Galaxy Formation and Evolution in different environments

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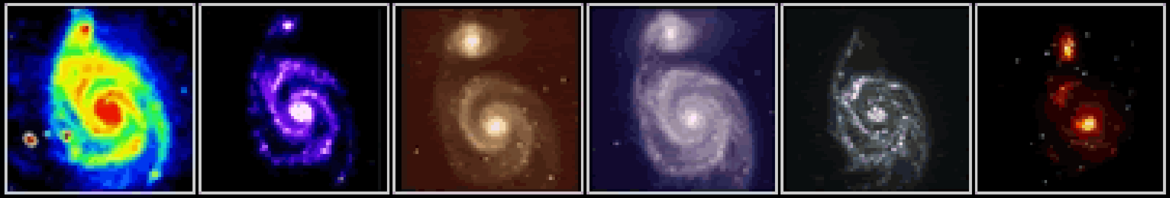
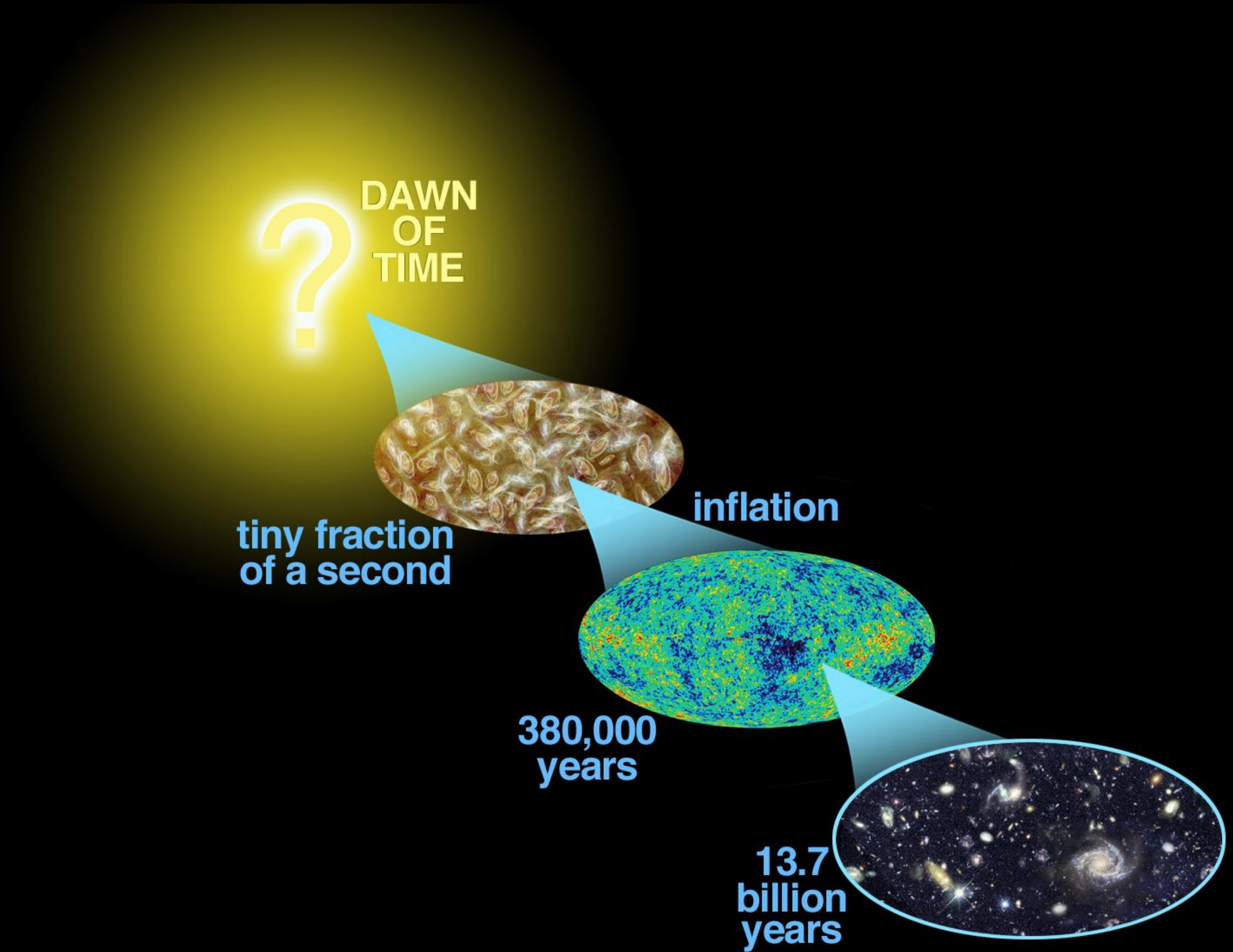


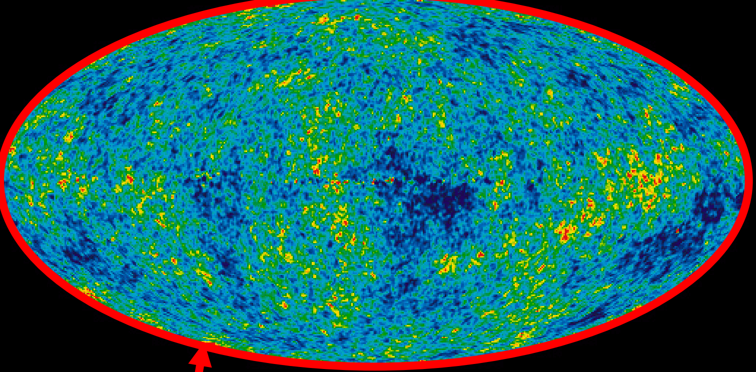
Overview:

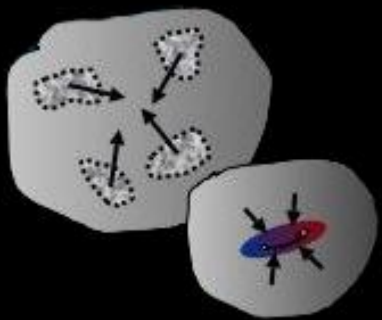
- Galaxy formation in a cosmological context
- The effect of the environment
- Clusters as laboratories of galaxy evolution
- Summary

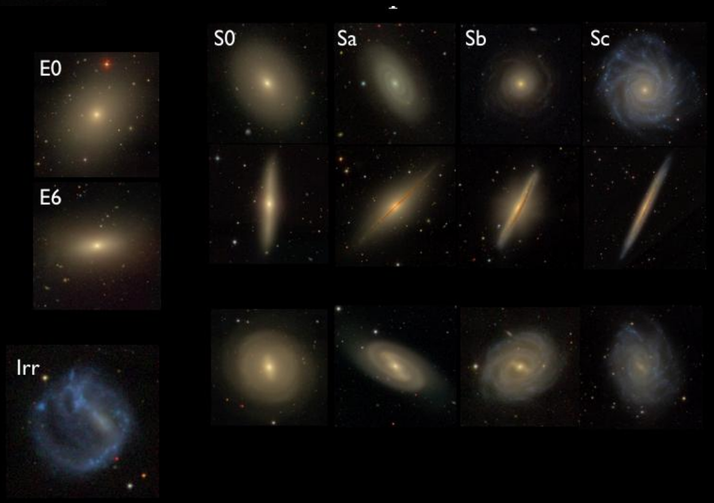


?
DAWN
OF
TIME
inflation
tiny fraction
of a second
380,000
years
13.7
billion
years

