

Current Picture: Hierarchical Galaxy formation

Galaxies don't assemble monolithically, but rather from the agglomeration of many small units - it takes a village of little monoliths to make a big one.

Early density field a Gaussian random mess of little density fluctuations. Many of these things collapse first, then merge to form bigger halos

This is what is seen in structure formation simulations

timing	CMB
$z \approx 30$	little dark matter halos form
$z \approx 10$	first baryons fall into little halos; reionize universe
$z \approx 2$	Galaxies merge continuously First big galaxies begin to emerge
$z \approx 1$	Most merging done in Λ CDM (not in SCDM) continual, gradual accretion of DM onto outer edge of halo
$z \approx 0$	Small mergers continue, big ones become rare.

Generally satisfactory but

Hierarchical Galaxy Formation looks a lot like Monolithic Galaxy Formation if it happens fast enough

Hierarchical merging good at building bulges, lousy at preserving cold stellar disks

"bulge-less" galaxy problem
MW only suffered one substantial merger, a long time ago
→ unusual for Λ CDM (thick disk)

12
12
24
36
48
60
72
84
96
108
120
132
144

2 things happen during disk formation
to alter DM halos

Adiabatic contraction (see keynote slides)

As baryons dissipate, they sink to the center of the potential well and drag some DM with them. If the process is gradual enough, this contraction can be modeled as adiabatic.

[This approximation appears to be better than it should be even in hierarchical simulations - Cho et al]

DM becomes denser in center, fluffier further out.

Details matter. Most commonly used "Blumenthal" algorithm is WRONG

Feedback

Fresh energy input by sources formed in the galaxy can, in principle, somewhat counteract compression by putting energy into the surroundings. Gas is heated and perhaps expelled, perhaps dragging dark matter with it.

Important energy sources:

Big galaxies	- AGN	thought to matter at high mass end
Small galaxies	- SN	" " " " low " "
	- stellar winds	"

Feedback is invoked in a hand-waving way to solve many problems