SMART

User Manual

Version 1.0

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Contents

1 Introduction

SMART (**S**pectral energy distributions **M**arkov chain **A**nalysis with **R**adiative **T**ransfer models) was developed by Varnava & Efstathiou (2024a,b) and is available at `https://github.com/ch-var/SMART`. The code is written in Python. The novelty of **SMART** is that it fits spectral energy distributions (SEDs) exclusively with radiative transfer models. The output of the MCMC code is post-processed to compute key physical properties, such as star formation rates (SFRs), stellar masses, active galactic nucleus (AGN) fraction etc.

SMART uses libraries of models (starburst, spheroidal, disc, four different AGN torus models, polar dust), which are described at `https://arc.euc.ac.cy/cygnus/` or in Efstathiou et al. (2022).

SMART is called by the wrapper routine *SMART* (written by CV and AE in Python) for the galaxies given in a list (see Appendix A). The user can select only a subset of the sample listed to be fitted by using the appropriate flag (third column).

The input of multi-wavelength data to **SMART** must be in the form of an ASCII file for each galaxy. The data should have the format of the example in Appendix B. The first column is the observed wavelength in microns, the second column is the flux density in Jy, the third column is the error in Jy and the fourth column indicates if the data point is to be treated as a detection (0) or an upper limit (1). The last column, which should be a character string, gives an indication of the source of the data. The ASCII files are included by default in the directory 'objects'. The user can specify any other directory name, which can be passed with the keyword 'data_file'. An example is given in §3.8 and in §4. The list of galaxies to be fitted is given by default in the file 'objects_list' or in the file given by the 'data_file' keyword.

All the parameters of the models used in **SMART** are listed and explained in Table 1.

A sample of the output from the routine *SMART* is given in Appendix C. This file gives the fitted parameters of the radiative transfer models and their errors.

The data generated by *SMART* are post-processed with the routine *post_SMART* (written by CV and AE in Python) to generate the output listed in Appendix D. This file gives the extracted physical quantities and their errors, which are explained in Table 2. The listed luminosities are $1-1000$ μm luminosities.

The user has the option to use a number of keywords. All the keywords used in **SMART** are explained in §4 and are briefly presented in Table 3.

The output of **SMART** can be reformatted with the routine *reformatter_SMART* (written by CV and AE in Python), which writes the parameters and extracted physical quantities of the selected sample of galaxies, as well as their errors, in the form of a LaTeX table (see Appendix E) and plots the parameters and physical quantities of interest.

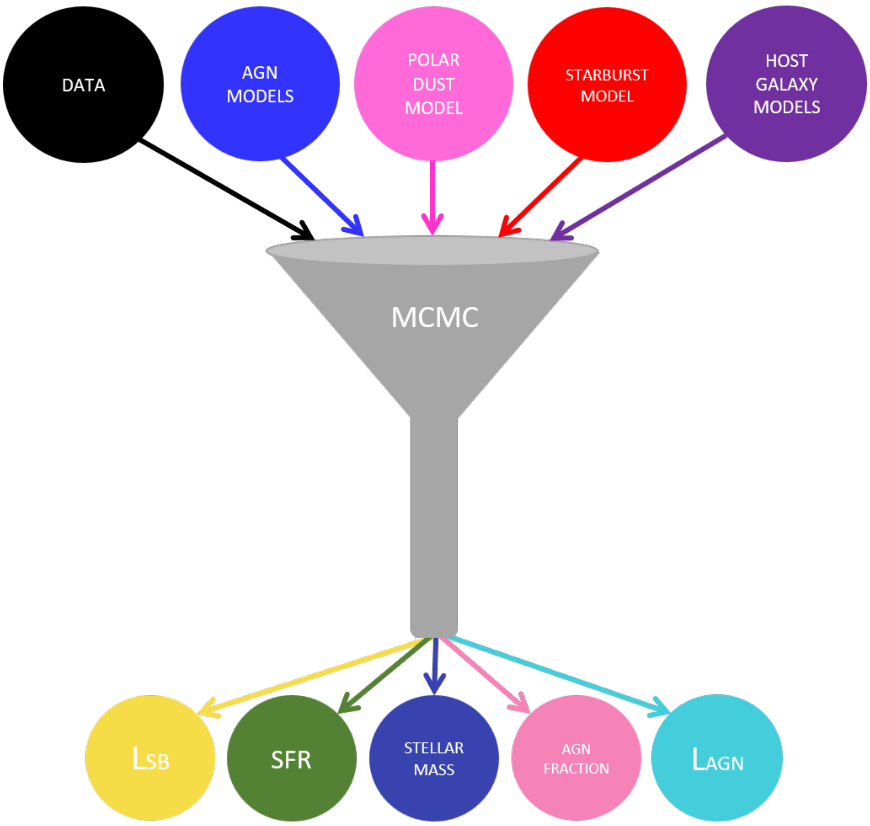

Figure 1: The **SMART** method

2 Summary of key novel features of SMART

- Can fit an SED exclusively with radiative transfer models
- Can fit with a combination of (a) host, (b) starburst, (c) AGN torus and (d) polar dust
- Any of (a), (b), (c) can be switched off with keywords
- Polar dust is switched off by default, but can be switched on with a keyword
- The AGN torus model can be any of 'CYGNUS', 'Fritz', 'SKIRTOR' or 'Siebenmorgen'
- A number of model parameters can be 'frozen' with keywords
- The output of MCMC is post-processed to extract physical quantities like luminosities, SFRs, stellar masses, AGN fraction, torus radius etc.

