitext(file)[0]
          print(f' -> Checking if galaxy {galaxy} has detected emission lines... \n')
          do_fit = spectrum_io.select_do_fit(data_dir/file, value=3)
          if do_fit == True:
              out_image = data_dir / f'{galaxy}_g.fits'
              config = spectrum_io.
      ↪generate_ifscube_configuration_file(continuum_degree=1, lines=lines_config,␣
      ↪out_image=out_image)
              # print(config)

              with open(ifscube_config_file, "w") as f:
                  f.write(config)

              output = subprocess.run(["specfit", "-oc", ifscube_config_file,␣
      ↪data_dir/file], check=True, text=True)
              stdout_ifscube[galaxy] = output.stdout
          else:
              print(f'Skipping galaxy {galaxy}. No emission lines detected.')

          # break
```

 -> Checking if galaxy spec-1497-52886-0498_starlight has detected emission
lines…

/home/kelly/Dropbox/bolsa-FAPESP/github/spectools/.venv/lib/python3.12/site-
packages/ifscube/onedspec.py:109: RuntimeWarning: Wavelength read in meters.
Changing it to Angstroms.
  warnings.warn(message="Wavelength read in meters. Changing it to Angstroms.",
category=RuntimeWarning)

```
-> Checking if galaxy spec-1079-52621-0424_starlight has detected emission
lines...
```

```
/home/kelly/Dropbox/bolsa-FAPESP/github/spectools/.venv/lib/python3.12/site-
packages/ifscube/onedspec.py:109: RuntimeWarning: Wavelength read in meters.
Changing it to Angstroms.
  warnings.warn(message="Wavelength read in meters. Changing it to Angstroms.",
category=RuntimeWarning)
```

```
 -> Checking if galaxy spec-f2ace614-8708-11ef-b7bb-525400f334e1_starlight has
detected emission lines...
```

```
/home/kelly/Dropbox/bolsa-FAPESP/github/spectools/.venv/lib/python3.12/site-
packages/ifscube/onedspec.py:109: RuntimeWarning: Wavelength read in meters.
Changing it to Angstroms.
  warnings.warn(message="Wavelength read in meters. Changing it to Angstroms.",
category=RuntimeWarning)
```

Plotting the fit...

```python
[13]: ifscube_fitted_galaxies = [f for f in os.listdir(data_dir) if f.endswith('_g.
       ↪fits')]
      for galaxy in ifscube_fitted_galaxies:
          fig = specutils.plot_ifscube_spectra(data_dir, galaxy)
          # plt.close(fig)
```


Spectra for spec-1497-52886-0498

Spectra for spec-f2ace614-8708-11ef-b7bb-525400f334e1

Spectra for spec-1079-52621-0424