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Spectral resolution is not important for modeling galaxy growth

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ABSTRACT

We compare actual $R \sim$ **800** spectroscopy to model predictions based on galaxy star formation histories (SFHs) inferred from much lower resolution data: $ugrizJK_s$ photometry and $R \sim 25$ rest-optical prism spectra. From **XXX** systems, we find a median difference of $\leq$1% between all predicted and measured absorption features in the Lick index bandpasses except the Blamer lines—explainable by unmodeled emission—and Ca4227 and Fe5270 in *UVJ*-classified passive galaxies, which are 1.7%–2.5% weaker than expected. χ^2 **stuff.** As such, absent a Ca– or Fe–age prior accurate to the 2% level—whose empirical apprehension is itself a motivation for SED fitting—we find no utility in adding high resolution spectroscopy as an SFH modeling constraint, at least when using models that capture the intrinsic diversity of real growth trajectories. Our results cast doubt on the extent to which spectra from the *James Webb Space Telescope* will enhance our understanding of galaxy growth and suggest that progress requires new tactics as much as new data.

Key words: galaxies: spectroscopy

1 INTRODUCTION

A central ambition of the study of galaxy evolution is to understand stellar mass growth; i.e., galaxy star formation histories (SFHs). Spectral energy distributions (SEDs) are the key data in this work because they can be decomposed into combinations of distinct stellar subpopulations of known ages. The resulting coefficients yield the amount of stellar mass a galaxy is inferred to have formed at the lookback time corresponding to each subpopulation's age.

Different stellar subpopulations have different but not orthogonal SEDs. As such, galaxy decompositions are degenerate. Of course, those degeneracies are compounded by age-independent effects like metallicity and dust.

High resolution spectra ($R \sim 500$–5000) are often used to alleviate those degeneracies in SFH model fitting. The hope is that the absorption features that emerge in those data will increase the contrast between constituent stellar subpopulations, constrain metallicities, and yield more accurate age/mass coefficients. The utility of these data is usually taken as axiomatic, but it is also testable.

Here we present experiment that shows there is in fact little information in high resolution spectra that enhance constraints on galaxy SFHs compared to inferences based on a combination of broadband photometry and low resolution ($R \sim 25$) prism spectra.[1] We use precomputed SFH inferences based on such low resolution SEDs for a set of **XXX** systems at $\langle z \rangle$ = **ZZZ** to produce predictions of each galaxy's high-resolution spectrum. We then compare those predictions to actual high resolution ($R \sim 800$) observations taken post-facto. With the exception of the Balmer lines—whose divergence from predictions is readily ascribable to emission line infilling—we find differences to be of order **whatever they are**, suggesting **whatever we say they do**.

Section 2 describes the data on which our experiment is based, Section 3 shows the comparisons between our spectral predictions and the high resolution data, and Section 4 describes the implications of these results. We use AB magnitudes and assume a Chabrier (2003) stellar initial mass function (IMF) with $(H_0, \Omega_M, \Omega_\Lambda) = (70\ \mathrm{km\ s^{-1}\ Mpc^{-1}}, 0.3, 0.7)$ throughout.

2 DATA

2.1 Master sample

This experiment is based on the *Carnegie Spitzer IMACS Survey* (CSI; Kelson et al. 2014). CSI provides Magellan-IMACS Low- and Uniform-Dispersion Prism spectroscopy (**CITE**) for objects with *Spitzer* [3.5] $\leq$ 21 in **XXX sq. deg.** from **THESE FIELDS**. Combined with supplemental $ugrizJK_s$ photometry from the NEWFIRM archive (**CITE**) and Canada-France-Hawai'i Telescope Legacy Survey (CFHTLS; **CITE**), these data were used to derive flexible SFHs for each galaxy as part of the redshift estimation process. The sample is complete to $\log M_*/\mathrm{M}_\odot \sim 10.3$ at $z \sim 0.7$. The spectral resolution of the prisms varies from $R \sim$ **XXX**

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[1] A future paper will extend this statement to pure photometry-based inferences.

to $R \sim$ **YYY** at **wavelengths**, about **THIS MUCH WORSE** than the Sloan Digital Sky Survey (York et al. 2000).

Dressler et al. (2016, 2018) examine the CSI SFHs in detail. Dressler et al. (2018) provides a thorough treatment of CSI SFH quality in its Appendix. We defer the reader to those texts for that information, but briefly review the SFH inference process here. *None of these details are important in the context of the experiment we detail below*, which should be repeated using other approaches.

The CSI spectrophotometry was using 5 precomputed SEDs based on SFHs with constant star formation rates (SFRs) spanning:

- 0.0 to 0.2 Gyr;
- 0.2 to 0.5 Gyr;
- 0.5 to 1.0 Gyr;
- 1.0 to 2.0 Gyr prior to $t_{\rm obs}$;
- either 2.0 Gyr prior to $t_{\rm obs}$ or $z \simeq 3$ to $z = 5$ (1 Gyr),

where $t_{\rm obs}$ corresponds to the object's redshift. The data determine the mode of the oldest bin. The median redshift of the samples studied in Dressler et al. (2016, 2018) is $z \sim 0.7$, or $t_{\rm obs} \sim 7$ Gyr.

Each of the above SEDs was allowed to take an independent A_V (assuming a Calzetti et al. 2000 extinction law) but not metallicity. The latter was inferred using a prior peaked at $Z = Z_\odot$. As such, the predicted spectra do not capture the likely enrichment history of any object (cf. Pacifici et al. 2012; Morishita et al. 2019)—a fact to bear in mind as we proceed.

The SEDs are generated using the Flexible Stellar Population Synthesis code (Conroy et al. 2009) assuming default abundance patterns.

2.2 High-resolution spectroscopy

3 CONFRONTING PREDICTIONS WITH HIGH-RESOLUTION DATA

3.1 Systematic errors

4 IMPLICATIONS

4.1 Where is the information going?

Redshifts.

5 SUMMARY

Foo.

Facilities: Magellan/IMACS
Software: IDL (Coyote libraries; `http://www.idlcoyote.com/`), python (`CarPy`).

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