On the last 10 billion years of stellar mass growth in star-forming galaxies

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A persistent SFR main sequence

Small scatter in SFR at $M_*$:
- $z \approx 0$ in SDSS (e.g. Brinchmann+04)
- $z \approx 0$ in local dwarfs (Lee+11)
- $z \approx 2$ in $M_* > 10^{10}$ (e.g. Rhodighiero+11)
Main Sequence Integration

Dutton et al. (2010)
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stellar mass fraction formed
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$\sigma = 0.24 \text{dex}$
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$z \approx 0$

$z \approx 2$

Wuyts+11
Observations: normalization of SFR-M$_*$

Salim et al. 2007; Noeske et al. 2007b; Elbaz et al. 2007; Pannella et al. 2009; Daddi et al. 2007; Dunne et al. 2009; Oliver et al. 2010; Rodighiero et al. 2010a; Karim et al. 2011;
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Observations: slope $\text{SFR}/M \sim M^\beta$

- Smaller galaxies grow faster (implies downsizing)
Observations: slope $\frac{\text{SFR}}{M_*} \sim M_*^{\beta}$

smaller galaxies grow faster (implies downsizing)
Typical stellar mass growth from main sequence integration

Star formation histories

Extrapolated data

Unreliable ($\rho_{SFR} \neq \Delta \rho_*$)

Robust early growth

Stellar mass growth
Quantifying the late formation of star forming galaxies

$z_{15\%}: M(z)=0.15M_\ast(z=0)$
Quantifying the late formation of star forming galaxies

$z_{15\%} : M(z)=0.15M_*(z=0)$
Quantifying the late formation of star forming galaxies

\[ z_{15\%} : M(z) = 0.15M_*(z=0) \]

Stellar mass at \( z=1 \)
Stellar mass growth from spectra

Averaged SED-based SFHs of $\sim$50,000 SDSS star-forming galaxies of $10^{10.5}-10^{11}M_\odot$ from the VESPA Database

*star formation histories*

*stellar mass growth*
Mimicking age uncertainty

SSPs with typical SDSS signal-to-noise are not distinguished over <0.5dex:

->Smooth by $\sigma=0.5\text{dex}$ in log-age

Tests show little bias, but resolution~1dex for non-SSPs with unknown metallicity

Ocvirk+06

Main Sequence Integration

MSI+age uncertainty
Main sequence integration and SEDs

\[ \langle M* \rangle = 6 \times 10^{10} M_\odot \]
Main sequence integration and SEDs

\[ \langle M_\ast \rangle = 2 \times 10^{10} M_\odot \]
Main sequence integration and SEDs

$<M_\ast> = 5 \times 10^9 M_\odot$
Main sequence integration and SEDs

\[ \langle M_* \rangle = 2 \times 10^8 M_\odot \]
Consistency between SEDs and the main sequence

- $\langle M_* \rangle = 6 \times 10^{10} M_\odot$
- $\langle M_* \rangle = 2 \times 10^{10} M_\odot$
- $\langle M_* \rangle = 5 \times 10^9 M_\odot$
- $\langle M_* \rangle = 2 \times 10^8 M_\odot$
A transition at low masses?
A transition at low masses? An SED/CMD discrepancy?
Summary and Conclusions

• The main sequence of star formation can be integrated to calculate stellar mass growth in star forming galaxies back to 10-20% of current stellar masses.
• Less than 15% of stellar mass (median bulge mass) is in place in star forming galaxies of about $M_* = 1-5 \times 10^{10}$ SFGs at $z > 2$.
• SED-based star formation histories are consistent with SFR-$M_*$ and its evolution after accounting for age uncertainties.
• Local CMD-analyzed dwarfs formed early(?) compared to SED and main sequence extrapolations.
• Details: merging, $\rho_{\text{SFR}} \neq \Delta \rho_*$, effect of scatter in SFR-$M_*$, other high S/N SED- and CMD-based disk observations.

arXiv:1108.0938
Merging and Scatter

\[ \frac{M_*(z)}{M_0} \]

lookback time [Gyr]

\[ \text{star formation rate} \quad [M_\odot \text{yr}^{-1}] \]

lookback time [Gyr]

\[ \log(M/M_\odot) = 10.50 \]
The effect of age resolution on mass growth in SED-based SFHs

![Graphs showing the effect of age resolution on mass growth in SED-based SFHs.](image)