A Theorist View of Galaxy Formation and Evolution

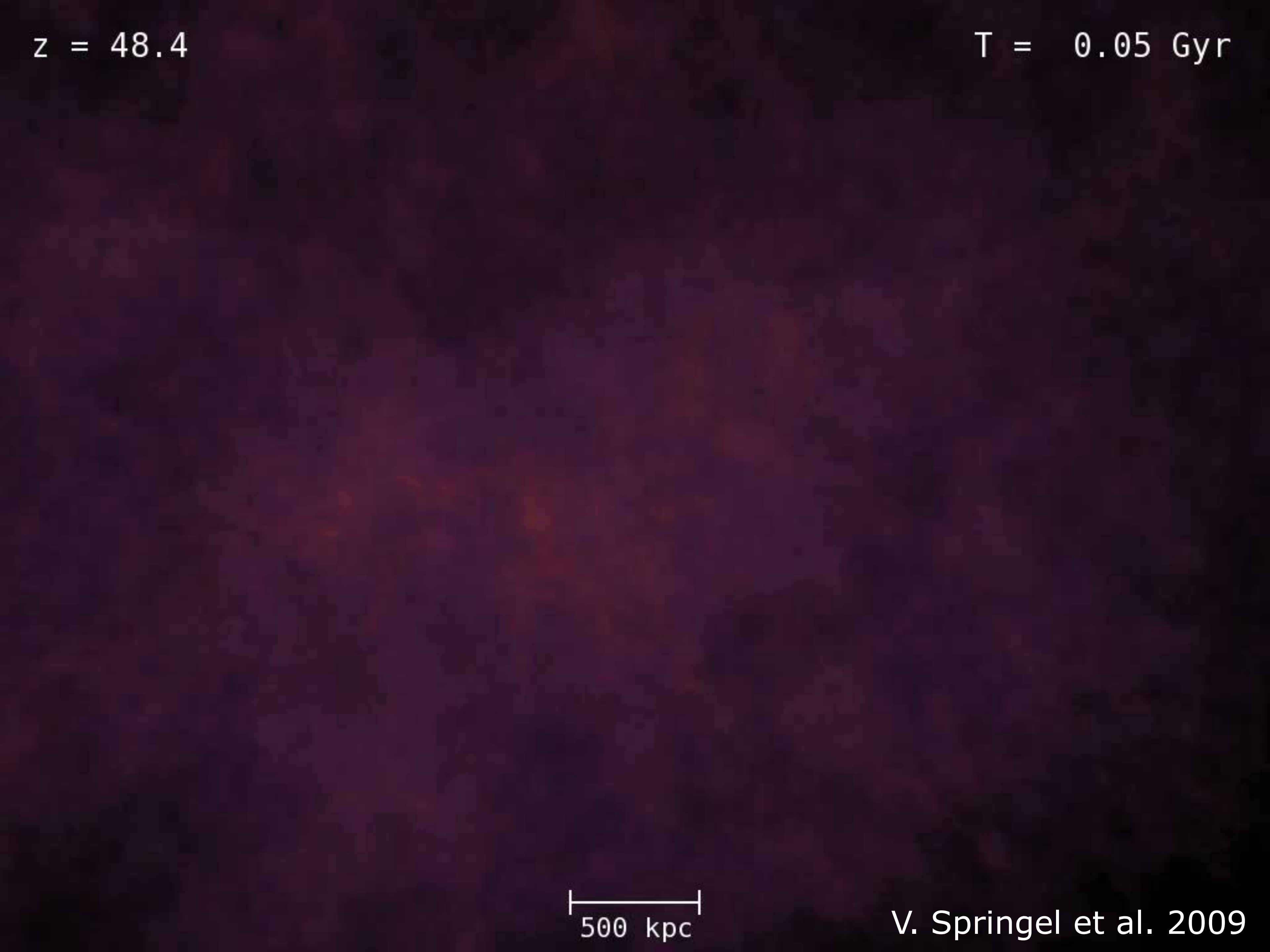


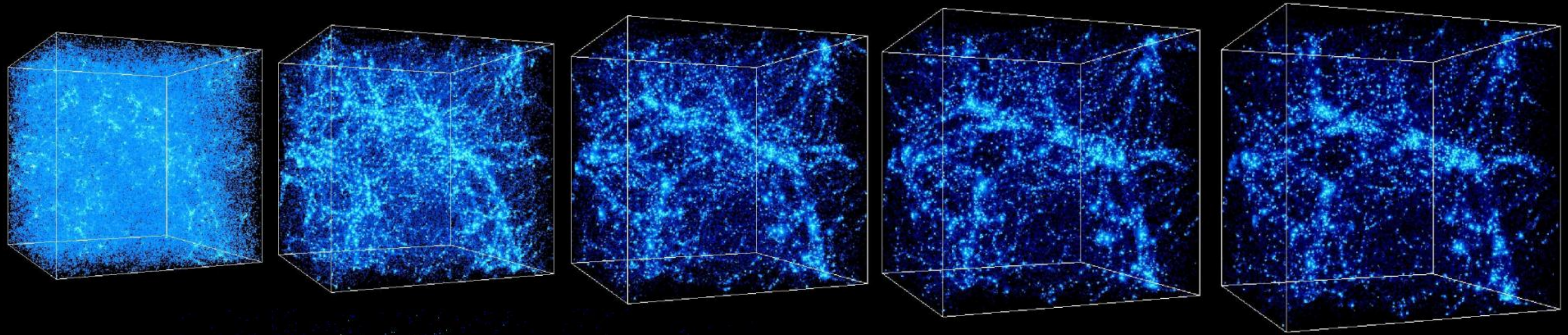


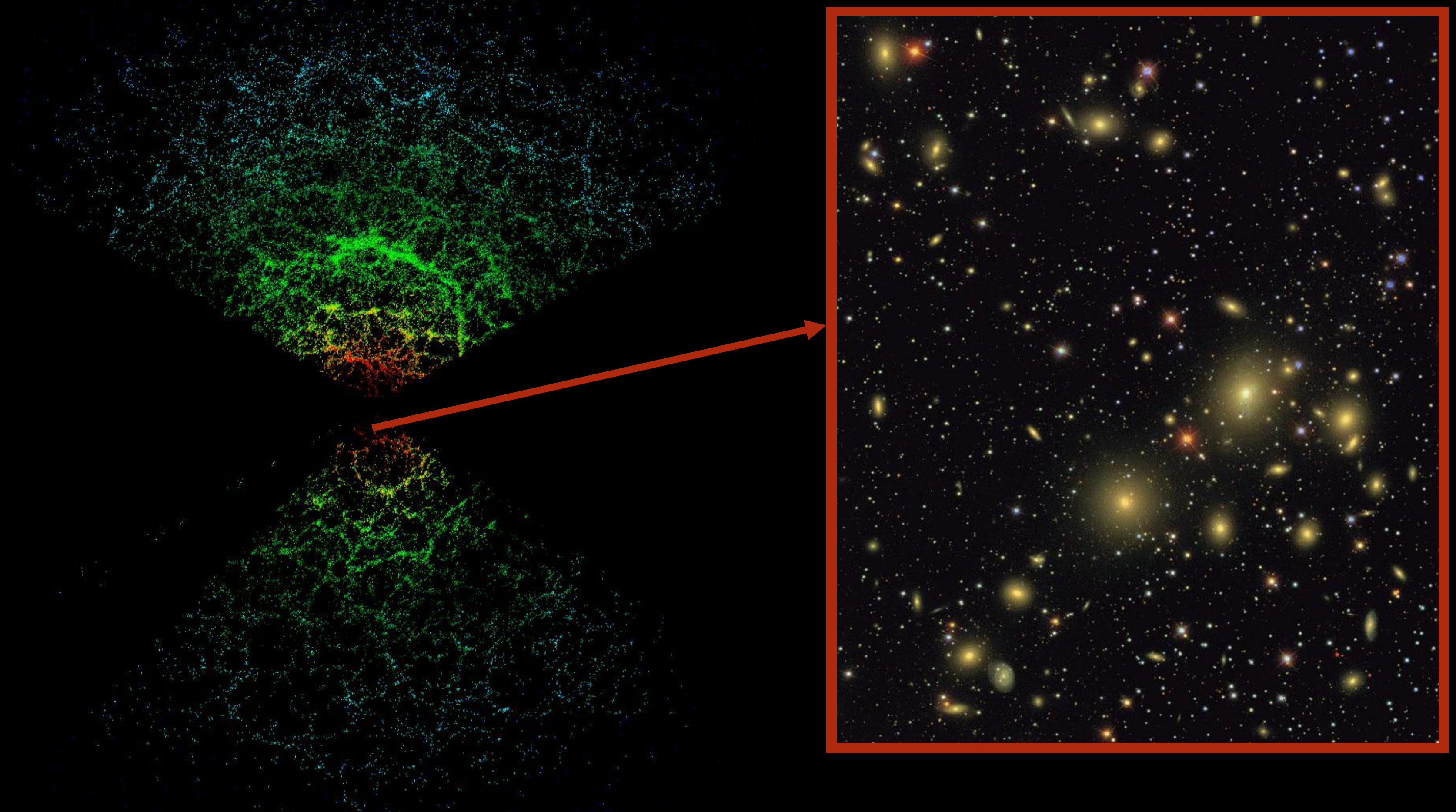


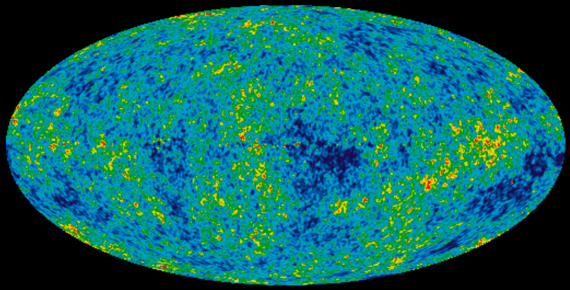
Growth of structure begins from initial dark matter distribution:

Cold-Dark-Matter Cosmogony

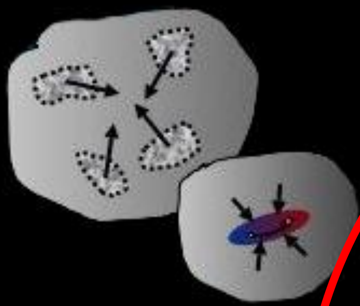

z = 48.4
T = 0.05 Gyr
500 kpc
V. Springel et al. 2009



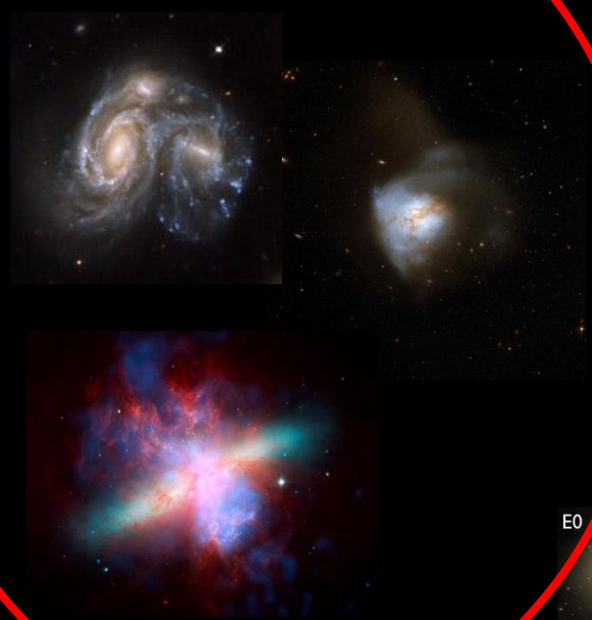


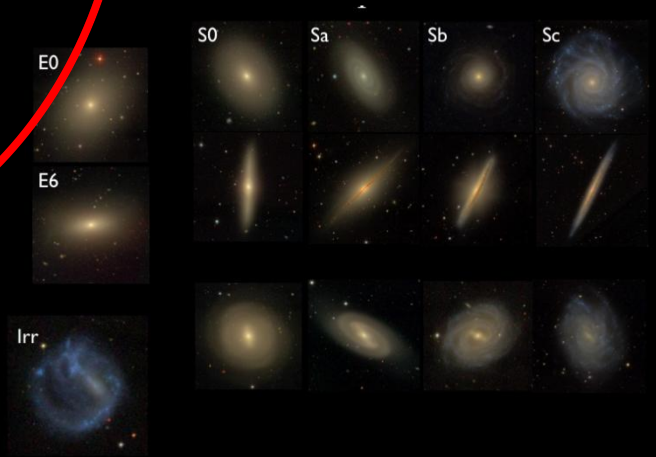


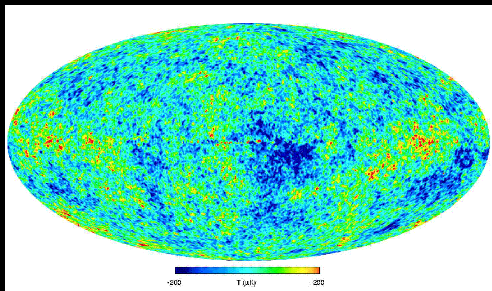
Complications
baryonic physics.

