A Census of Stellar Mass in Massive Central Galaxies

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Star formation and mass assembly of dark matter halos.

- Star formation efficiency
- Gas accretion history
- Gas recycling (ISM/IGM)
- Feedback (SNe/AGN)
- Mergers
- Hierarchical assembly
- …
The stellar mass function places stringent constraints on galaxy formation models.

Rodrigues, Vernon, & Bower 2017

GALFORM semi-analytic model
However, models differ widely, especially at the massive end of the $z \sim 0$ stellar mass function.

Models have been calibrated to match at the *knee*.

**Cosmic CARNage:** Knebe et al. 2018
Similarly, the stellar mass-halo mass relation is highly model-dependent.

Central galaxies, $z \sim 0$. 

Cosmic CARNage: Knebe et al. 2018
But measurements of the massive end of the stellar mass function are also discrepant, even at $z \sim 0$. 

![Graph showing the mass function at different redshifts](image_url)
Use massive (elliptical) galaxies as tracers of the galaxy formation process in massive halos.

Blanton & Moustakas 2009
The goal of the *legacyhalos* project is an accurate census of the stellar mass content and growth of massive central galaxies.

http://legacysurvey.org
https://github.com/moustakas/legacyhalos
http://risa.stanford.edu/redmapper

All public data & code!
Tracing the stellar mass growth of massive galaxies—

- deep, well-calibrated wide-field imaging
- multiple colors; solid redshifts
- halo mass estimates
The Legacy Surveys—legacy surve y.org
Imaging surveys for the Dark Energy Spectroscopic Instrument (DESI)

- ~14,000 deg²; g=24, r=23.4, z=22.5
- WISE/NEOWISE-r 5-year stacks
- <10 mmag PSF photometry; astrometry tied to Gaia/DR2
- 6 data releases in three years!; DR7 imminent

Dey et al. 2018
Meisner, Lang, & Schlegel 2018
Dark Energy Spectroscopic Instrument (DESI)

- 5-year survey (2020-2024);
- 9 deg$^2$ FOV + 5000 robotic fiber positioners;
- 3600-9800 Å spectra with $R=2000-5000$;
- >30 million precise redshifts from $z=0-4$ +10 million stellar spectra!
- Dark energy, tests of GR/infation, neutrino hierarchy + tons of galaxy science

The DESI Collaboration et al., 2017ab
Sampling of the density field at redshift $\sim 0.3$. 

Credit: Jeremy Tinker
Sample consists of $>10^5$ central galaxies at $0.1<z<0.6$ with richness-derived halo masses ($10^{13.5}-10^{15}$ $M_{\text{sun}}$).

http://risa.stanford.edu/redmapper
Inferring the integrated stellar mass of each central.

1. Isolate the light of the central.

A success…

The Tractor

Lang, Hogg, & Schlegel 2014
Lang et al., in prep.
Inferring the integrated stellar mass of each central.

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A success…

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300 kpc at z~0.35
Inferring the integrated stellar mass of each central.

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...and a failure.

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The Tractor

Lang, Hogg, & Schlegel 2014
Lang et al., in prep.

300 kpc at z~0.17
Inferring the integrated stellar mass of each central.

1. Isolate the light of the central.

...and a failure.

*The Tractor*

Lang, Hogg, & Schlegel 2014
Lang et al., in prep.

300 kpc at $z \sim 0.17$
Inferring the integrated stellar mass of each central.

2. Perform forced photometry using elliptical isophotes.
Inferring the integrated stellar mass of each central.


\[ n(\lambda) = n_{\text{ref}} \left( \frac{\lambda}{\lambda_{\text{ref}}} \right)^\alpha \]

\[ r_{50}(\lambda) = r_{50,\text{ref}} \left( \frac{\lambda}{\lambda_{\text{ref}}} \right)^\beta \]
Inferring the integrated stellar mass of each central.

4. Extract stellar mass using Bayesian stellar population synthesis fitting.

Prospector & iSEDfit

B. Johnston et al., in prep.
Moustakas et al. 2013
We find good agreement between stellar masses inferred from our custom and SDSS/cModel photometry.
Convergence on the stellar mass-halo mass relation remains elusive.

\[ M_\ast \propto M_{\text{halo}}^{0.33} \]

Preliminary
Ongoing & future work—

- Full sample analysis
- Size-mass relation
- Mass density profiles
- Stellar mass function
- Image stacking
- Baryon budget
- Comparisons with theory

Pillepich et al. 2018