Modelling and interpreting galaxy spectral energy distributions in the era of JWST/NIRSpec

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Introduction

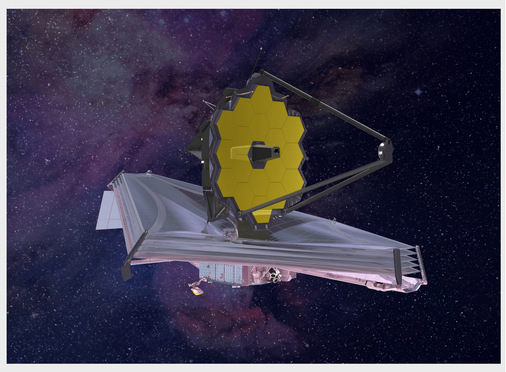
To compare predictions of **galaxy formation** models with observations we must relate properties pertaining to the evolution of baryons in dark-matter haloes, such as gas cooling and star formation, with observables, such as ultraviolet, optical and infrared spectral energy distributions (SEDs). This can be achieved using models of **stellar population synthesis** and of the transfer of starlight through the interstellar and intergalactic media.

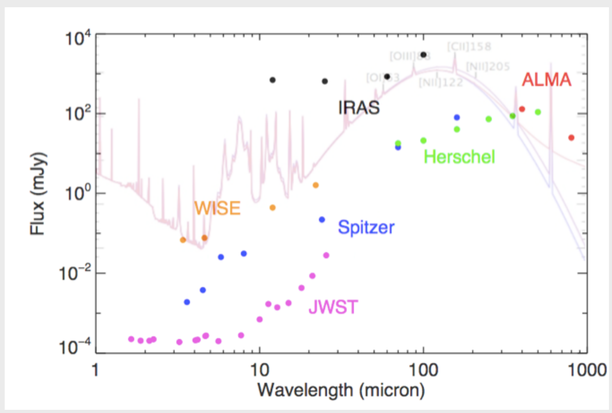
In the future, new observatories such as the **James Webb Space Telescope** (JWST) and **Extreme Large Telescopes** (ELTs) will provide us with a wealth of high-quality (spectroscopic and photometric) data for large samples of high-redshift galaxies. Interpreting such data in the framework of different **galaxy evolution** scenarios requires the development of new models and tools tailored at the interpretation of **high-redshift galaxy spectral energy distributions** (SEDs).

James Webb Space Telescope

The James Webb Space Telescope comprises a **6.5 m primary mirror** (7x HST collecting area) and 4 instruments operating at **near- to mid-infrared** wavelengths.

It provides a wide range of **imagining** (narrow- and broad-band filters) and **spectroscopic** (low to medium resolution) capabilities from **0.6 to 30 micron**.