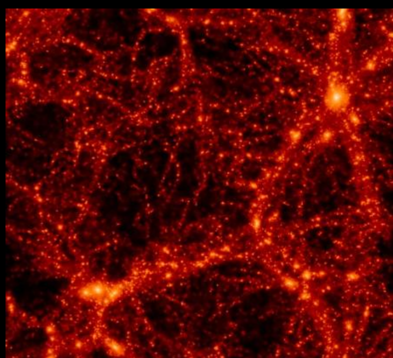


(Difficult to model)









Cosmological model

$(\Omega_m, \Omega_\Lambda, h)$; dark matter

Primordial fluctuations

$\delta\rho/\rho(M, t)$

Well established

Dark matter halos

(N-body simulations)

Well understood

Gas processes

(cooling, star formation, feedback)

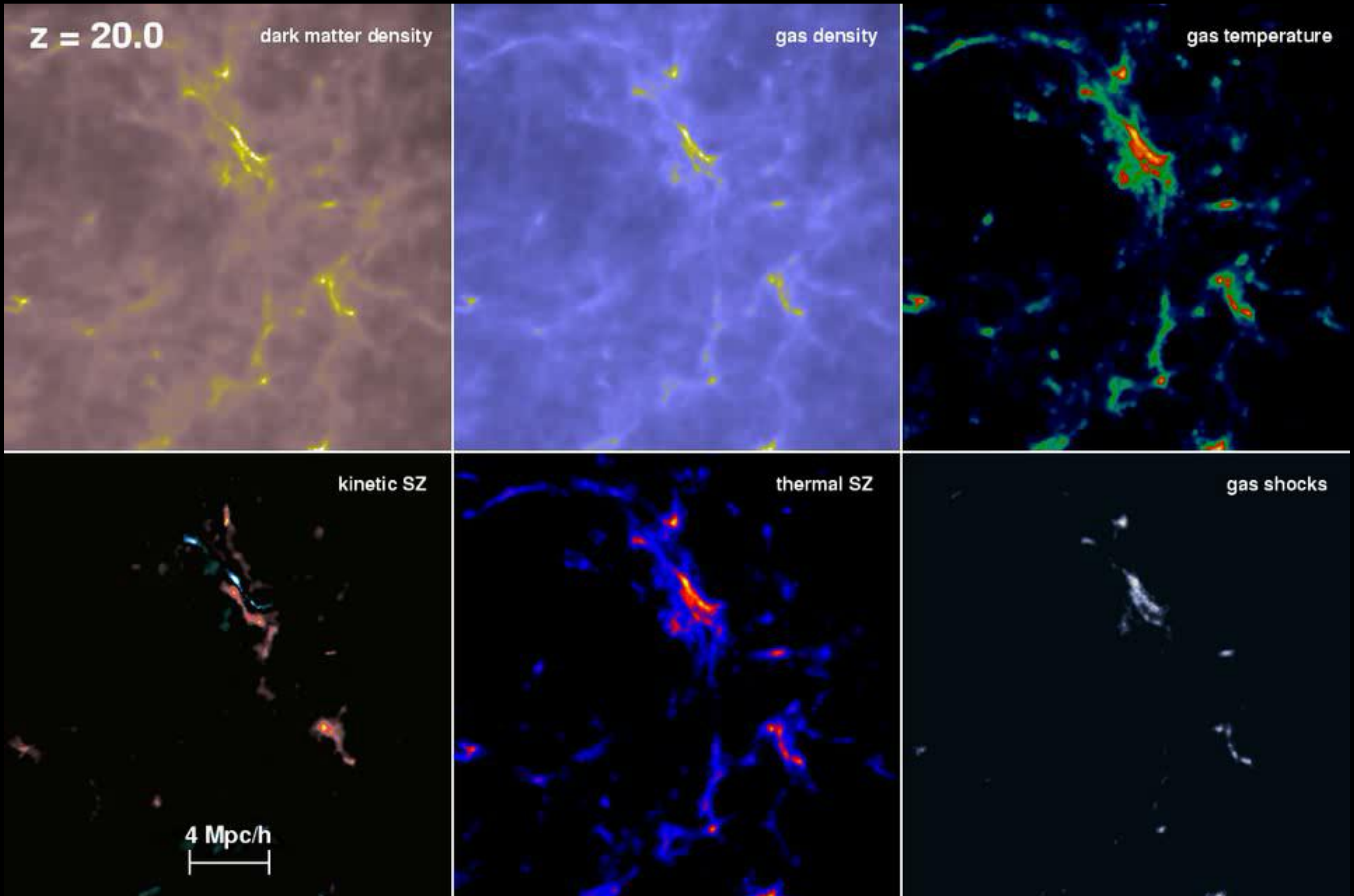
Gasdynamic simulations

Semi-analytics

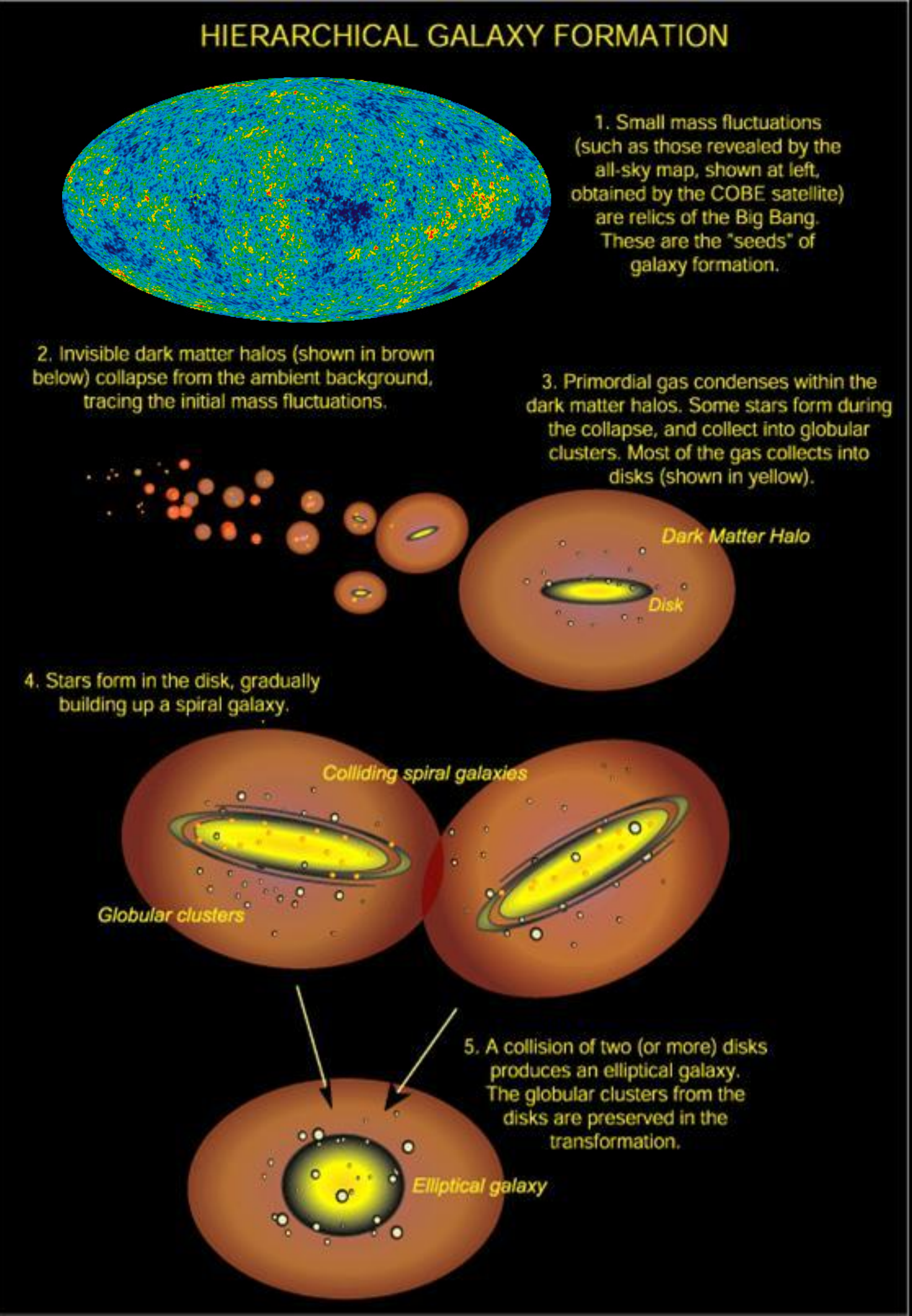
Formation and evolution of galaxies

V Springel et al.

