Galaxy Structure as a Driver of the Slope and Scatter of the Star Formation Sequence

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log(M★)

log(SFR)

Star Formation

Gas Collapse

Structure Formation

log(M★)
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Gas Collapse → Structure Formation → Log(SFR)

log(M★) vs. Log(M*)

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3D-HST Conference
November 17, 2015
From the **Initial Gas Collapse** to the **Formation of Structure**

- **Little to No Rotation**
  - Spheroidal distribution of stars and gas

- **Some Rotation**
  - Flattened spheroid and extended gas-rich disk

- **Strong Rotation**
  - Extended gas-rich disk with no spheroid
Star-forming galaxies well characterized by exponential disks (n=1)
- Quiescent galaxies have de Vaucouleur profiles (n=4)
- Galaxies at the tip/upper envelope have cuspier light profiles, akin to dead galaxies.
The Star Formation Sequence: how is star formation regulated?

Turn-over in the log(SFR)-log(M\*) relation
— star forming galaxies only —

- Turn-over in the log(SFR)-log(M\*) relation for different redshift ranges:
  - 0.5<z<1.0
  - 1.0<z<1.5
  - 1.5<z<2.0
  - 2.0<z<2.5

- Logarithmic scales for SFR and mass.
- High-mass galaxies: log(M\*/M_\text{sun})>10.2
- Low-mass galaxies: log(M\*/M_\text{sun})<10.2

Whitaker et al. 2014b

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Bulge Formation: does a bulge lower the global star formation rate?

Star formation occurs in exponential disks (e.g. Nelson et al. 2012, 2013)

\[ \text{SFR} \propto M_{\text{disk}} \]

e.g., Abramson et al. 2014

log(star formation rate) vs log(stellar mass)
star formation occurs in exponential disks
(e.g. Nelson et al. 2012, 2013)

\[ \text{SFR} \propto M_{\text{disk}} \]

older stars
young stars
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\[ \text{SFR} \propto M_{\text{disk}} \]

M_{\text{bulge}} increases

log(star formation rate)

log(stellar mass)

older stars

young stars

e.g., Abramson et al. 2014
star formation occurs in exponential disks
(e.g. Nelson et al. 2012, 2013)

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\[ \text{SFR} \propto M_{\text{disk}} \]

\[ s\text{SFR} = \frac{\text{SFR}}{M_{\text{bulge}} + M_{\text{disk}}} \]

older stars
young stars

\[ \text{M}_{\text{bulge}} \text{ increases} \]

\[ \text{SFR} \propto M_{\text{disk}} \]

e.g., Abramson et al. 2014

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\[ \log(\text{star formation rate}) \]

\[ \log(\text{stellar mass}) \]

Sersic Index

E.g., Abramson et al. 2014
Bulge Formation: does a bulge lower the global star formation rate?

All Galaxies

log(SFR) [M\(_{\odot}\) yr\(^{-1}\)]

log(stellar mass)

Sersic Index

0.5<z<1.0

1.0<z<1.5

1.5<z<2.5

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**Figure:***

*Left panel:* Logarithm of the specific star formation rate (SFR) vs. Sersic Index. The range 0.5<z<1.0 is shown.
*Right panel:* All galaxies plot with colors representing different Sersic Index values. The regions 0.5<z<2.5 and 10<log(M/M☉)<11 are highlighted.

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**Whitaker et al. 2015**

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Star-forming Galaxies

log(SFR) [M\textsubscript{sun}\ yr\textsuperscript{-1}]

log(stellar mass)

0.5<z<1.0

1.0<z<1.5

1.5<z<2.5

Sersic Index

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Star-forming Galaxies

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Why don’t we see a strong trend at z=2?

![Graph showing the relationship between Sersic Index and slope of log(SFR)-log(M)].

(UVJ) Star-forming

0.5<z<1.0
1.0<z<1.5
1.5<z<2.5

Whitaker et al. 2015

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Bulge Formation: does a bulge lower the global star formation rate?

Why don’t we see a strong trend at z=2?
This epoch marks the peak of the cosmic star formation history

But how does the bulge grow?

- Do stars form in situ and migrate from the (unstable) disk to the bulge?
- Is the bulge the result of accreted satellites?
- Is some other mechanism at play?

Nelson et al. (2012, 2013):
Star formation at z~1 occurs at all radii in exponential disks

van Dokkum et al. (2014):
Little growth in the centers of galaxies from z~0.8-0, but at higher redshifts there is growth at all radii.

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- We measure a systematic decrease in the global sSFRs of galaxies with increasing n: pure exponential-disk galaxies exhibit a steeper slope of the log(SFR)-log(M) relation than those with a significant bulge component.
  - Galaxies with n=2 track the average relation from Whitaker et al. 2014
- The process of forming a significantly massive bulge at z >1 appears to be connected to a transformation in the rest-frame optical galaxy structure before the decrease of the global sSFR of galaxies.