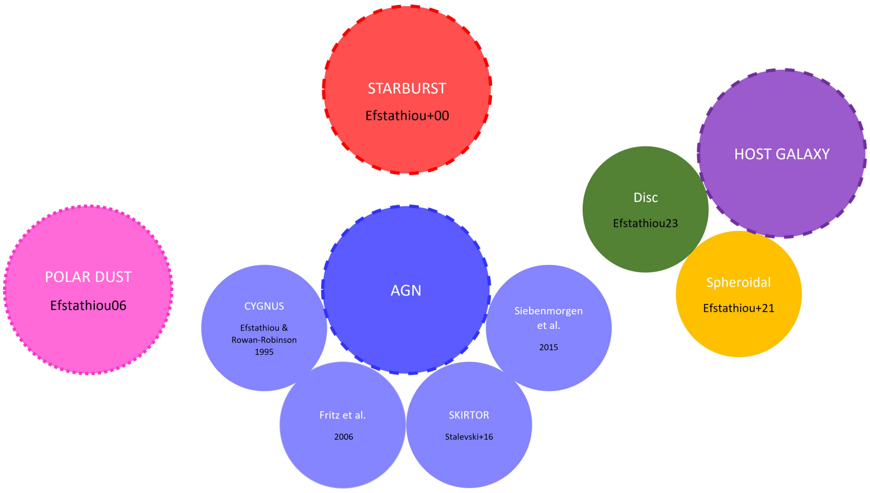

Figure 2: Models used by **SMART**

Table 1: Parameters of the models currently used in **SMART**, symbols used, their assumed ranges and summary of other information about the models. In the Fritz et al. (2006) model there are two additional parameters that define the density distribution in the radial direction (β) and azimuthal direction (γ). In **SMART** we assume $\beta = 0$ and $\gamma = 4$. In the SKIRTOR model there are two additional parameters that define the density distribution in the radial direction (p) and azimuthal direction (q). In **SMART** we assume $p = 1$ and $q = 1$. In addition, the SKIRTOR library fixes the fraction of mass inside clumps to 97 per cent. There are four additional scaling parameters for the starburst, spheroidal or disc, AGN and polar dust models, f_{SB}, f_{sph} or f_{disc}, f_{AGN} and f_p, respectively.

Parameter	Symbol	Range	Comments
CYGNUS Starburst			
Initial optical depth of GMCs	τ_v	50−250	Efstathiou et al. (2000), Efstathiou & Siebenmorgen (2009)
Starburst SFR e-folding time	τ_*	10−35 Myr	Incorporates Bruzual & Charlot (1993, 2003)
Starburst age	t_*	5−35 Myr	Metallicity=solar, Salpeter Initial Mass Function (IMF)
			Standard galactic dust mixture with polycyclic aromatic hydrocarbon molecules (PAHs)
CYGNUS Spheroidal Host			
Spheroidal SFR e-folding time	τ^s	0.125−8 Gyr	Efstathiou & Rowan-Robinson (2003), Efstathiou et al. (2021)
Starlight intensity	ψ^s	1−17	Incorporates Bruzual & Charlot (1993, 2003)
Optical depth	τ_v^s	0.1−15	Range of metallicities, Salpeter IMF
			Standard galactic dust mixture with PAHs
CYGNUS Disc Host			
Disc SFR e-folding time	τ^d	0.5−8 Gyr	Efstathiou & Rowan-Robinson (2003), Efstathiou (in preparation)
Starlight intensity	ψ^d	1−9	Incorporates Bruzual & Charlot (1993, 2003)
Optical depth	τ_v^d	0.1−29	Range of metallicities, Salpeter IMF
Inclination	θ_d	$0^\circ-90^\circ$	Standard galactic dust mixture with PAHs
CYGNUS AGN torus			
Torus equatorial UV optical depth	τ_{uv}	260−1490	Smooth tapered discs
Torus ratio of outer to inner radius	r_2/r_1	20−100	Efstathiou & Rowan-Robinson (1995), Efstathiou et al. (2013)
Torus half-opening angle	θ_o	$30^\circ-75^\circ$	Standard galactic dust mixture without PAHs
Torus inclination	θ_i	$0^\circ-90^\circ$	The subranges θ_o-90° and $0^\circ-\theta_o$ are assumed for AGN_type=2 and AGN_type=1, respectively.
Fritz et al. (2006) AGN torus			
Torus equatorial optical depth at 9.7μm	$\tau_{9.7\mu m}$	1−10	Smooth flared discs
Torus ratio of outer to inner radius	r_2/r_1	10−150	Fritz et al. (2006)
Torus half-opening angle	θ_o	$20^\circ-70^\circ$	Standard galactic dust mixture without PAHs
Torus inclination	θ_i	$0^\circ-90^\circ$	The subranges θ_o-90° and $0^\circ-\theta_o$ are assumed for AGN_type=2 and AGN_type=1, respectively.
SKIRTOR AGN torus			
Torus equatorial optical depth at 9.7μm	$\tau_{9.7\mu m}$	3−11	Two-phase flared discs
Torus ratio of outer to inner radius	r_2/r_1	10−30	Stalevski et al. (2012), Stalevski et al. (2016)
Torus half-opening angle	θ_o	$20^\circ-70^\circ$	Standard galactic dust mixture without PAHs
Torus inclination	θ_i	$0^\circ-90^\circ$	The subranges θ_o-90° and $0^\circ-\theta_o$ are assumed for AGN_type=2 and AGN_type=1, respectively.

Siebenmorgen et al. (2015) AGN torus			
Cloud volume filling factor (per cent)	V_c	1.5−77	Two-phase anisotropic spheres
Optical depth of the individual clouds	A_c	0−45	Siebenmorgen et al. (2015)
Optical depth of the disc mid-plane	A_d	50−500	Fluffy dust mixture without PAHs
Inclination	θ_i	0°−90°	The subranges 45°−90° and 0°−45°are assumed for AGN_type=2 and AGN_type=1, respectively.
Polar dust			
Temperature	T_p	800K−1200K	Optically thick spherical clouds (Efstathiou, 2006)