Galaxy Formation: gas-dynamic simulations

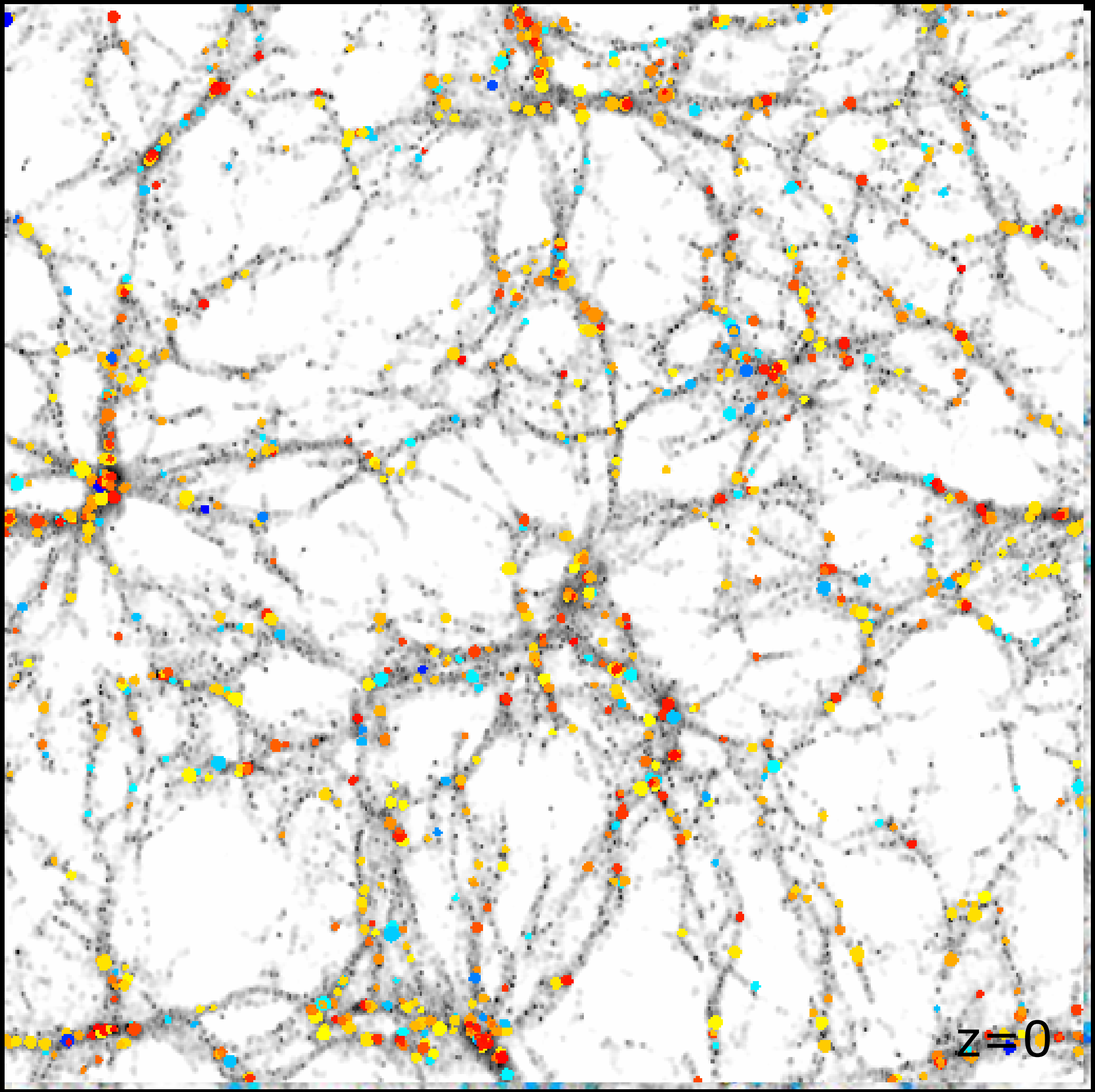


Galaxy Formation: Semi-analy models



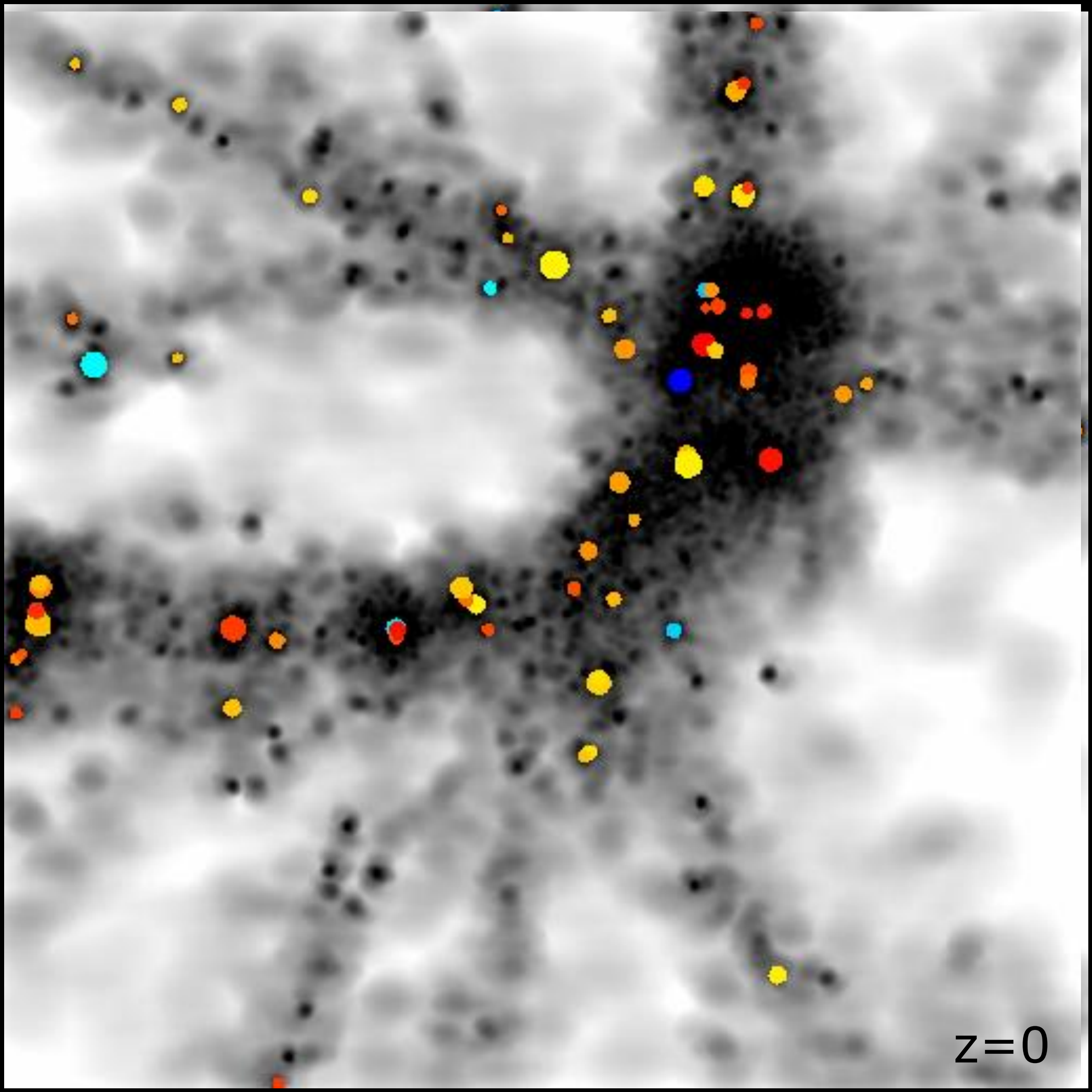
Kauffmann et al.
Cole, Baugh et al.

Galaxy Formation:
Semi-analytic models

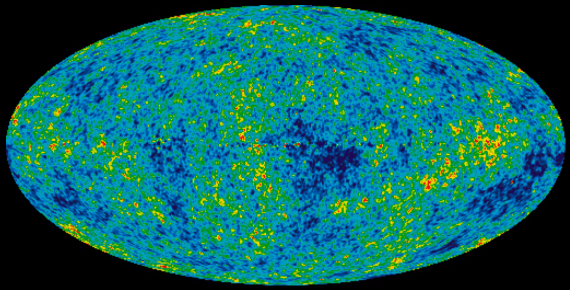


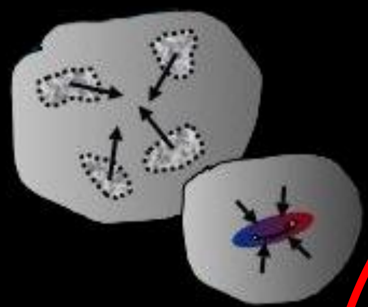
Andrew Benson

Galaxy Formation in clusters: Semi-analytic models



Andrew Benson



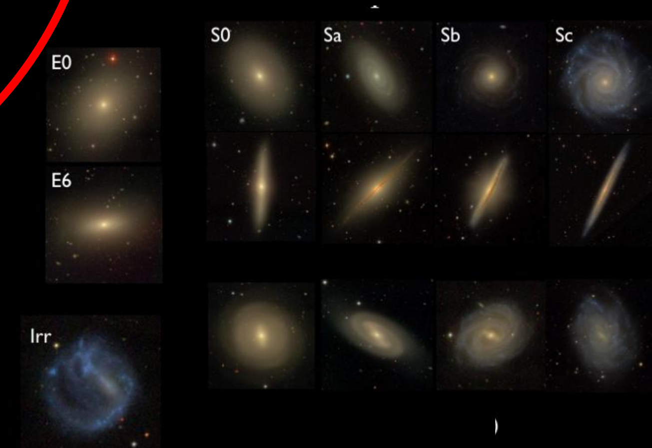


Complications and inconsistencies from baryonic physics.

