CIGALE: Code Investigating GALaxy Emission

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Abstract. We present CIGALE ([Burgarella et al. 2005; Noll et al. 2009]), a software developed at the Laboratoire d’Astrophysique de Marseille to fit galaxy spectral energy distributions from the rest-frame far-UV to far-IR wavelength range, and to derive some of their physical parameters. We also give some examples of scientific results obtained with CIGALE.

1. Aim of the software

The multi-wavelength observation of galaxies allows astrophysicists to derive some of their physical parameters from the comparison of their spectral energy distributions (SEDs) to computed SEDs based on models and templates (SED fitting). Scientists from the Laboratoire d’Astrophysique de Marseille developed CIGALE (/si.gal/), a Code Investigating Galaxy Emission, that takes into account both the dust ultraviolet-optical attenuation and its corresponding infra-red re-emission. CIGALE is able to statistically derive reliable physical parameters from UV to IR observations.

2. How CIGALE works

The user provides CIGALE with multi-λ fluxes and redshift for each galaxy, and with a list of possible values for each physical parameter. The parameters are those related to star formation history (τ and ages for young and old stellar populations (SP), mass fraction of young SP), dust attenuation (V-band attenuation, reduction factor of A_v for old SP) and dust emission (IR power-law slope, AGN related fraction of L_dust).

Using various models, libraries and templates (see figure [1]), CIGALE computes all the possible spectra and derives mean fluxes in the observed filter bands. Then a

http://lam.oamp.fr
Figure 1. CIGALE operation workflow
Bayesian-like statistical analysis permits to determine for each galaxy the best value for each parameter as well as the best computed model (see figure 2).

3. Example of scientific applications

![Graphical representation](image)

Figure 2. Examples of scientific use. Left: $z = 1.38$ galaxy SED showing 217.5\(\text{nm}\) depression ([Buat et al. 2011]). Right: CIGALE fitting of HLSW-01 - adapted from [Conley et al. 2011].

3.1. High-redshift galaxy study

[Buat et al. 2011] combined photometric data with broad and intermediate band filters, and far-infrared data from Herschel to sample the ultraviolet spectrum of high redshift galaxies and characterize their dust extinction (see figure 2 left). A depression at 217.5\(\text{nm}\) is clearly identified in all sources. An analytical formula of the dust attenuation curve is deduced from CIGALE with a bump of moderate amplitude at 217.5\(\text{nm}\) (see also [Burgarella et al. 2011; Giovannoli et al. 2011]).

3.2. Multiply-lensed galaxy study

[Conley et al. 2011] used CIGALE to study the multiply-lensed galaxy HLSW-01 and compute some of its physical properties, in particular its stellar mass, its star formation rate and the proportion of young stars. The right part of figure 2 compares the best CIGALE model to the best combination of templates from [Rowan-Robinson et al. 2010] and IR SEDs of Arp220 and M82.

4. CIGALEMC - Using Monte Carlo Markov Chain statistical method

From the CIGALE code base [Serra et al. 2011] developed CIGALEMC that uses a Monte Carlo Markov Chain method to find the best fit parameters. CIGALEMC is made to be efficient (needed CPU time grows linearly, not exponentially, with the number of fitted parameters), accurate (statistical quantities are robustly determined using Gelman & Rubin diagnostic as convergence criteria) and user friendly (a priori deciding the parameter density, to find a compromise between accuracy and speed, is not necessary).
5. Future evolutions

In addition to Dale & Helou (2002), we want to propose the use of Chary & Elbaz (2001), Siebenmorgen & Krügel (2007) and Draine & Li (2007) libraries, as well as the use of CB07 stellar population model from Bruzual and Charlot in addition to Maraston (2005).

We are studying the port of CIGALE to Python – presently the code is written in Fortran – for more modularity, more readability of the code and more evolution opportunities.

6. Contact and download

CIGALE is available for download on its web site where you will also find an on-line, java applet based, version. For more information on CIGALE software, you can contact Denis Burgarella <denis.burgarella@oamp.fr>.

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