Table 2: Index of the physical quantities extracted by *post_SMART*

Extracted physical quantity	Description
lum_agn_raw	Raw or observed total luminosity
lum_agn_cor	Anisotropy corrected AGN torus luminosity
lum_sb	Starburst luminosity
lum_sph	Spheroidal luminosity
lum_disc	Disc luminosity
lum_pol	Polar dust luminosity
lum_tot_raw	Raw or observed total luminosity
lum_tot_cor	Anisotropy corrected total luminosity
sfr_sb	Starburst SFR averaged over 50 Myr
sfr_sb_age	Starburst SFR averaged over its age
sfr_sph	Spheroidal SFR
sfr_disc	Disc SFR
sfr_total	Total SFR
stellar_mass_sph	Spheroidal stellar mass
stellar_mass_disc	Disc stellar mass
stellar_mass_sb	Starburst stellar mass
stellar_mass_tot	Total stellar mass
agn_fraction	AGN fraction
aniso_factor	AGN torus anisotropy factor

3 Python examples

To fit galaxies from the sample of galaxies listed in the file object_list.txt , we proceed as follows:

In Anaconda we type:

```
>>> from SMART import *
>>> from post_SMART import *
```

3.1 Example A: Fitting with a type 2 AGN without polar dust, using the CYGNUS AGN torus model

To fit the first galaxy (with flag=1001) with a type 2 AGN (indicated with the flag=2 in the last column) without polar dust, using the CYGNUS AGN torus model, we type:

```
>>> SMART('1001')
```

We can then quickly post-process the data of the object with:

```
>>> post_SMART('1001')
```

This creates a .png plot for each object and a .txt file that lists the extracted physical quantities.

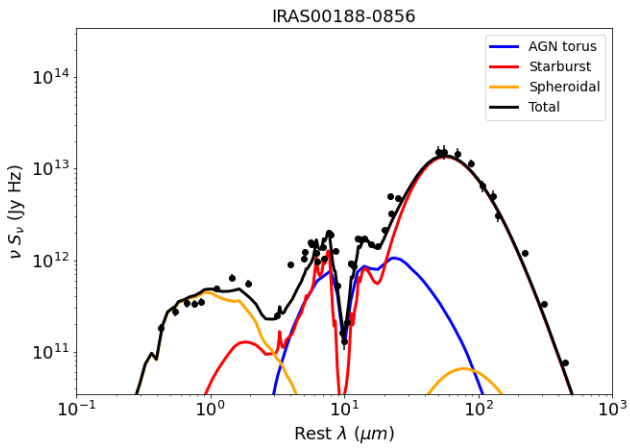

Figure 3: SED fit plot of the galaxy IRAS 00188-0856 created by **SMART**, using the CYGNUS AGN torus model

3.2 Example B: Fitting with a type 2 AGN without polar dust, using the Fritz et al. (2006) AGN torus model

To fit the first galaxy (with flag=1001) with a type 2 AGN (indicated with the flag=2 in the last column) without polar dust, using the Fritz et al. (2006) AGN torus model, we type:

```
>>> SMART('1001',AGN_model='Fritz')
```

We can then quickly post-process the data of the object with:

```
>>> post_SMART('1001',AGN_model='Fritz')
```

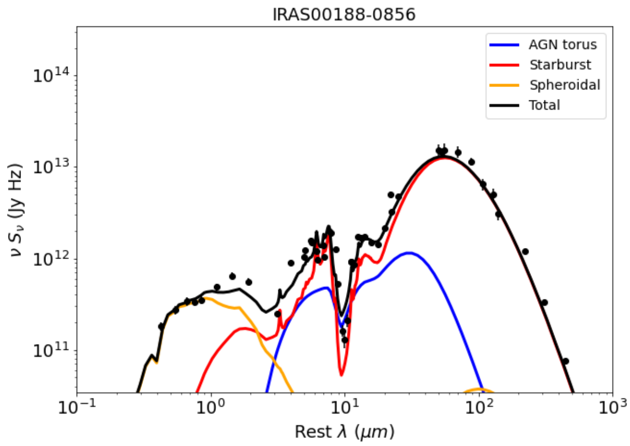

Figure 4: SED fit plot of the galaxy IRAS 00188-0856 created by **SMART**, using the Fritz et al. (2006) AGN torus model

3.3 Example C: Fitting with a type 2 AGN and polar dust

Similarly, to fit the galaxy with flag=1002 with a type 2 AGN and polar dust, we type:

```
>>> SMART('1002',polar='yes')
>>> post_SMART('1002',polar='yes')
```

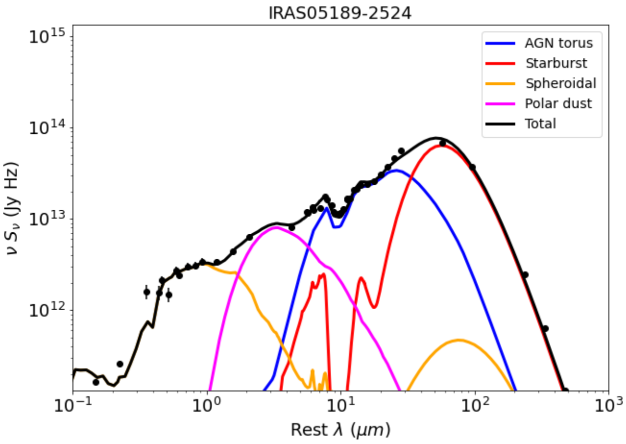

Figure 5: SED fit plot of the galaxy IRAS 05189-2524 created by **SMART**

3.4 Example D: Plotting the relative residual

To plot the relative residual of the galaxy with flag=1002, we type:

```
>>> SMART('1002',polar='yes',rel_residual_plot='yes')
```

or

```
>>> post_SMART('1002',polar='yes',rel_residual_plot='yes')
```

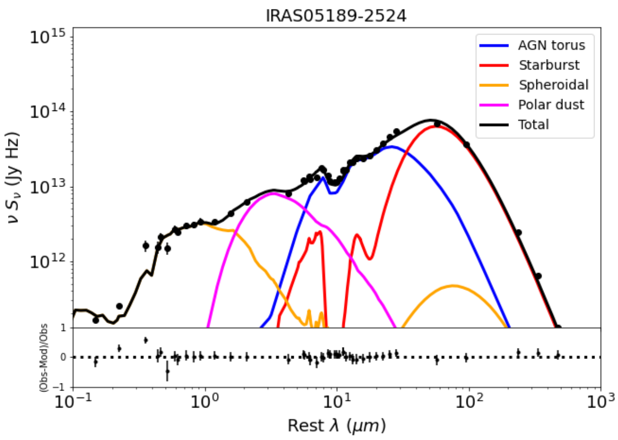

Figure 6: SED fit plot along with the relative residual plot of the galaxy IRAS 05189-2524 created by **SMART**