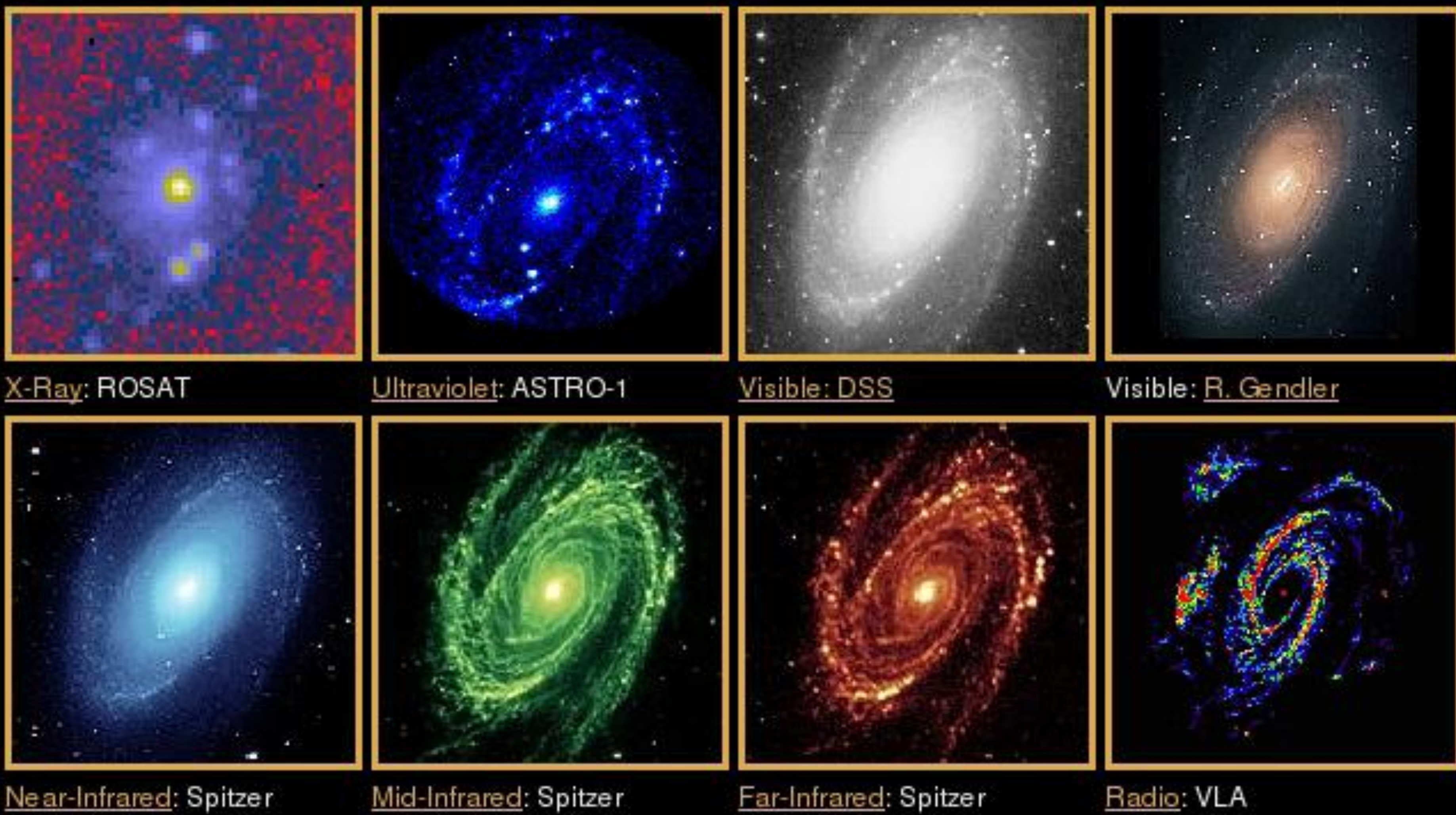
(Difficult to model)

Want to observe fundamental properties comparable to models:

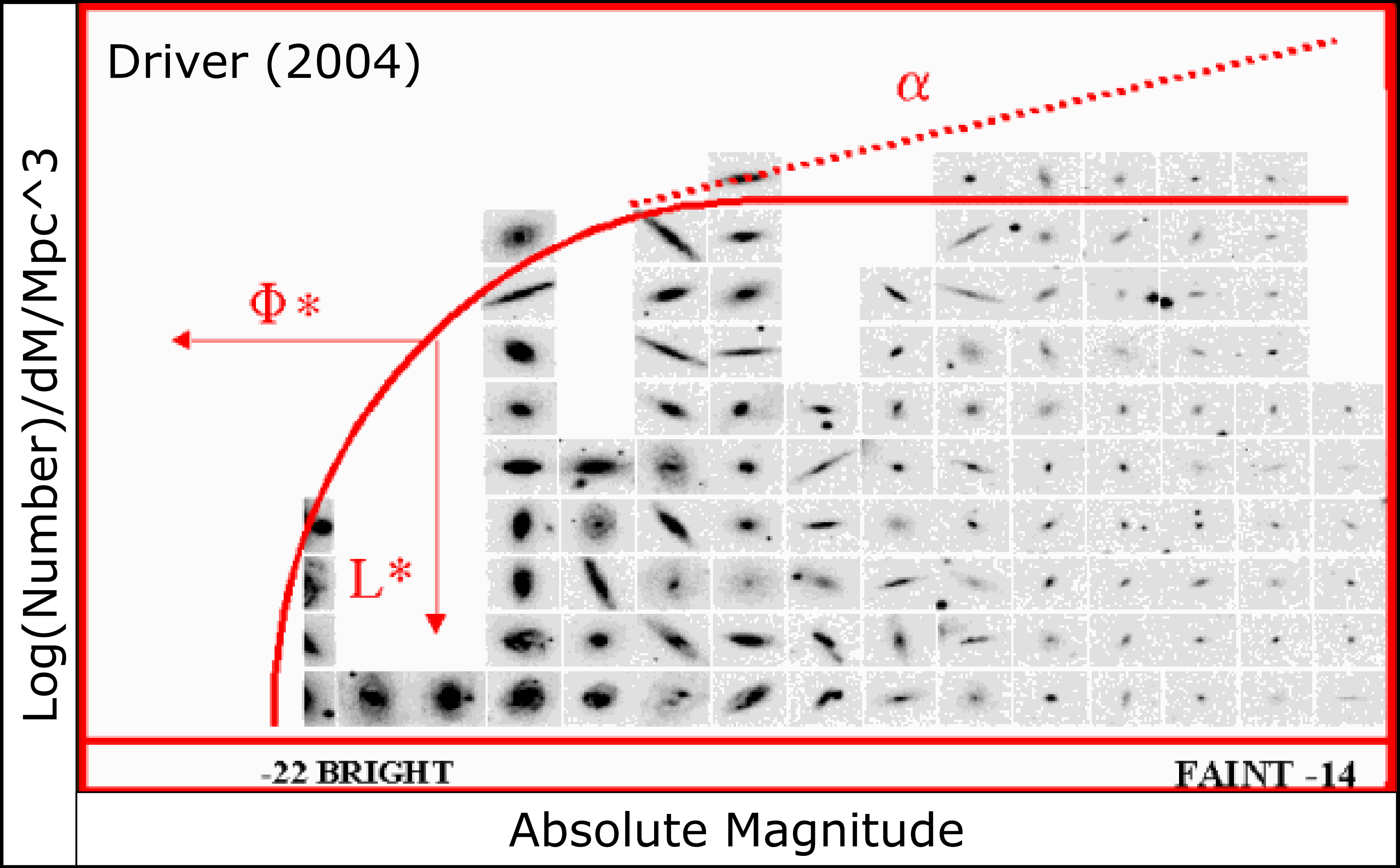
Stellar Masses
Star formation rates
Morphologies



