Measuring Stellar Masses of Low-mass Galaxies?

It's more complicated than you think!

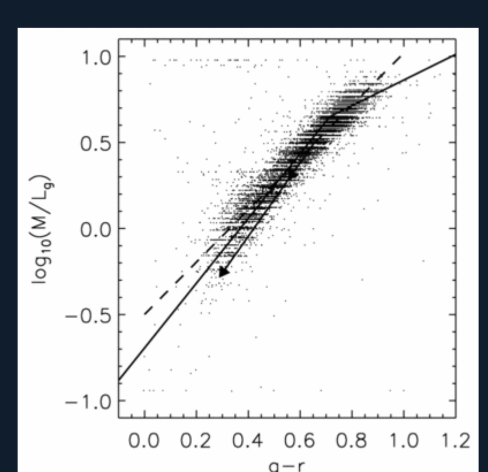
Mia de los Reyes, Will Grant, Yasmeen Asali, Marla Geha, Risa Wechsler

The premise

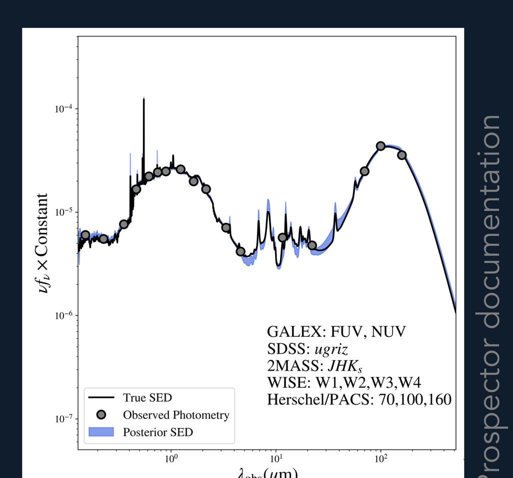
Stellar mass ($M_\star$) traces a galaxy's cumulative evolution!

Commonly used in empirical relations: mass-metallicity relation, star formation main sequence, $M_\star$-M_{halo} relation, etc.

To measure $M_\star$ from photometry:



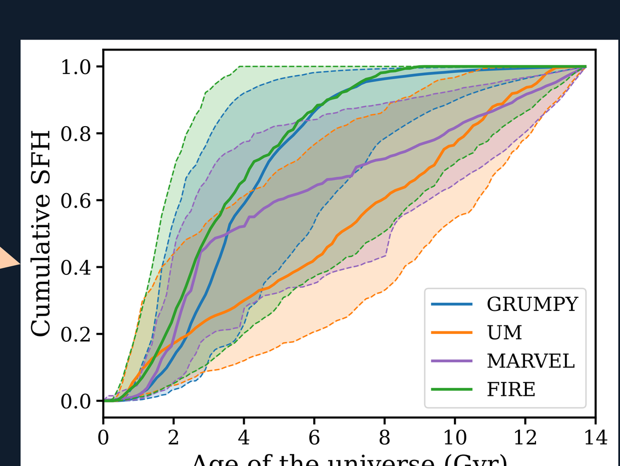
Color-$M_\star$/L relations

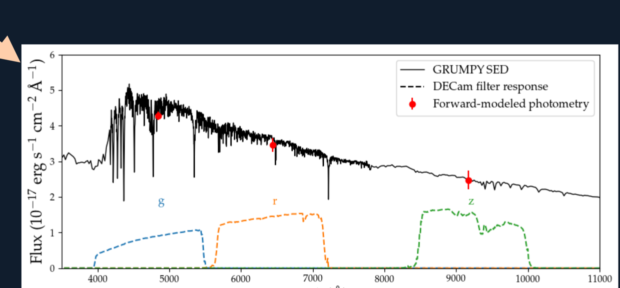


SED fitting

Both methods mostly tested on high-mass galaxies... **Let's extend to <10^8 $M_\odot$!**

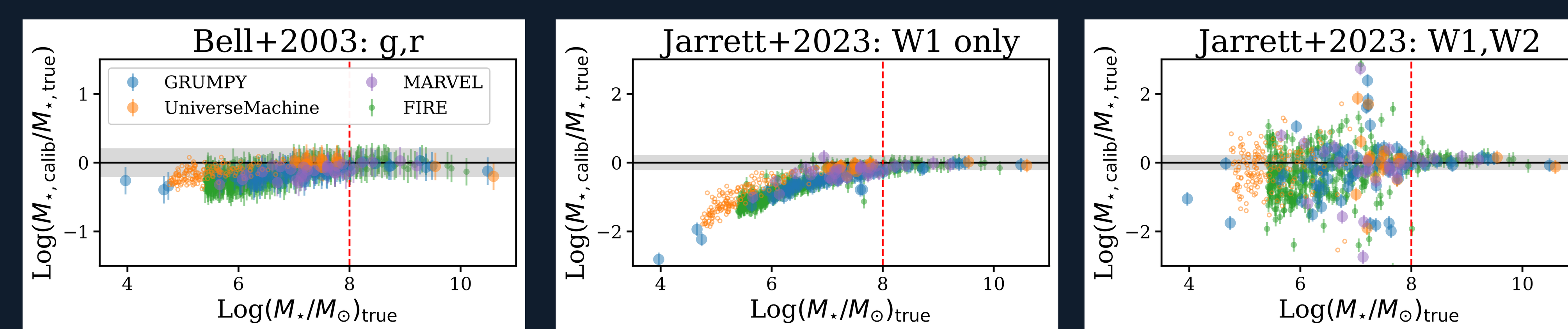
1. Get lots of dwarf galaxy simulations
2. Make mock observations (with FSPS)
3. Compare "true" and "observed" $M_\star$