3.5 Example E: Fitting with a type 1 AGN and polar dust

To fit the galaxy with flag=1003 with a type 1 AGN and polar dust, we type:

```
>>> SMART('1003',polar='yes')
>>> post_SMART('1003',polar='yes')
```

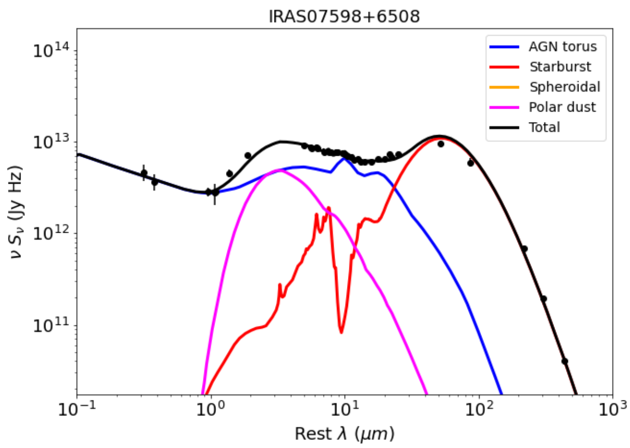

Figure 7: SED fit plot of the galaxy IRAS 07598+6508 created by **SMART**

3.6 Example F: Fitting with a disc host galaxy geometry and type 2 AGN without polar dust

To fit the galaxy with flag=1004 with a disc host galaxy geometry and a type 2 AGN without polar dust, we type:

```
>>> SMART('1004',host_geometry='disc')
>>> post_SMART('1004',host_geometry='disc')
```

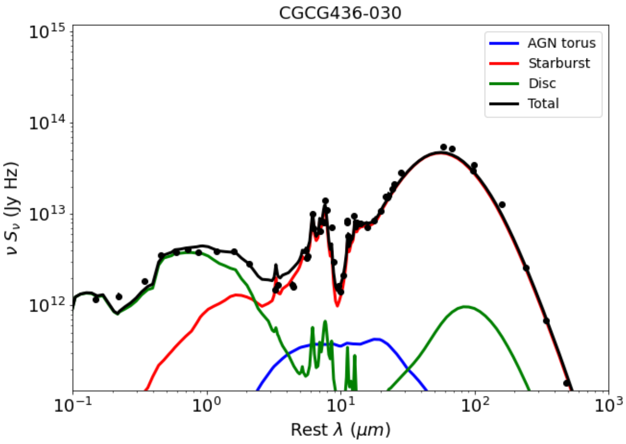

Figure 8: SED fit plot of the galaxy CGCG436 030 created by **SMART**

3.7 Example G: Creating tables and plots of the parameters and physical quantities

To create tables and plot the parameters and physical quantities of interest, we run the routine *reformatter_SMART*. In Anaconda we type:

```
>>> from reformatter_SMART import *
```

For a sample of spheroidal galaxies with flag=1000 and run_name='S', we then type:

```
>>> reformatter_SMART('1000')
```

If we had a sample of spheroidal galaxies, in which we find evidence of polar dust, with flag=1000 and run_name='S', we would type:

```
>>> reformatter_SMART('1000',polar='yes')
```

If we had a sample of disc galaxies (that we ran using the CYGNUS AGN torus model) with flag=1000 and run_name='D', we would type:

```
>>> reformatter_SMART('1000',run_name='D',host_geometry='disc')
```

If we used the AGN torus model of Fritz et al. (2006) to run a sample of disc galaxies with flag=1000 and run_name='D', we would type:

```
>>> reformatter_SMART('1000',run_name='D',host_geometry='disc',AGN_model='Fritz')
```

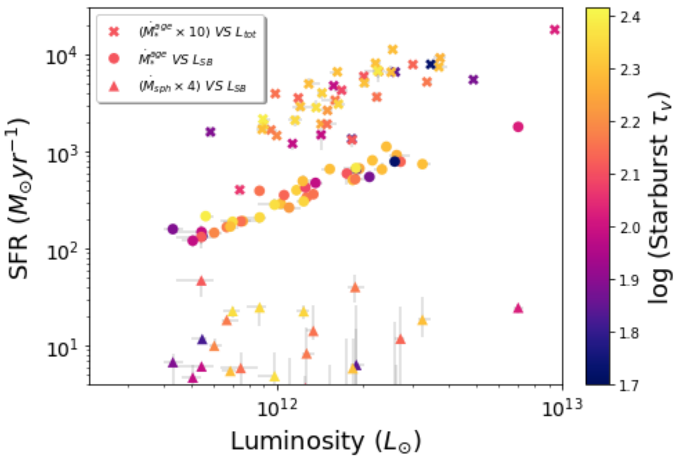

Figure 9: Plot of the SFR against infrared luminosities (starburst or total) created by **SMART**

3.8 Example H: Changing the directory name of the input data file

If we want to name the directory of the input data file for example 'ULIRGs', we first create a folder named 'ULIRGs' and add the ASCII files in this folder. The list of galaxies to be fitted, which is 'objects_list' by default, should then be renamed to 'ULIRGs_list'. To fit the sample of galaxies we type for example:

```
>>> SMART('1000',data_file='ULIRGs')
>>> post_SMART('1000',data_file='ULIRGs')
>>> reformatter_SMART('1000',data_file='ULIRGs')
```

The code creates automatically the folder 'ULIRGs_results', which includes all the results of the SED fitting of the sample of galaxies.