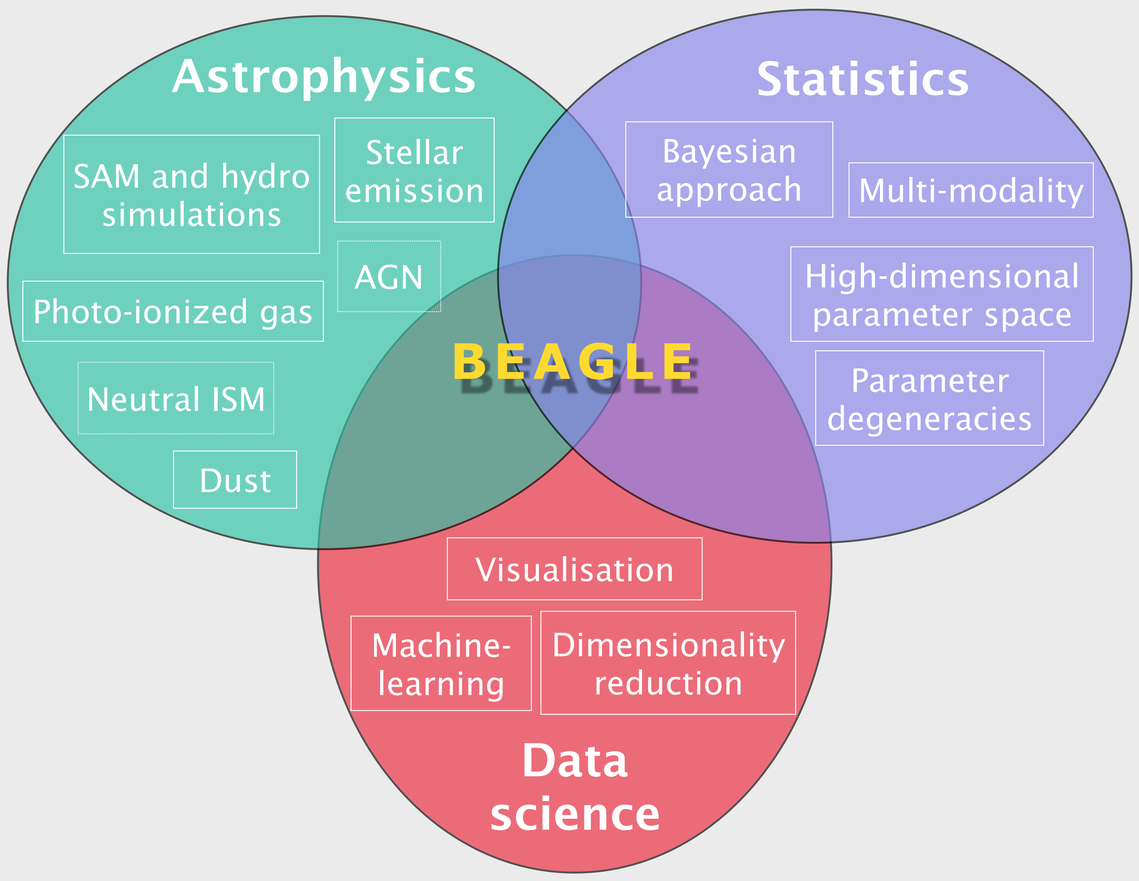




The design and exquisite **sensitivity** of JWST (scheduled for launch in November 2018) will provide unique data to improve our understating on the formation and evolution of the **first galaxies**, **cosmic reionization**, **birth of stars** and **of proto-planetary systems**, composition of **exoplanets**, and **origin of life**.

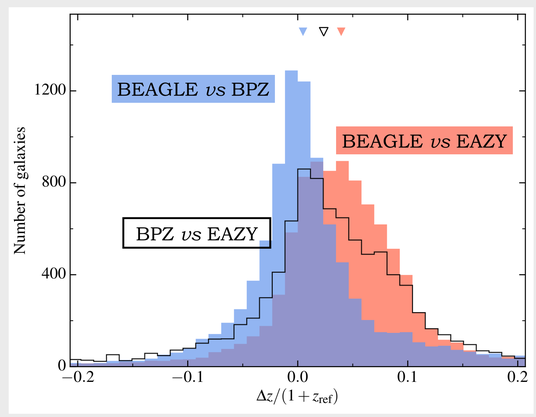
BEAGLE: BayEsian Analysis of GaLaxy sEds

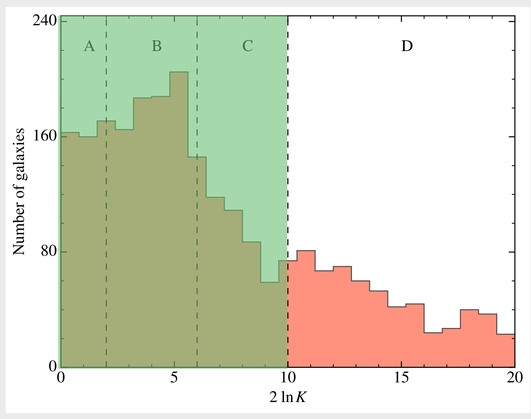
BEAGLE is a new-generation tool to **model and interpret galaxy SEDs**, which incorporates in a consistent way the production of radiation and its transfer through the interstellar and intergalactic media. This flexible tool allows one to build **mock galaxy catalogues** as well as to interpret in terms of **physical parameters** any combination of photometric and spectroscopic galaxy observations.