The results

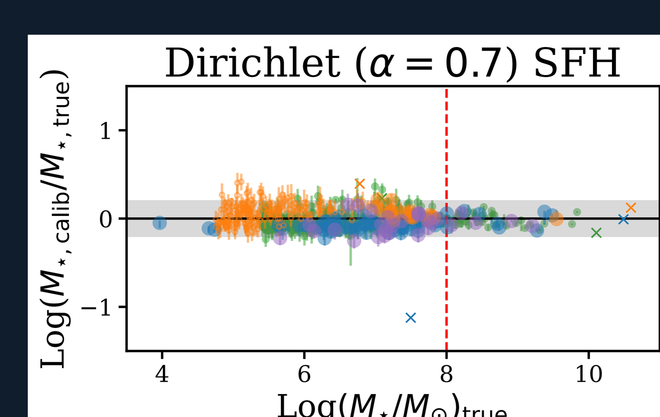
Color-$M_\star$/L relations



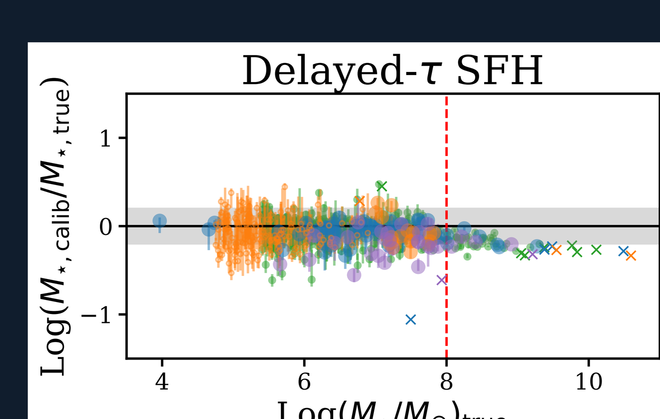
Optical g-r color predicts $M_\star$ well at low masses! Near-IR (WISE 1, 2) doesn't.

SED fitting (with Prospector)

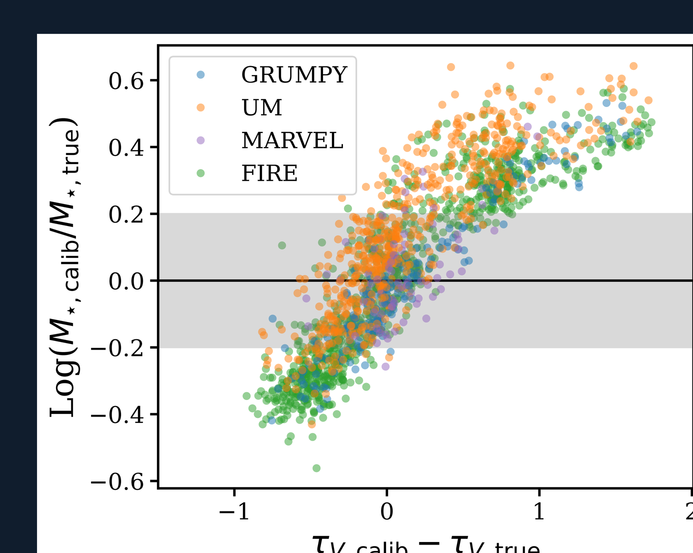
SFH prior



Non-parametric SFHs perform better than parametric SFHs



Dust attenuation



Normalization of dust attenuation law can produce systematic offsets in recovered $M_\star$

Form of attenuation law mostly affects $M_\star$ for dusty ($A_V \gtrsim 1$) galaxies

Other params

Dust emission
No effect on $M_\star$ recovery

Stellar initial mass function
Constant offset in $M_\star$, as expected

Hyperparameters in non-parametric SFH priors
$M_\star$ recovery most accurate when number of age bins $N_{bins} > 6$

The takeaways

1. Good news for LSST: literature optical color-$M_\star$/L relations can recover $M_\star$ for low-mass galaxies within ~0.2 dex!
2. Near-IR colors don't predict $M_\star$ well for low-mass galaxies
3. Most SED fitting assumptions don't significantly affect recovered $M_\star$—except possibly dust

The future

- **On the observational side:** We need improved measurements of dust attenuation in low-z dwarf galaxies!
- **Other fitting codes** Our mock observations and Prospector both use FSPS! We can try other SED fitting codes (and maybe also full spectral fitting)
- **Other properties from SED fitting** Star formation rates/histories next?

References

Applebaum+2021, ApJ, 906, 96 · Bell+2003, ApJS, 149, 289 · Conroy+2009, ApJ, 699, 486 · Jarrett+2023, ApJ, 946, 95 · Johnson+2021, ApJS, 252, 22 · Kravtsov & Manwadkar 2022, MNRAS, 514, 2667 · Leja+2019, ApJ, 876 · Wang+2021, ApJ, 915, 116 · Wetzel+2023, ApJS, 265, 44

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