4 List of the keywords used in SMART

- "**data_file**" refers to the name of the input file that includes the data. It can be any name. It is 'objects' by default.
  - If we want to have the default name, we type for example:

    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```

  - If we want to name it for example ULIRGs, we type:

    ```
    >>> SMART('1005',data_file='ULIRGs')
    >>> post_SMART('1005',data_file='ULIRGs')
    ```

- "**host_gal**" refers to the host galaxy model. It can be 'yes' or 'no'. It is 'yes' by default.
  - If we want to have a host galaxy model, we type for example:

    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```

  - If we don't want to have a host galaxy model, we type for example:

    ```
    >>> SMART('1005',host_gal='no')
    >>> post_SMART('1005',host_gal='no')
    ```

- "**host_geometry**" refers to the geometry of the host galaxy. It can be 'sph', referring to a spheroidal geometry, or 'disc', referring to a disc geometry. It is 'sph' by default.
  - If we want to have a spheroidal geometry, we type for example:

    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```

  - If we want to have a disc geometry, we type for example:

    ```
    >>> SMART('1005',host_geometry='disc')
    >>> post_SMART('1005',host_geometry='disc')
    ```

- "**starburst_gal**" refers to the starburst model. It can be 'yes' or 'no'. It is 'yes' by default.
  - If we want to have a starburst model, we type for example:

    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```

  - If we don't want to have a starburst model, we type for example:

    ```
    >>> SMART('1005',starburst_gal='no')
    >>> post_SMART('1005',starburst_gal='no')
    ```

- "**AGN_gal**" refers to the AGN torus model. It can be 'yes' or 'no'. It is 'yes' by default.
  - If we want to have an AGN torus model, we type for example:

    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```

  - If we don't want to have an AGN torus model, we type for example:

    ```
    >>> SMART('1005',AGN_gal='no')
    >>> post_SMART('1005',AGN_gal='no')
    ```

- "**AGN_model**" refers to the library of the AGN torus model. It can be 'CYGNUS', referring to the CYprus models for Galaxies and their NUclear Spectra (CYGNUS) smooth AGN torus model (more details are given in Efstathiou et al. 2021, 2022), or 'Fritz', referring to the smooth AGN torus model of Fritz et al. (2006), or 'SKIRTOR', referring to the two-phase AGN torus model SKIRTOR of Stalevski et al. (2016), or 'Siebenmorgen', referring to the two-phase AGN torus model of Siebenmorgen et al. (2015). It is 'CYGNUS' by default.
  - If we want to use the CYGNUS AGN torus model, we type for example:

    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```

  - If we want to use the AGN torus model of Fritz et al. (2006), we type for example:

    ```
    >>> SMART('1005',AGN_model='Fritz')
    >>> post_SMART('1005',AGN_model='Fritz')
    ```

  - If we want to use the SKIRTOR AGN torus model, we type for example:

```
>>> SMART('1005',AGN_model='SKIRTOR')
>>> post_SMART('1005',AGN_model='SKIRTOR')
```

  - If we want to use the AGN torus model of Siebenmorgen et al. (2015), we type for example:

```
>>> SMART('1005',AGN_model='Siebenmorgen')
>>> post_SMART('1005',AGN_model='Siebenmorgen')
```

- "**polar**" refers to the polar dust model. It can be 'yes' or 'no'. It is 'no' by default.

  - If we want to have a polar dust model, we type for example:

```
>>> SMART('1005',polar='yes')
>>> post_SMART('1005',polar='yes')
```

  - If we don't want to have a polar dust model, we type for example:

```
>>> SMART('1005')
>>> post_SMART('1005')
```

- "**x_axis**" refers to the x-axis range of the SED fit plots. It can be any subrange of the default range, which is [0.1, 1000.].

  - If we want to plot using the default range, we type for example:

```
>>> SMART('1005')
>>> post_SMART('1005')
```

  - If we want to plot using the range [1., 1000.], we type for example:

```
>>> SMART('1005',x_axis=[1., 2000.])
>>> post_SMART('1005',x_axis=[1., 2000.])
```

- "**y_axis**" refers to the y-axis range of the SED fit plots. It can be any subrange of the default range, which is [1.e10, 1.e14].

  - If we want to plot using the default range, we type for example:

```
>>> SMART('1005')
>>> post_SMART('1005')
```

- If we want to plot using the range [1.e8, 1.e13], we type for example:

```
>>> SMART('1005',y_axis=[1.e8, 1.e13])
>>> post_SMART('1005',y_axis=[1.e8, 1.e13])
```

- "**walkers**" refers to the number of walkers we want to use in the *SMART* routine. It can be for example 32, 64, 128, 256, 512 etc. The default number is 128.
  - If we want to use 128 walkers, we type:

```
>>> SMART('1005')
```

  - If we want to use for example 256 walkers, we type:

```
>>> SMART('1005',walkers=256)
```

- "**num_of_runs**" refers to the number of runs (executions) we want to do. It can be any number we want. The default number is 1. It is useful to increase the number of runs in the case where one or more objects are not fitted well, because then *SMART* makes a sequence of runs for each object and the best fit is given by *post_SMART*.
  - If we want to have 1 run, we type:

```
>>> SMART('1005')
>>> post_SMART('1005')
```

  - If we want to have for example 3 runs, we type:

```
>>> SMART('1005',num_of_runs=3)
>>> post_SMART('1005',num_of_runs=3)
```

- "**run_name**" refers to the name at the end of the outputs of each object. It can be any name we prefer. It is 'S' by default.
  - If we want to name it 'S', we type:

```
>>> SMART('1005')
>>> post_SMART('1005')
```

  - If we want to name it for example 'D', we type:

```
>>> SMART('1005',run_name='D')
>>> post_SMART('1005',run_name='D')
```

