SED fitting: best practices for gaining insight into high-redshift galaxies and AGN

EURECA discussion
March 1, 2024

Discussion: a comparison between SED fitting codes and outlook for future work

- Commonly used defaults in EAzY/EAzY-py, Bagpipes, BEAGLE & Prospector
- Pros and cons of each code
- Summary of best practices
- Understanding the differences between galaxy properties inferred from different codes
- Future work
  - IMF considerations
  - IGM attenuation to correct photo-z's
  - Including spectroscopic information in SED fit

Some defaults in commonly used codes

	Stellar isochrones (all single star)	SPS models	Nebular emission models	IMF	Dust attenuation model	IGM absorption model
BAGPIPES Carnall et al. (2018)	PARSEC	BC03, updated 2016	Byler et al. (2017)	Kroupa (2001)	No real default	Inoue et al. (2014)
Prospector Johnson et al. (2021)	MIST	FSPS	Byler et al. (2017)	Kroupa (2001)	Power law with default slope of -0.7	Madau (1995) can't change model but can change normalization
BEAGLE Chevallard and Charlot (2016)	PARSEC	BC03, updated 2016	Gutkin et al. (2016)	Chabrier (2003) can't change IMF but can change mass range (1-100 $M_\odot$ or 1-300 $M_\odot$)	No real default	No real default either Inoue et al. (2014) or Madau (1995)* *Lily thinks, she's not totally sure

Pros & Cons

	Computational Speed	Ease of use	Galaxy properties	AGN properties	Ideal for
BAGPIPES Carnall et al. (2018)	Medium fast	Fairly easy	Very detailed	Not included	Photometric redshifts, galaxy properties
Prospector Johnson et al. (2021)	Very slow	Very complicated lol	Very detailed	Can be included with Prosp-beta/ask Jianwei nicely	Galaxy properties, star formation histories, *maybe* AGN
BEAGLE Chevallard and Charlot (2016)	Medium slower than BAGPIPES, faster than Prospector	Mildly complicated it's mostly kind of limited by docker	Very detailed	Yes turned off by default	Galaxy properties, photometric redshifts (arguably)
EAZY Brammer et al. (2008) EAZY-Py repo	Very fast	Very eazy	Not included	Not included	Photometric redshifts

General best practices & common pitfalls

- Understand your IMF, SPS, and IGM attenuation assumptions
- Number of free parameters < number of data points
- Star formation history considerations:
    - Non-parametric is popular but unconstraining for sparse photometric coverage
    - Constant SFH is a lower limit on stellar mass → continuity prior is ~a maximum
    - DPL seems most appropriate for older/lower-redshift galaxies but not high-z
- Understand your redshift limitations: not all codes optimized to fit for photo-z and also derive galaxy properties
- What do you think are the most common pitfalls or bad assumptions?

Understanding discrepancies between codes

- Which basic assumption do you think has the biggest impact on inferred galaxy properties (e.g. IMF, attenuation curves, SPS)?
- What do you think causes systematic photo-z/spec-z offsets?
- How do you decide an appropriate prescription for star formation history? (delayed-tau, non-parametric, constant, etc)
  - Star formation history parameters greatly affect the best-fit spectrum translating to discrepancies in stellar age and stellar mass: a lot to do with outshining and extended star formation at early times
- What impact does including AGN prescriptions have on inferred galaxy properties?

Future work

- Careful treatment of resolved vs. integrated photometry
- Taking AGN into account as a default
- Adding spectral information when available → direct input of line fluxes vs. feeding in a full spectrum
- Empirically motivated priors: MZR
- What do you think is most important in improving:
    - the design of new features in existing/new codes?
    - best practice use of existing codes?

Understanding how to use spectra when available

- The organizers have no expertise in spectrophotometric fitting: thoughts on how to best use spectral information?
  - Pseudo-narrowbands containing line fluxes
  - BEAGLE allows direct input of line fluxes
  - Directly using spectra: still a difficult task, but possible with all codes presented here besides EAzY
- Bagpipes allows for direct input of 1D spectra and takes into account variable spectral resolution, modeling velocity dispersion, and flux calibrating spectral fluxes to photometry
  - https://github.com/ACCarnall/bagpipes/blob/master/examples/Example%205%20-%20Fitting%20spectroscopic%20data.ipynb