SINFONI Data Cube Analysis Tool Manuel - Version 1.1 -

Benoît Epinat Julien Queyrel

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Contents

1 Introduction

2 What is possible ?

2.1 With the current version

Due to the 3D nature of our data, the aim of this analysis tool is to create maps of different physical parameters over the extent of the object. This program studies the spectrum of each pixel in order to create:

- continum maps (polynomial with a chossen degree),
- line flux maps (such as Hα map),
- velocity maps,
- velocity dispersion maps, ...

By the way, it is also possible to fit several lines at the same time. For instance, if you tell the program to fit both Hα and [N II]6584 lines, you will get both Hα and [N II]6584 maps (with the same width or not), and you will be able, taking the ratio to derive a metallicity map (using empirical calibrations). Some usual lines are available, but it is also possible to specify an additional line wavelength.

The input cube is usually large in both spatial and spectral directions and the object only covers a small area and the emission lines to study span over a narrow wavelength range. The program enables to cut spatially and spectrally the cube.

It also enables to perform spatial and spectral smoothings in order to improve the signal to noise ratio.

One can also specify the spectral PSF width in order to correct the dispersion maps.

2.2 In the future

Several enhancements are forseen:

- Using a spectral PSF: with the use of a spectral PSF we will be able to get a profile by convolving the analytical shape of the line with the PSF, before fitting the line, and thus getting accurate results
- Using several additional lines, ...

3 How does it works ?

The program fits the spectrum behind each spatial element of the cube. It uses a combination of one or several gaussian lines for each emission lines one wants to model added to a polynomial continuum. A unique redshift is fitted for the various lines but the width can be fitted separately for each line.

The program can use an error spectrum in order to weight the contribution of each wavelength. This error spectrum is usually given by the sky spectrum. It allows to diminuish the contribution of wavelength with the strongest night sky emission lines.

4 How to use the program ?

This section will guide you through basic stuff for you to be able to analyse your data cubes.

4.1 The configuration file

First of all, when your cube is finally reduced correctly, you'll need to edit a configuration file. An example of such a file can be found in the root directory of the untared archive under the name '`type.config`'. In this file you will have to fill-in several values of keywords. If you look carefully at it you will remark that it has the form of a fits Header[1]: each keyword is followed by its value, and after the '/', a commentary defining the field and its default value.

There is mainly two types of keywords: some of them are in relation with the I/O and others are more specific to the nature of the analysis. The later type is of course very important because it determines how the procedures will analyse your data: two different set of parameters in the configuration file will *a priori* not give the same output. Now, let's go through the description of the keywords:

FITSFILE in this field you must specify the path of your science data cube, which is going to be analysed by the program (e.g.: `FITSFILE= '/input_path/file.fits'`);

OUTPUT in this field you have to specify the directory where you want the ouputs to be written and the prefixe of the output products (e.g.: `OUTPUT='/output_path/output_prefix'`). Default is the current directory with no prefix;

SKYFILE in this field you have to specify the path of the sky spectrum or cube (e.g.: `SKYFILE='/sky_path/sky.fits'`). Note that the wavelength range has to be the same as the input cube and that it can be either a cube (same dimensions as the input cube) or a 1D spectrum. It is used to evaluate the error spectra fro each spatial elements. Default is to use no sky;

HALPHA type `'TRUE'` or `'FALSE'` whether you want to fit the Hα line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'TRUE'`;

NII6545 type `'TRUE'` or `'FALSE'` whether you want to fit the [N II]6545 line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'FALSE'`;

NII6584 type `'TRUE'` or `'FALSE'` whether you want to fit the [N II]6584 line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'FALSE'`;

[1] Thanks to this trick the analysis procedures will append this header to the header of the output, thus keeping a trace of how the analysis has been made

SII6717 type `'TRUE'` or `'FALSE'` whether you want to fit the [S II]6717 line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'FALSE'`;

SII6731 type `'TRUE'` or `'FALSE'` whether you want to fit the [S II]6731 line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'FALSE'`;

OIII4959 type `'TRUE'` or `'FALSE'` whether you want to fit the [O III]4959 line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'FALSE'`;

OIII5007 type `'TRUE'` or `'FALSE'` whether you want to fit the [O III]5007 line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'FALSE'`;

HBETA type `'TRUE'` or `'FALSE'` whether you want to fit the Hβ line. The position of the line will be found found using the value of the `'REDSHIFT'` keyword. Default is `'FALSE'`;

EXTRAL is used to specify a specific line wavelength not included in the previous lines. The value has to be given in angstroms Default is no additional line;

COMMW type `'TRUE'` or `'FALSE'` whether you want to use a common linewidth when various lines are to be fitted silmultenaously. Default is `'FALSE'`;

REDSHIFT here you must write the redshift of the galaxy in your data cube. This value will be used to calculate the position of the emission lines of interest. A redshift with 4 decimals is suitable;

REDMIN here you must write the minimum redshift of the galaxy in your data cube. When no value is specified, the program use the value given in the `REDSHIFT` keyword minus 0.01;

REDMAX here you must write the maximum redshift of the galaxy in your data cube. When no value is specified, the program use the value given in the `REDSHIFT` keyword plus 0.01;

INITW initial guess of the linewidth (in km.s^{-1}) for the fitting procedure (`mpfitfun`);