- "**samples_plot**" refers to the plot of the samples produced by the MCMC method, which can be done in the *SMART* routine. It can be 'yes' or 'no'. It is 'no' by default.
  - If we want the to plot samples, we type for example:
    ```
    >>> SMART('1005',samples_plot='yes')
    ```
  - If we don't want the to plot the samples, we type for example:
    ```
    >>> SMART('1005')
    ```
- "**rel_residual_plot**" refers to the plot of the relative residual. It can be 'yes' or 'no'. It is 'no' by default.
  - If we want to plot the relative residual, we type for example:
    ```
    >>> SMART('1005',rel_residual_plot='yes')
    >>> post_SMART('1005',rel_residual_plot='yes')
    ```
  - If we don't want to plot the relative residual, we type for example:
    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```
- "**corner_plot**" refers to the corner plot, which can be done in the *SMART* routine. It can be 'yes' or 'no'. It is 'no' by default.
  - If we want to have a corner plot, we type for example:
    ```
    >>> SMART('1005',corner_plot='yes')
    ```
  - If we don't want to have a corner plot, we type for example:
    ```
    >>> SMART('1005')
    ```
- "**metallicity**" refers to the metallicity. The default value is 0.008.
  - If want to have the default range, we type for example:
    ```
    >>> SMART('1005')
    >>> post_SMART('1005')
    ```
  - If we want to have for example the value 0.0013, we type:

```
>>> SMART('1005',metallicity=0.0013)
>>> post_SMART('1005',metallicity=0.0013)
```

- "**cy_t_e**" refers to the e-folding time of the SFR of the starburst model, τ_*. The default range is [1.e7, 3.5e7] and the user can change it in the *SMART* routine.
  - If want to have the default range, we type for example:

    ```
    >>> SMART('1005')
    ```

  - If we want to have for example the value 3×10^7, we type:

    ```
    >>> SMART('1005',cy_t_e=3.e7)
    ```

We proceed similarly for the other keywords that refer to the model parameters listed in Table 3:

Table 3: Index of the keywords used in **SMART**

Keyword	Possible values	Default value	Description
data_file	any name	'objects'	name of input file
host_gal	'yes'/'no'	'yes'	host galaxy model
host_geometry	'sph'/'disc'	'sph'	geometry of the host galaxy
starburst_gal	'yes'/'no'	'yes'	starburst model
AGN_gal	'yes'/'no'	'yes'	AGN torus model
AGN_model	'CYGNUS'/'Fritz'/ 'SKIRTOR'/'Siebenmorgen'	'CYGNUS'	library of the AGN torus model
polar	'yes'/'no'	'no'	polar dust model
x_axis	any value in the default range	[0.1, 1000.]	x-axis range of the SED fit plots
y_axis	any value in the default range	[1.e10, 1.e14]	y-axis range of the SED fit plots

walkers	multiple of 32	128	number of walkers
num_of_runs	any number	1	number of runs (executions)
run_name	any preferred name	'S'	name at the end of the outputs
samples_plot	'yes'/'no'	'no'	plot of the samples produced by MCMC
rel_residual_plot	'yes'/'no'	'no'	plot of the relative residual
corner_plot	'yes'/'no'	'no'	corner plot
metallicity	any number	0.008	Metallicity
cy_t_e	any value in the default range	[1.e7, 3.5e7]	e-folding time of starburst model
cy_age	any value in the default range	[5.e6, 3.5e7]	Starburst age
cy_tau_v	any value in the default range	[51., 250.]	Initial optical depth of GMCs
cy_tvv	any value in the default range	[0.1, 15.]	Optical depth of spheroidal model
cy_psi	any value in the default range	[1.1, 16.9]	Starlight intensity of spheroidal model
cy_cirr_tau	any value in the default range	[1.26e8, 7.9e9]	e-folding time of spheroidal model
cy_iview	any value in the default range	[0.1, 89.9]	Inclination of disc model
cy_r2tor1	any value in the default range	[21., 99.]	Torus ratio of outer to inner radius of the CYGNUS model
cy_theta_1	any value in the default range	[16., 58.]	Torus half-opening angle of the CYGNUS model
cy_tau_uv	any value in the default range	[260., 1490.]	Torus equatorial UV optical depth of the CYGNUS model
fr_ct	any value in the default range	[31., 69.]	Torus half-opening angle of the model of Fritz et al. (2006)
fr_rm	any value in the default range	[11., 149.]	Torus ratio of outer to inner radius of the model of Fritz et al. (2006)
sk_oa	any value in the default range	[21., 75.]	Torus half-opening angle of the SKIRTOR model
sk_rr	any value in the default range	[10., 30.]	Torus ratio of outer to inner radius of the SKIRTOR model
sk_tt	any value in the default range	[3., 11.]	Torus equatorial optical depth at $9.7\mu m$ of the SKIRTOR model

si_vc	any value in the default range	[16., 770.]	Cloud volume filling factor of the model of Siebenmorgen et al. (2015)
si_ac	any value in the default range	[1., 440.]	Optical depth of the individual clouds of the model of Siebenmorgen et al. (2015)
si_ad	any value in the default range	[50., 499.]	Optical depth of the disc mid-plane of the model of Siebenmorgen et al. (2015)
po_polt	any value in the default range	[800., 1200.]	Polar dust temperature

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Appendices

A Example of file with the name flobject_listfl that lists the galaxies to be fitted

```
name                redshift          flag      AGN_type
IRAS00188-0856       0.12840          1001         2
IRAS05189-2524       0.04256          1002         2
IRAS07598+6508       0.14830          1003         1
CGCG436-030          0.03123          1004         2
```