Insights on photometric redshifts

We validate the BEAGLE tool on a large sample of ~**10^4 galaxies** in the Hubble Ultra Deep Field (**UVUDF**, Rafelski et al., 2015) with **UV to NIR photometry** (HST ACS and WFC3). The **photo-*z* performance** obtained using this multi-purpose tool are comparable to those obtained using public, dedicated photo-*z* codes (see fig. on the right).

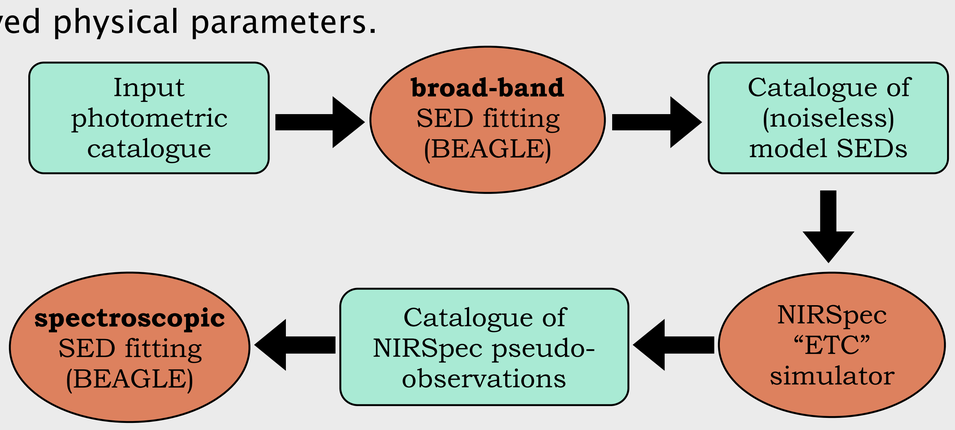




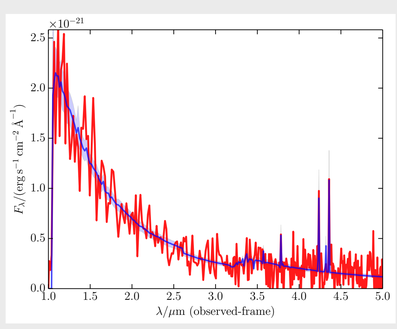
By means of the BEAGLE tool, we can identify galaxies exhibiting **multiple redshift solutions** of comparable probability, i.e. with a Bayes factor 2 ln K < 10 (left fig.). These galaxies appear preferentially as **outliers** in comparisons between spectroscopic and photometric redshifts, and between photo-*z* obtained with different codes.

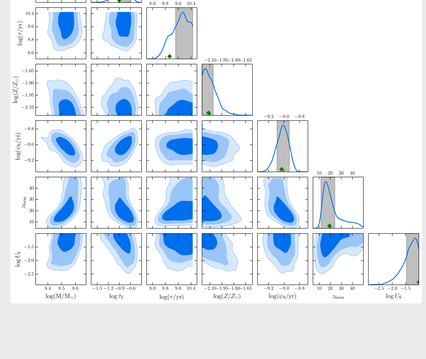
Simulating JWST/NIRSpec observations

We fit with BEAGLE the **XDF** photometric **catalogue** (Bouwens et al., 2015) to obtain a catalogue of noiseless galaxy SEDs. which we use as input to simulate **deep** (~10^5 s) **NIRSpec/PRISM** exposures. We then fit, pixel-by-pixel, the simulated NIRSpec observation and compare the input and retrieved physical parameters.



We show below an example of a simulated NIRSpec observation (red) for the XDF galaxy #3920463221, a *Y*-dropout with H_{AB}=**28.75**, that we position at ***z*=8.648**. The blue line show the retrieved SED, along with its variation (shaded blue). The figure on the right show the posterior *pdf* of the model parameters, along with the input values (green diamonds).





Future developments

Several people are contributing to the further development of the BEAGLE tool, to include the emission from an **AGN** (Anna Feltre), the effect of absorption and emission form the **neutral ISM** in galaxies (Alba Vidal, Aida Wofford), the effect of chemical abundance variations on the emission from **HII regions** (Julia Gutkin), the implementation of **multi-level Bayesian modelling** approach to constrain population-wide relations among galaxy physical parameters (Emma Curtis-Lake and David Stenning).

References:

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