Multi-wavelength Observations

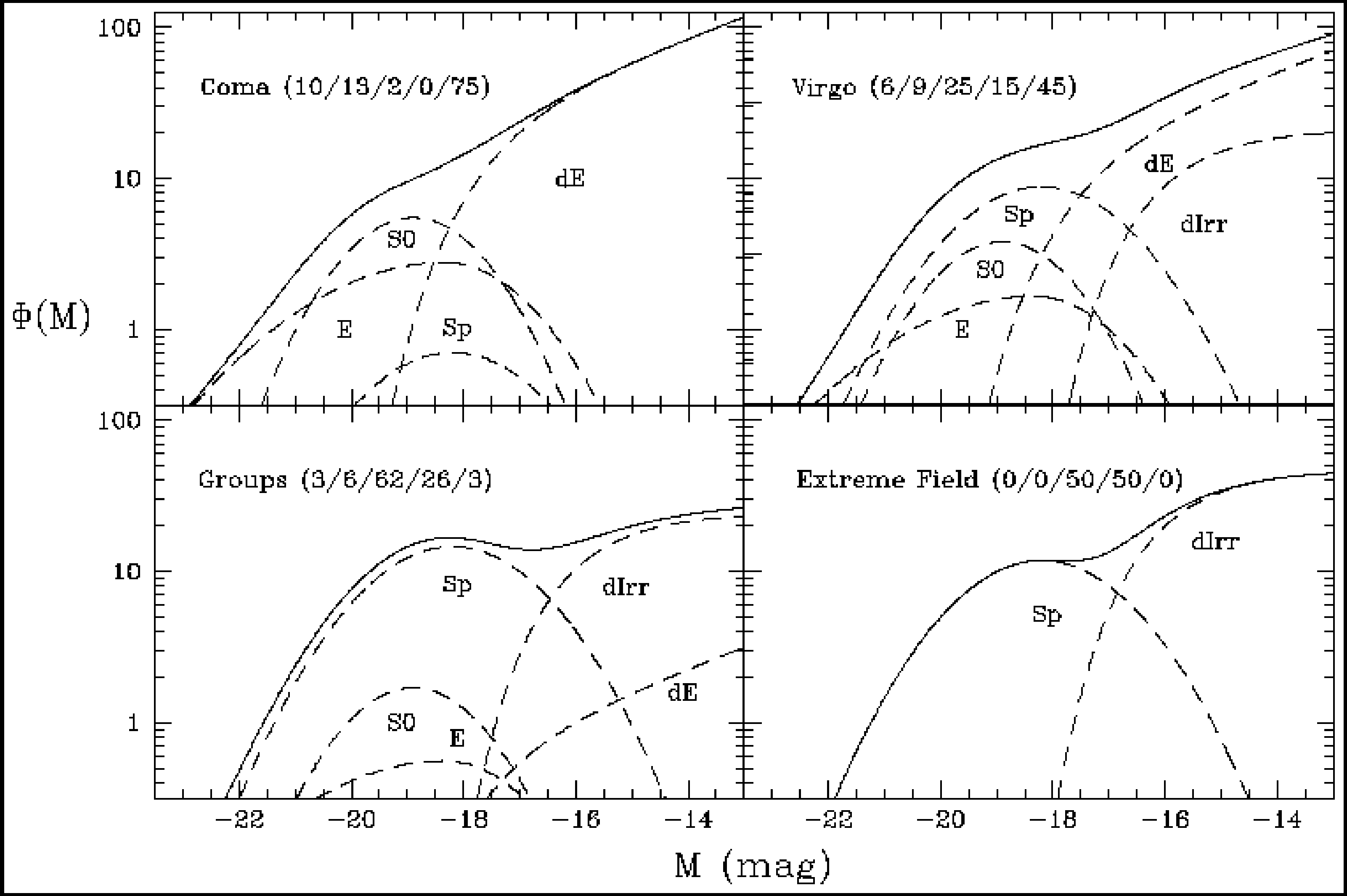


Luminosity Function



Schechter function: $$\phi(L)dL = \phi^{*}\left(\frac{L}{L^{*}}\right)^{\alpha} exp\left(-\frac{L}{L^{*}}\right)\frac{dL}{L^{*}}$$

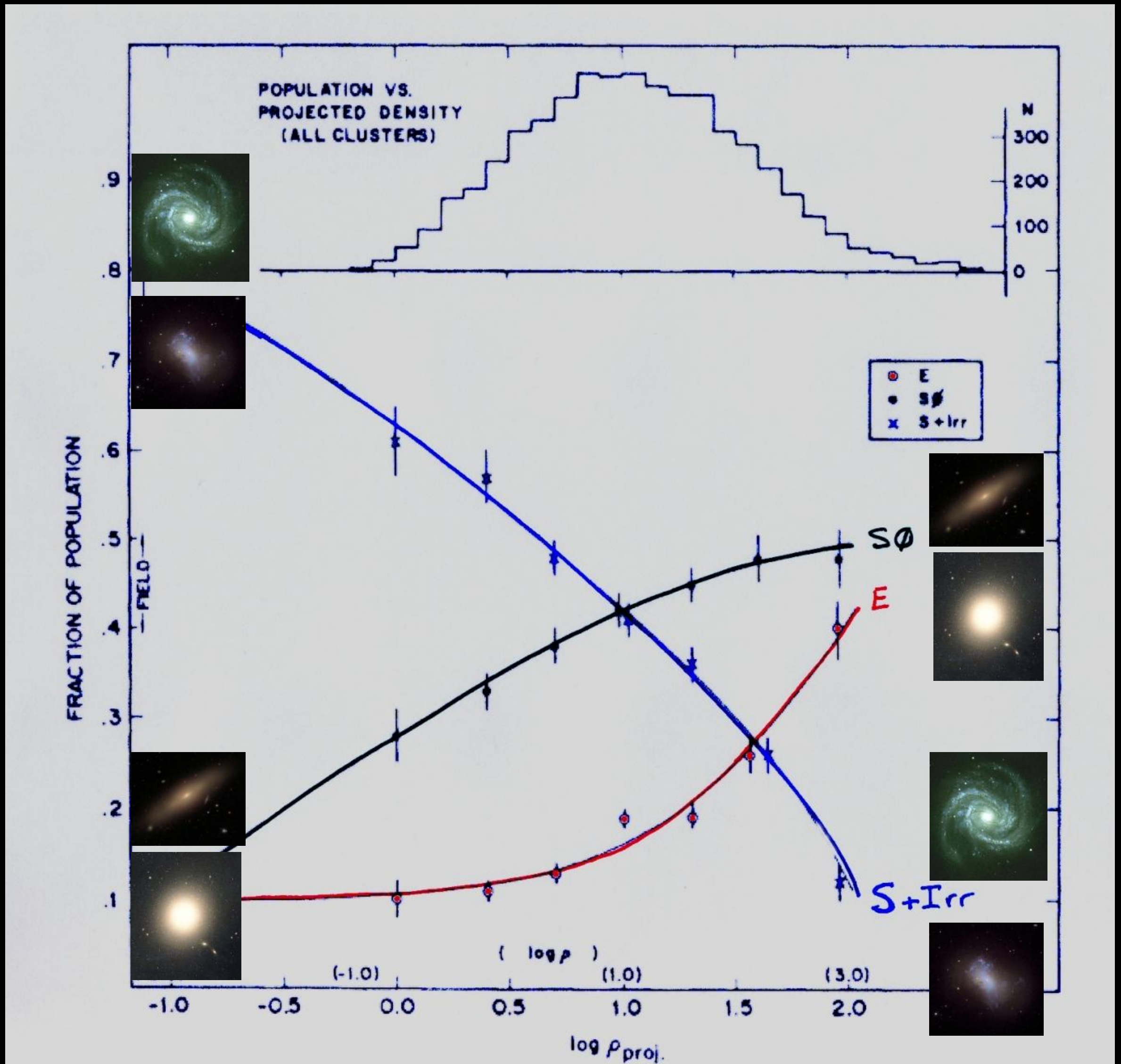
Luminosity Functions at z~0



Jerjen & Tammann (1997)

Sandage, Binggeli, & Tammann (1985)

Morphology-Density Relation at z~0

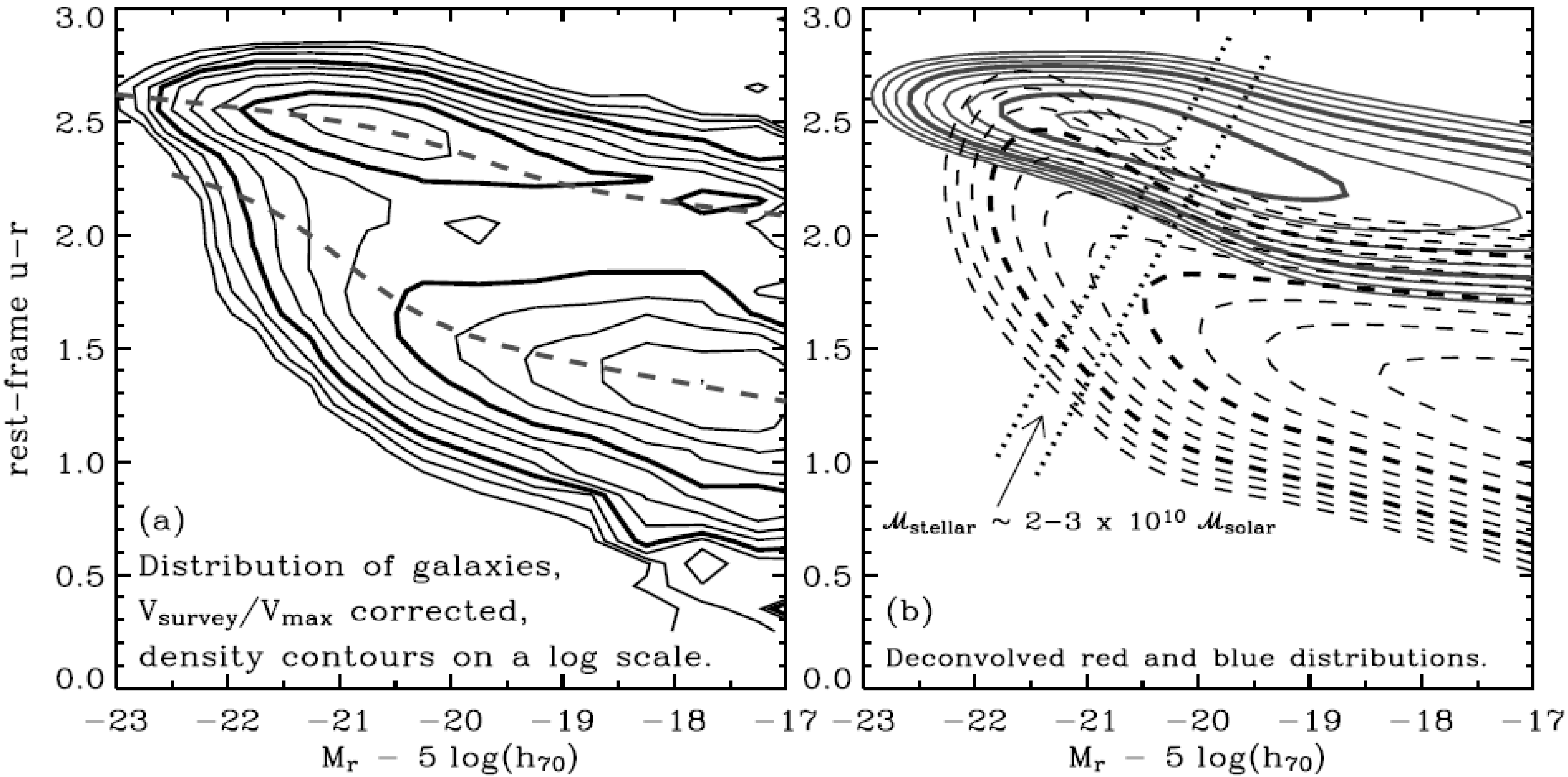


Density

Hubble & Humason (1931)