B Example of data file

```
micron     Jy          Jy             quality   source
5.65540    0.0174535   0.000907397    0         IRS
6.34546    0.0290198    0.00153100    0         IRS
7.11972    0.0203924    0.00130375    0         IRS
7.98846    0.0246947    0.00123474    0         IRS
8.96320    0.0502866    0.00251433    0         IRS
10.0569    0.0158481   0.000818068    0         IRS
11.2840   0.00428702   0.000786947    0         IRS
11.9526   0.00740522    0.00108871    0         IRS
12.6609    0.0342756    0.00171378    0         IRS
13.4111    0.0334787    0.00185416    0         IRS
14.2057    0.0718382    0.00359191    0         IRS
15.0475    0.0741791    0.00370895    0         IRS
15.9391    0.0806690    0.00403345    0         IRS
17.8839    0.0784355    0.00392178    0         IRS
20.0661    0.0852169    0.00426085    0         IRS
22.5145     0.141823    0.00709115    0         IRS
25.2617     0.241376     0.0120688    0         IRS
28.3441     0.399525     0.0199762    0         IRS
6.43188    0.0284149    0.00163181    0         IRS
6.99608    0.0250463    0.00175742    0         IRS
8.68868    0.0506195    0.00253098    0         IRS
9.70424    0.0362319    0.00181160    0         IRS
10.9455   0.00524488   0.000779330    0         IRS
12.7509    0.0346699    0.00173349    0         IRS
0.481000  0.000256110 2.56110e-005    0         Panstarrs
0.617000  0.000497080 4.97080e-005    0         Panstarrs
0.752000  0.000753748 7.53748e-005    0         Panstarrs
0.866000  0.000859857 8.59857e-005    0         Panstarrs
0.962000   0.00100375  0.000100375    0         Panstarrs
250.000     0.877300     0.0438650    0         HERUS
350.000     0.345100     0.0172550    0         HERUS
500.000     0.111000    0.00555000    0         HERUS
0.153846 5.57000e-006 1.26000e-006    0         NED
0.232558 1.45000e-005 1.65000e-006    0         NED
1.25000   0.00179000   0.000163000    0         NED
1.64835   0.00313000   0.000267000    0         NED
2.17391   0.00359000   0.000321000    0         NED
3.55450   0.00260000   0.000130000    0         NED
```

4.49775	0.0120000	0.000600000	0	NED
5.73614	0.0208000	0.00104000	0	NED
7.87402	0.0324000	0.00162000	0	NED
25.0000	0.372000	0.0222000	0	NED
60.0000	2.59000	0.233000	0	NED
100.000	3.40000	0.340000	0	NED
57.0000	2.59000	0.360000	0	Farrah13
63.0000	2.84000	0.510000	0	Farrah13
79.0000	3.42000	0.500000	0	Farrah13
122.000	2.33000	0.333000	0	Farrah13
145.000	2.15000	0.330000	0	Farrah13
157.000	1.43000	0.210000	0	Farrah13

C Example of output from *SMART*, giving the fitted parameters and their errors

```
IRAS00188-0856

fsph  :  0.001 0.000 0.000
tvv  :  1.234 0.609 11.336
psi  :  5.587 0.916 0.877
cirr_tau  :  1471065581.161 94680228.622 601254236.996
fsb  :  2.907 0.115 0.249
tau_v  :  128.655 17.771 9.163
age  :  32192730.293 1922139.865 833378.381
t_e  :  15531883.227 500333.872 1042925.385
fagn  :  0.090 0.010 0.017
r2tor1  :  57.422 21.085 30.866
tau_uv  :  394.958 18.886 77.681
theta_1  :  43.577 3.950 2.659
theta_v  :  13.543 0.373 4.457
fpol  :  0.000 0.000 0.000
polt  :  900.497 26.340 63.532
Min_chi_squared :  100.94364426130923
```

D Example of output from *post_SMART*, giving the extracted quantities and their errors

```
IRAS00188-0856

fsph  :  0.001 -0.000 0.000
tvv  :  1.234 -0.609 11.336
psi  :  5.587 -0.916 0.877
cirr_tau  :  1471065581.161 -94680228.622 601254236.996
fsb  :  2.907 -0.115 0.249
tau_v  :  128.655 -17.771 9.163
age  :  32192730.293 -1922139.865 833378.381
t_e  :  15531883.227 -500333.872 1042925.385
fagn  :  0.090 -0.010 0.017
r2tor1  :  57.422 -21.085 30.866
tau_uv  :  394.958 -18.886 77.681
theta_1  :  43.577 -3.950 2.659
theta_v  :  13.543 -0.373 4.457
fpol  :  0.000 -0.000 0.000
polt  :  900.497 -26.340 63.532
lum_agn_raw :  1.809e+11 -1.519e+10 2.914e+10
lum_agn_cor :  4.729e+11 -6.289e+10 6.002e+10
lum_sb :  1.763e+12 -4.775e+10 8.771e+10
lum_sph :  3.853e+10 -4.796e+09 8.567e+10
lum_pol :  0.000e+00 -0.000e+00 0.000e+00
lum_tot_raw :  2.022e+12 -9.423e+10 7.063e+10
lum_tot_cor :  2.327e+12 -1.544e+11 8.907e+10
sfr_sb :  3.857e+02 -6.789e+01 3.137e+00
sfr_sb_age :  5.926e+02 -6.936e+01 7.096e+00
sfr_sph :  3.768e-01 -1.811e-01 2.573e+00
sfr_total :  5.928e+02 -6.563e+01 7.287e+00
stellar_mass_sph :  1.454e+11 -2.346e+09 2.833e+10
stellar_mass_sb :  1.725e+10 -3.015e+09 3.425e+07
stellar_mass_total :  1.627e+11 -3.061e+09 2.528e+10
agn_fraction :  0.200 -0.012 0.021
aniso_factor :  2.538 -0.137 0.310
redshift :  0.12840001
Max_log_likelihood :  -546.7661749939144
Min_chi_squared :  100.94364426130923
Data_points :  50
Reduced_chi_squared :  2.656411691087085
```

E Example of tables with parameters and extracted physical quantities and their errors, done using *reformatter_SMART*

Name	z	$\chi^2_{min,\nu}$	τ^s_v	ψ^s	τ^s $(10^7 yr)$	τ_v
IRAS00188-0856	0.12840001	2.66	$1.23^{11.34}_{-0.61}$	$5.59^{0.88}_{-0.92}$	$147.11^{60.13}_{-9.47}$	$128.66^{9.16}_{-17.77}$
IRAS00397-1312	0.2617	2.78	$0.44^{0.54}_{-0.24}$	$8.92^{6.17}_{-2.37}$	$326.65^{50.05}_{-65.95}$	$105.47^{5.39}_{-3.12}$
IRAS01003-2238	0.1178	1.3	$0.77^{0.17}_{-0.36}$	$2.56^{0.4}_{-0.4}$	$778.94^{6.75}_{-29.1}$	$65.58^{4.93}_{-7.73}$
IRAS03158+4227	0.1344	1.64	$0.44^{0.67}_{-0.2}$	$3.07^{2.46}_{-1.15}$	$178.15^{208.11}_{-127.35}$	$186.57^{12.27}_{-14.86}$
IRAS03521+0028	0.1519	3.16	$4.42^{4.06}_{-1.95}$	$2.28^{0.9}_{-0.45}$	$25.37^{3.22}_{-4.22}$	$179.99^{14.26}_{-15.5}$