WMIN minimum value for the linewidth of the lines in km.s^{-1}(constraint for the fit). Default is 50 km.s^{-1};

WMAX maximum value for the linewidth of the lines in km.s^{-1}(constraint for the fit). Default is 500 km.s^{-1};

DFIT bin in km.s^{-1} for searching the central wavelength of the fit (default is 60);

DGCTNUM degree, n, of the polynomial used to fit the continum (default is 0) : $a_0 + \cdots + a_n \lambda^n$;

MFIT the analytic shape of the fit (gaussian, barycenter). *For now, just gaussian is available and is the default choice*;

SPSF spectral PSF width in angstroms (dispersion of the gaussian instead of FWHM) (default is 0);

WSMOOTH indicates the kind of spectral smoothing to be applied: 0 for no smoothing, 1 for Hanning and 2 for gaussian with a 3 pixels FWHM (default is 0);

SSMOOTH indicates the gaussian spatial smoothing FWHM in pixels. Set 0 for no smoothing (default is 0);

XMIN, XMAX, YMIN, YMAX you may want to reduce the spatial extent of your science data cube, these keywords allow you to do so, see fig 1. By default the program uses the minimum and/or maximum index;

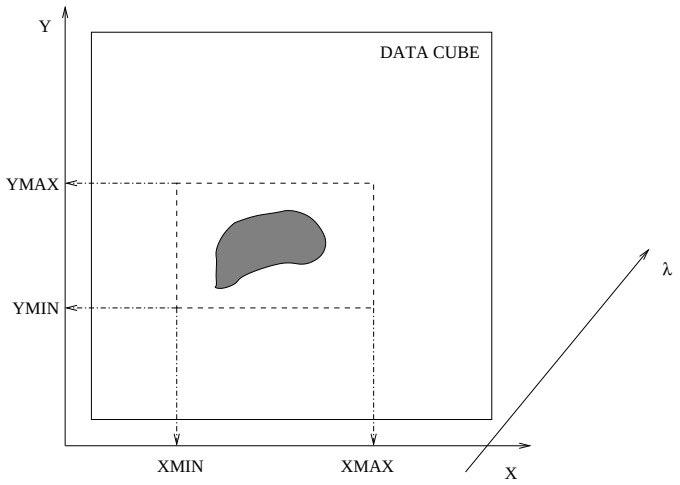

Figure 1: How to limit the spatial size aroud the object.

ZMIN you may want to reduce the spectral extent of your science data cube to focus on specific lines. This keywords allow you to indicate the minimum spectral channels to take into account. By default, it uses the first channel;

ZMAX you may want to reduce the spectral extent of your science data cube to focus on specific lines. This keywords allow you to indicate the maximum spectral channels to take into account. By default, it uses the last channel.

4.2 Running the program

First of all you need to have IDL installed on you computer. Moreover the MPfit librairy and the AstroLib must be present and reachable by IDL. Once this is the case you need to add the procedures contained in the tarball to your IDL PATH: in your $IDL_STARTUP file you need to add the directory containing these file to the PATH.

As soon as everything is correct, you can try analyse your data. After you created your configuration file, you may want to launch IDL, and typing after the prompt:

```
vvdssinfoni_analysis,file,plot=plot,debug=debug
```

where:

- `file` corresponds to the location of your configuration file;
- `plot` should be set to 1 if you want to see the plot of the fit for each pixel in your cube interactively (in this case the execution time will be more important);
- `debug` sould be set to 1 if you want to display debug information during the execution.

At least, keep in mind that wrong parameters in your configuration file may lead to bad analysis: the fitting procedure is highly dependant on these parameters (for instance: fitting sky-lines instead of emission lines from the galaxy).

4.3 Outputs

The IDL routine creates at least 20 outputs. Each of them have a suffix linked to their nature.

- the prefix `ssmooth_` is used when a spatial smoothing has been applied;
- the prefix `wsmooth_` is used when a spectral smoothing has been applied;
- the suffix `_indep` is used when the linewidth is independant for each line;
- the suffix `_common` is used when the linewidth is common for all lines.

Two cubes are created:

- `output_prefix_cube_cut.fits` cut or not in spatial and/or spectral directions;
- `output_prefix_ssmooth_cube.fits` smoothed or not in spatial and/or spectral directions (and also cut).

Some maps are created independantly for the fit:

- `chi2` a χ^2 map;
- `status` fit status map (see mpfit to see the signification of the status or the README file);
- `cont` the continuum;
- `econt` the continuum error map;
- `dispcont` the dispersion of the continuum;
- `vel` the velocity map;
- `evel` the velocity error map;

and eventually, if a common line has been used:

- `sigma` the velocity dispersion map;
- `esigma` the velocity dispersion error map;

If an independant linewidth has been used, these two maps are created for each line.

These following maps are always created for each fitted line, with an additional suffix to identify the line:

- `intensity` the intensity map (maximum of the gaussian);
- `eintensity` the intensity error map;
- `flux` the integrated line flux map (expressed in flux/micron);
- `eflux` the integrated line flux error map;
- `wave` the line position wavelength map (in Angstroms);
- `ewave` the line position wavelength error map;
- `wavedisp` the line width map (in Angstroms);
- `ewavedisp` the line width error map;
- `snr` the signal to noise ratio map defined as the intensity of the line divided by the residual line dispersion (spectrum-model).