Dressler (1980)

Very large photometric & spectroscopic datasets at z~0: SDSS



Baldry et al. 2004

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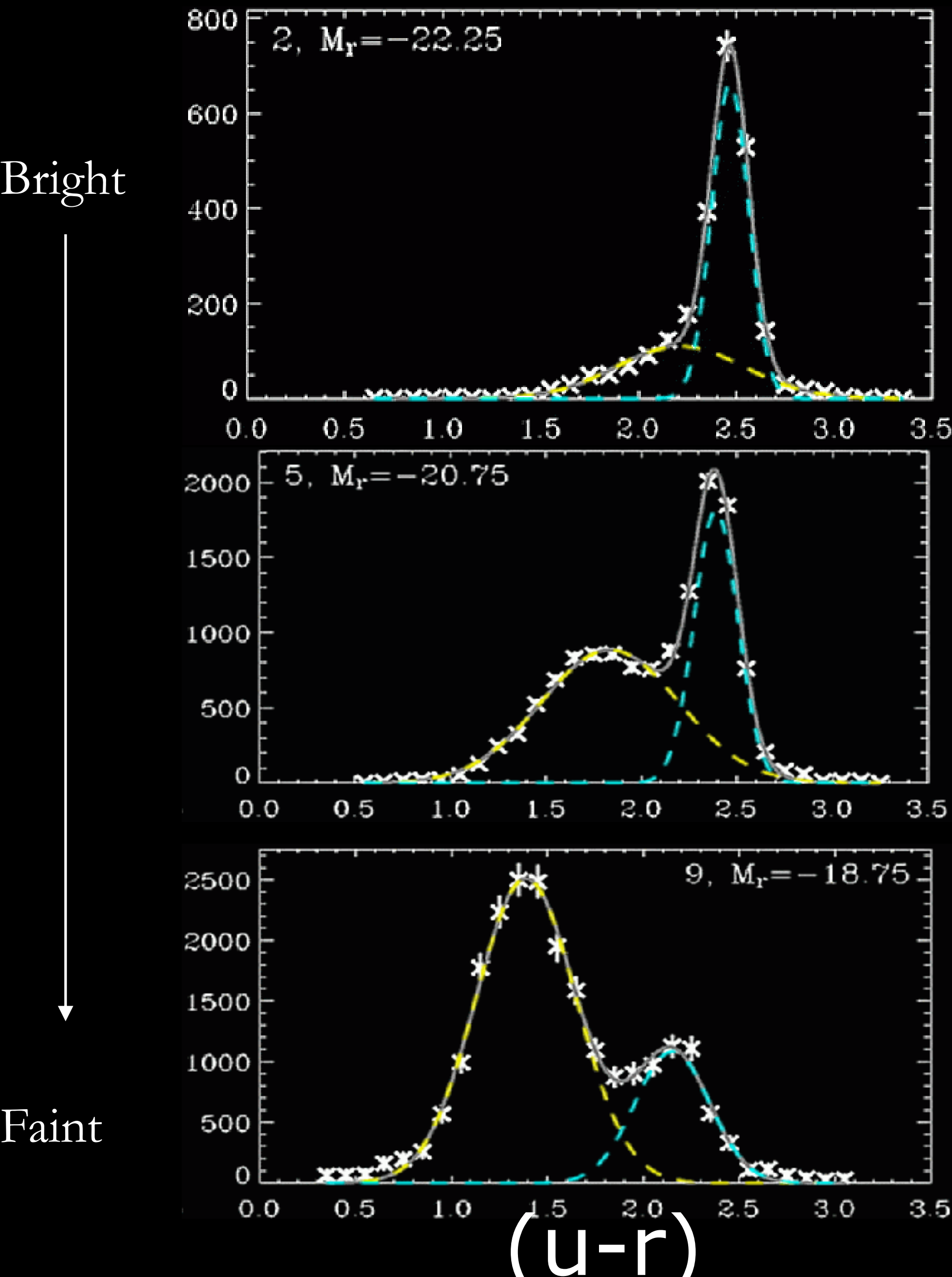
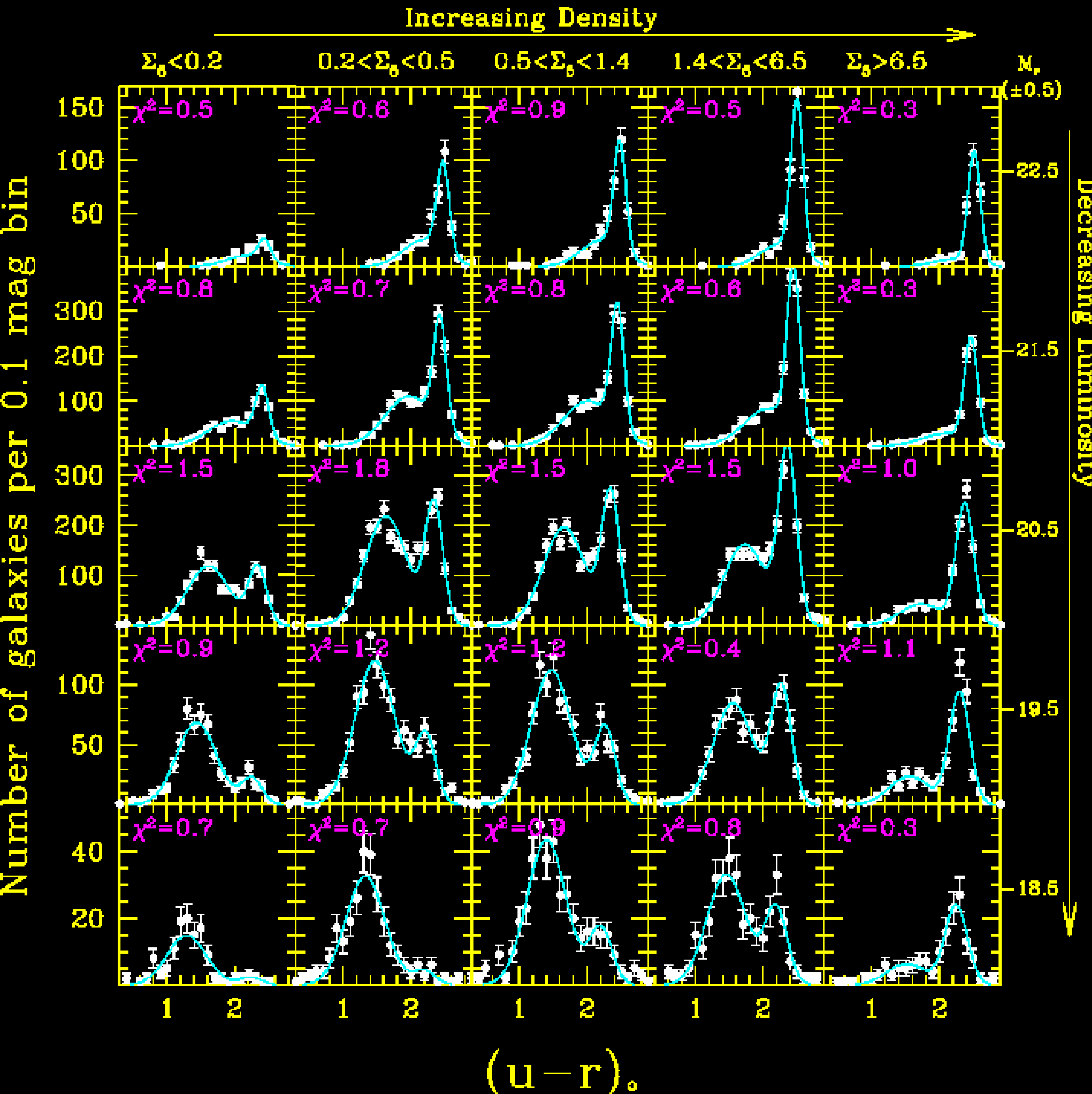
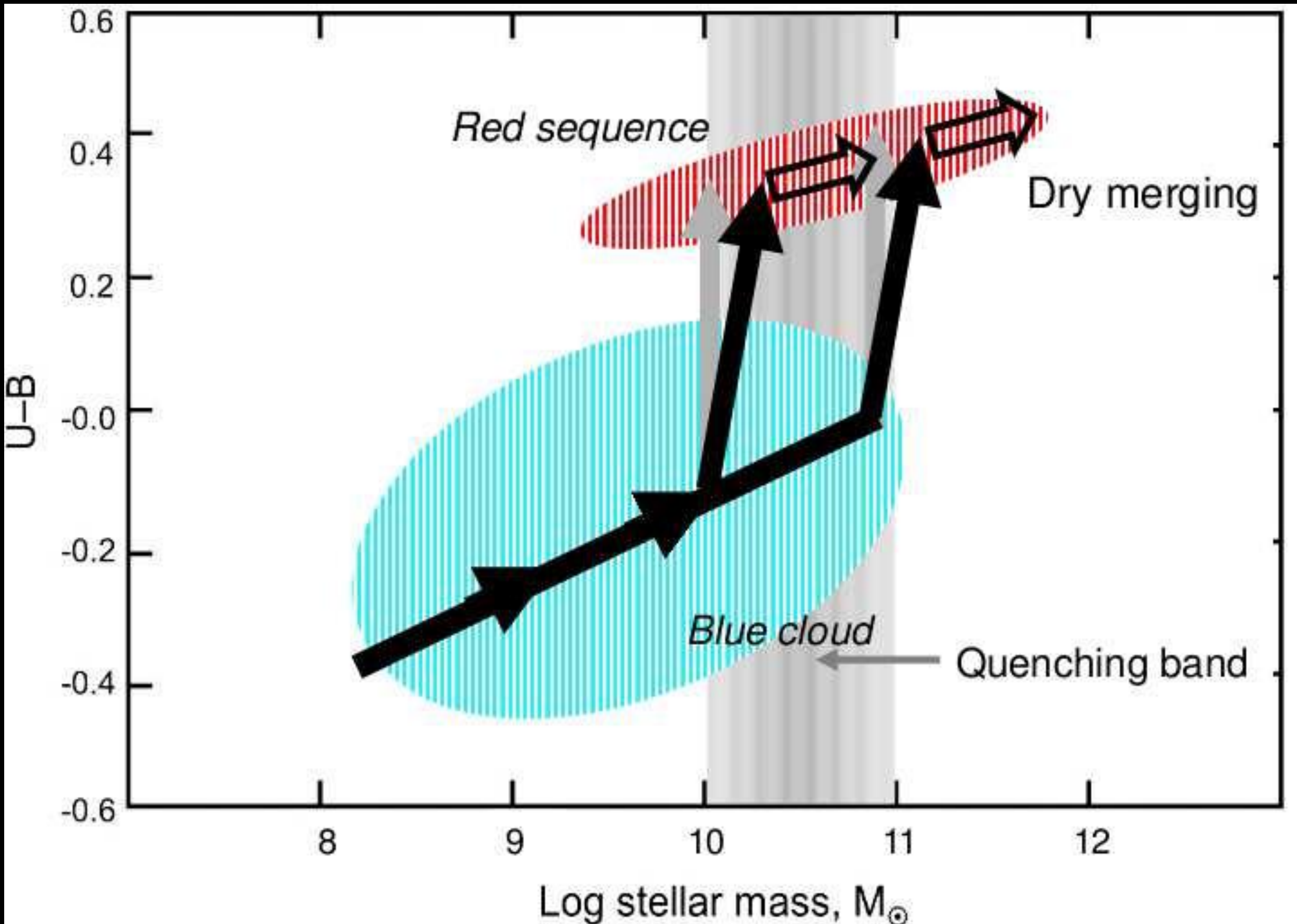