Name	t_* $(10^7 yr)$	τ_* $(10^7 yr)$	r_2/r_1	τ_{uv}	θ_o $(^\circ)$	θ_i $(^\circ)$
IRAS00188-0856	$3.22^{0.08}_{-0.19}$	$1.55^{0.1}_{-0.05}$	$57.42^{30.87}_{-21.08}$	$394.96^{77.68}_{-18.89}$	$46.42^{2.66}_{-3.95}$	$76.46^{4.46}_{-0.37}$
IRAS00397-1312	$0.77^{0.14}_{-0.16}$	$2.01^{0.22}_{-0.23}$	$89.46^{6.71}_{-5.84}$	$329.52^{9.58}_{-9.24}$	$73.81^{0.27}_{-0.09}$	$83.12^{1.11}_{-0.87}$
IRAS01003-2238	$1.38^{0.25}_{-0.19}$	$1.45^{0.28}_{-0.11}$	$52.48^{5.82}_{-3.25}$	$1310.68^{86.96}_{-24.24}$	$61.37^{0.19}_{-0.09}$	$69.32^{0.27}_{-0.2}$
IRAS03158+4227	$3.03^{0.25}_{-0.39}$	$1.39^{0.15}_{-0.15}$	$30.93^{5.92}_{-3.6}$	$959.57^{33.8}_{-51.93}$	$53.97^{4.84}_{-2.01}$	$76.88^{0.62}_{-0.6}$
IRAS03521+0028	$3.4^{0.07}_{-0.05}$	$1.55^{0.2}_{-0.2}$	$45.37^{1.6}_{-3.74}$	$1245.22^{81.44}_{-99.23}$	$58.9^{3.52}_{-3.74}$	$70.52^{1.82}_{-1.4}$

Name	z	L^c_{AGN}	L_{SB}	L_{sph}	L^c_{tot}	$\dot{M}^{age}_*$	$\dot{M}_{sph}$
		$10^{12} L_\odot$	$10^{11} L_\odot$	$10^{10} L_\odot$	$10^{12} L_\odot$	$M_\odot yr^{-1}$	$M_\odot yr^{-1}$
IRAS00188-0856	0.12840001	$0.43^{0.11}_{-0.1}$	$17.63^{0.88}_{-0.48}$	$3.47^{8.95}_{-0.09}$	$2.27^{0.14}_{-0.15}$	$592.6^{7.1}_{-69.36}$	$0.24^{2.71}_{-0.05}$
IRAS00397-1312	0.2617	$19.42^{1.85}_{-1.52}$	$69.97^{5.4}_{-2.61}$	$5.39^{0.63}_{-0.31}$	$26.25^{1.97}_{-1.1}$	$1822.0^{107.8}_{-170.2}$	$6.17^{0.63}_{-0.8}$
IRAS01003-2238	0.1178	$7.07^{0.25}_{-0.39}$	$5.56^{0.13}_{-0.5}$	$2.3^{0.14}_{-0.37}$	$7.6^{0.29}_{-0.34}$	$134.8^{10.72}_{-8.25}$	$2.94^{0.05}_{-0.44}$
IRAS03158+4227	0.1344	$6.61^{1.48}_{-1.22}$	$26.49^{3.6}_{-1.41}$	$1.35^{1.71}_{-0.58}$	$9.26^{1.38}_{-1.14}$	$904.6^{37.53}_{-41.98}$	$0.42^{2.44}_{-0.42}$
IRAS03521+0028	0.1519	$1.98^{0.93}_{-0.82}$	$19.51^{0.79}_{-2.43}$	$1.84^{1.25}_{-0.5}$	$3.91^{1.06}_{-0.83}$	$667.3^{33.28}_{-95.5}$	$0.0^{0.0}_{-0.0}$

Name	$\dot{M}_{tot}$	M^*_{sph}	M^*_{SB}	M^*_{tot}	F_{AGN}	A
	$M_\odot yr^{-1}$	$10^{10} M_\odot$	$10^9 M_\odot$	$10^{10} M_\odot$		
IRAS00188-0856	$592.8^{7.29}_{-65.63}$	$14.44^{2.94}_{-0.13}$	$17.25^{0.03}_{-3.02}$	$16.16^{2.64}_{-0.2}$	$0.19^{0.03}_{-0.04}$	$2.48^{0.37}_{-0.26}$
IRAS00397-1312	$1827.0^{109.7}_{-169.2}$	$9.7^{2.66}_{-1.79}$	$13.19^{1.34}_{-1.91}$	$11.03^{2.79}_{-1.72}$	$0.73^{0.03}_{-0.02}$	$8.26^{0.24}_{-0.3}$
IRAS01003-2238	$137.6^{10.41}_{-8.06}$	$2.21^{0.06}_{-0.27}$	$1.74^{1.11}_{-0.25}$	$2.35^{0.09}_{-0.13}$	$0.93^{0.0}_{-0.01}$	$5.57^{0.1}_{-0.06}$
IRAS03158+4227	$907.5^{34.95}_{-44.92}$	$4.0^{3.42}_{-1.96}$	$24.02^{2.03}_{-2.02}$	$6.31^{3.59}_{-1.74}$	$0.7^{0.05}_{-0.04}$	$6.43^{0.8}_{-1.01}$
IRAS03521+0028	$667.3^{33.28}_{-95.5}$	$7.96^{3.06}_{-1.55}$	$19.9^{1.03}_{-2.48}$	$9.94^{3.17}_{-1.44}$	$0.51^{0.08}_{-0.13}$	$7.67^{0.87}_{-2.51}$