The Evolution of Massive, Compact Galaxies in the Illustris Simulation

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Compact quiescent galaxies

van der Wel et al. 2014, 3D-HST+CANDELS
**Illustris simulation**

- Simulation volume of $(106.5 \text{ Mpc})^3$
- Runs from $z=127$ to $z=0$
- Co-evolution of dark matter and baryons throughout entire volume
- Nbody + hydro (AREPO) + models for star formation, evolution, feedback, gas cooling, BH accretion & feedback
- Gravitational softening length $\sim 0.5 \text{ kpc}$ at $z=2$ for stars & DM, adaptive (smaller) for gas
- Baryonic resolution elements have mass $1.3 \times 10^6 \text{ M}_\odot$
What are the $z=0$ descendants of compact galaxies?

Wide dispersion in stellar mass
Evolution: examples

- Stellar Mass
- Compact galaxy
- Consumer

- Time (Gyr)
- Surface density

- Stellar Mass (M_☉)
- Compact fraction
Evolution: examples

- **Stellar Mass**
  - Time (Gyr): 4, 6, 8, 10, 12
  - Values: $10^{11}$, $10^{12}$

- **Stellar Half-mass Radius**
  - Time (Gyr): 4, 6, 8, 10, 12

- **Surface density**

- **Compact fraction**

- **Stellar Mass (M$_\odot$)**
  - Values: $10^{12}$

- **z = 0**

- **Time (Gyr)**
  - Values: 0.74, 0.71

- **Compact fraction**

- **Surface density**
Evolution: examples

- Surface density
- Compact fraction

Time (Gyr):
- 4
- 6
- 8
- 10
- 12

Stellar Mass:
- $10^{11}$
- $10^{12}$

Stellar Half-mass Radius:
- $10$
- $10^{12}$

Compaction Timescale:
- $z = 0$

Stellar Mass (M$_\odot$)
Evolution: examples

Graphs showing changes in stellar mass, half-mass radius, and time (Gyr). The graphs demonstrate the evolution of stellar systems over time, with representations of compact fraction and surface density at different stages.

Key points:
- Stellar Mass: $10^{11}$ to $10^{12}$
- Stellar Half-mass Radius: $10$ to $10^{12}$
- Time (Gyr): 4 to 12

The graphs illustrate the evolution of stellar systems from $z = 0$ to different time intervals, highlighting changes in stellar mass and compact fraction.
Descendant Types

Surface density

Cumulative Stellar Mass

Radius

Half-mass Radius (kpc)

Stellar Mass ($M_\odot$)

$z = 0$

Compact fraction

Surface density
Descendant Types

Cumulative Stellar Mass

- 5 consumed
- 17 cores
- 3 mixed
- 10 undisturbed

Radius

Half-mass Radius (kpc)

Stellar Mass ($M_\odot$)

Surface density

Compact fraction

$z = 0$
Environmental influence

More mergers -> more mass growth

Denser environment -> more mergers
Summary

- We found a sample of compact galaxies at \(z=2\) in Illustris which are reasonable analogs to observed compact ellipticals, and traced them forward to discover their \(z=0\) descendants.

- About half of the compact galaxies exist as the core of their more massive descendant at \(z=0\), a quarter are essentially undisturbed, and a few are mixed or consumed in major mergers.

- A galaxy’s environment at \(z=2\) has some predictive power for what type of descendant it will have, as compact galaxies in denser in environments are more likely to undergo mergers and gain stellar mass.