Extracting Accurate Physical Parameters From Broadband Photometry With a New Generation of SED Models

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with Benjamin Johnson, Charlie Conroy, and Pieter van Dokkum
Simple SED models can result in misleading error bars and biased parameters.
Galaxies are complex

Many parameters control the observed SED

Highly degenerate problem when fitting broadband photometry

Leja et al. 2016 in prep
Two fitters with reasonable but different implementations can produce drastically different galaxy properties.

Leja et al. 2016 in prep
It is not yet possible for models to fully match both the observed SFRs and the observed stellar mass function! 

also see Leja+14, Madau+14, Genel+14, Tomczak+15, Davé+16, and many others...!
**Inference Framework**

Prospector, maintained by Ben Johnson
- **On-the-fly** stellar population generation allows flexibility + high dimensionality
- **Bayesian statistics** with transparent + easily customizable priors
- **MCMC ensemble sampling** with the emcee python package
- **fits photometry + spectroscopy** with flexible noise modeling
- See poster #18 for more information

**Stellar Population Synthesis**

FSPS, maintained by Charlie Conroy
- performs **fast, accurate, state-of-the-art** stellar population synthesis

**Leja et al. in prep Model**

11 parameters + normalization

**Stars**

- **SFH (4 parameters)**
  flexible, allows for bursts and quenching (Simha+14)
- **Stellar Metallicity (1 parameter)**
  metallicity distribution function
- **Attenuation (3 parameters)**
  two-component Charlot & Fall model with variable attenuation curve
- **Emission (3 parameters)**
  Draine & Li (2007) model and circumstellar dust

**Dust**

**Gas**

CLOUDY grids (0 parameters)
nebular line and continuum emission
Test Sample

- 129 z=0 galaxies from Brown et al. 2014.

- GALEX to Spitzer 24 μm broadband imaging, +subsample have Herschel imaging

- Optical spectroscopy, aperture-matched to photometry

- Eclectic mix of stellar masses, sSFRs, and galaxy morphologies.

Leja et al. 2016 in prep
Model $H\alpha$ compared to observed $H\alpha$
calculated from the Kennicutt+98 conversion between $H\alpha$ and SFR
tests model dust attenuation and model SFR

Prospector

public version of MAGPHYS

Leja et al. 2016 in prep
Model $H\alpha$ compared to observed $H\alpha$
using built-in CLOUDY $H\alpha$ flux

integrates ionizing UV flux from model, adding information about \textit{stellar metallicity}

Prospector

public version of MAGPHYS

Leja et al. 2016 in prep
Dust Attenuation Towards HII Regions
from the observed Balmer decrement

S/N (H\(\alpha\), H\(\beta\)) > 5
N = 45

Prospector \(A_{H\alpha} - A_{H\beta}\)

observed \(A_{H\alpha} - A_{H\beta}\)

star-forming composite AGN

Leja et al. 2016 in prep
The $D_n(4000)$ Break

test of stellar age and metallicity

Leja et al. 2016 in prep
H$\delta$ Absorption

test of stellar age

log($\log$ (observed H$\delta$ EQW))

log(Prospector H$\delta$ EQW))

S/N H$\delta$ > 5
N = 29

mean offset = 0.07 dex
biweight scatter = 0.13 dex

Leja et al. 2016 in prep
We built a galaxy SED model that fits broadband photometry to predict $H_\alpha$ luminosities with both high accuracy and precision.

In addition to $H_\alpha$, we investigate and validate the following quantities:

- dust PAH mass fractions
- $H\delta$ absorptions
- $D_n(4000)$
- nebular attenuation
- stellar metallicities
- dust attenuation curves

The Future
simultaneous, self-consistent derivation of stellar masses($z$) and star formation rates($M,z$)
— new values? new consistency?