Baldry et al. 2004



Very large photometric & spectroscopic datasets at z~0: SDSS

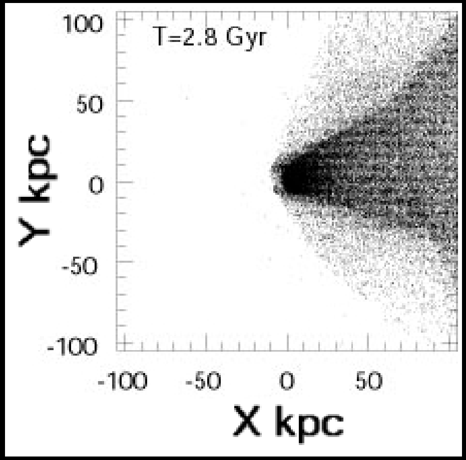
Balogh et al. 2004

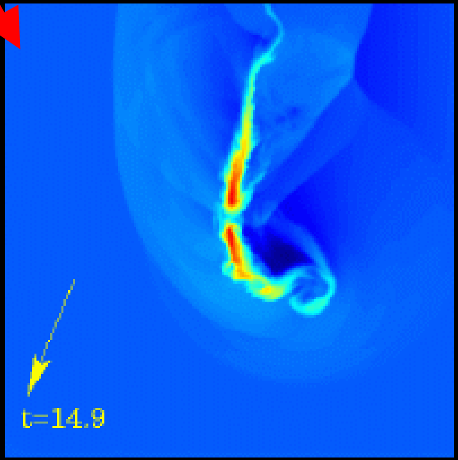


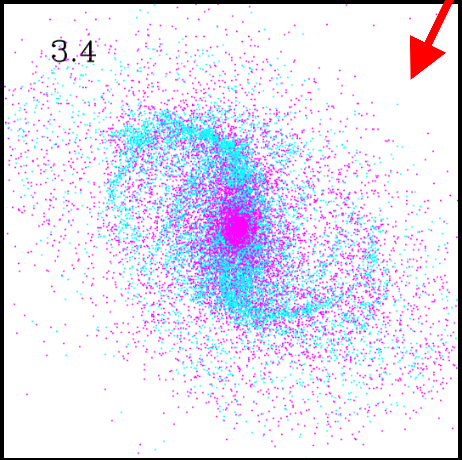
Faber et al. 2007

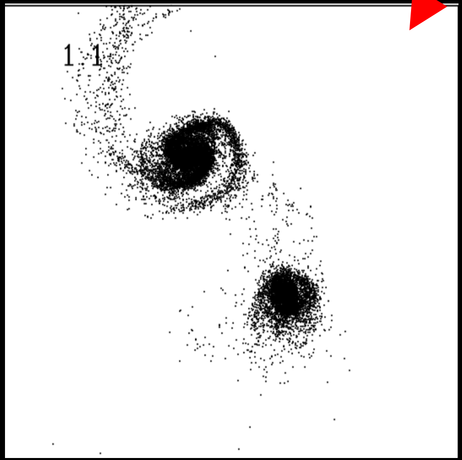
Clusters as Laboratories of Galaxy Evolution

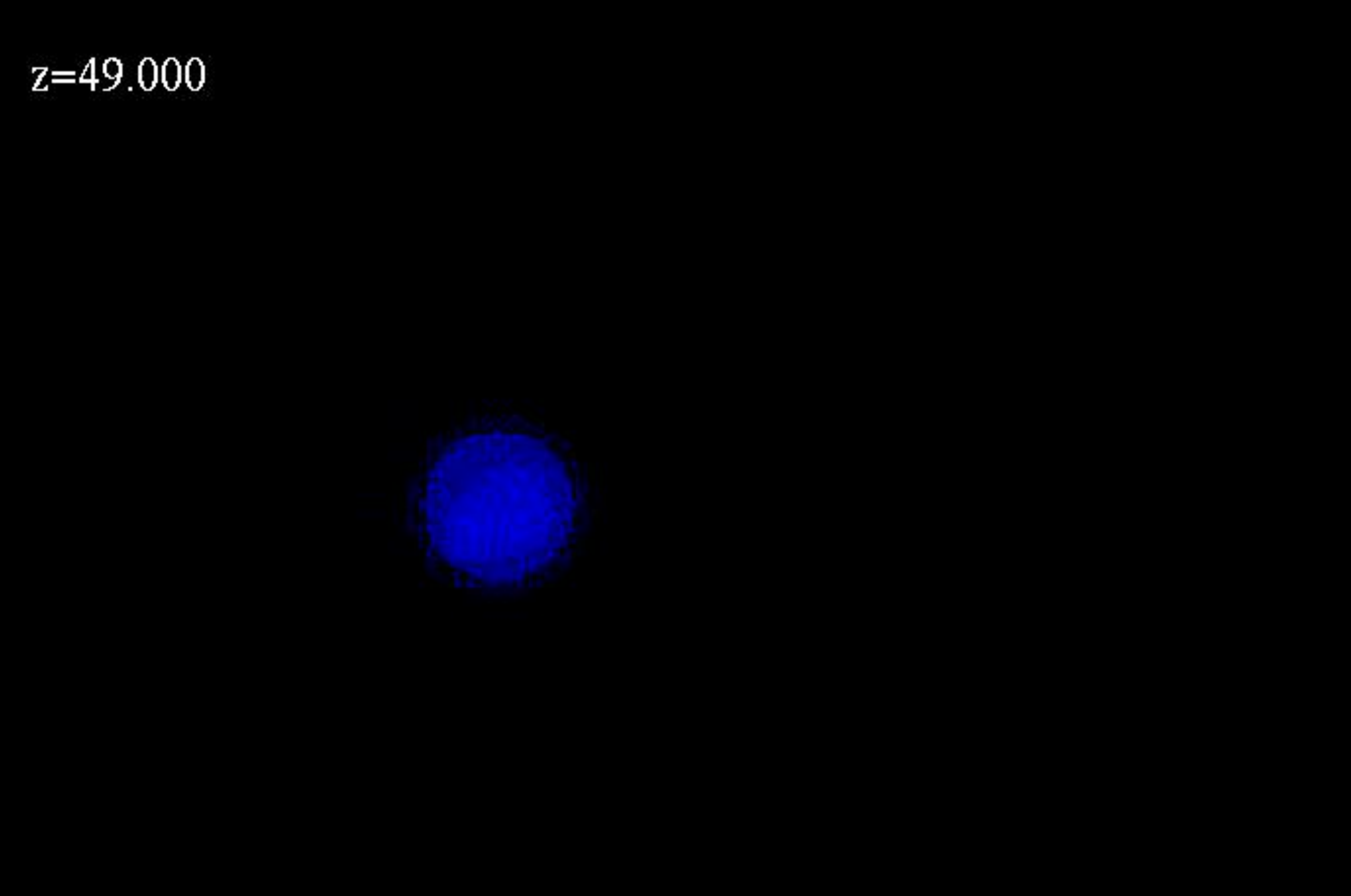
- Physical processes:
  - ram-pressure stripping
    - of gas halo (Bekki et al. 2002)
    - of disk gas (Quilis et al. 2000)
  - galaxy-galaxy interactions
    - harassment (Moore et al. 1998)
    - mergers (Bekki 1998)
  - cluster tidal field (Bekki 1999)
  - &cetera





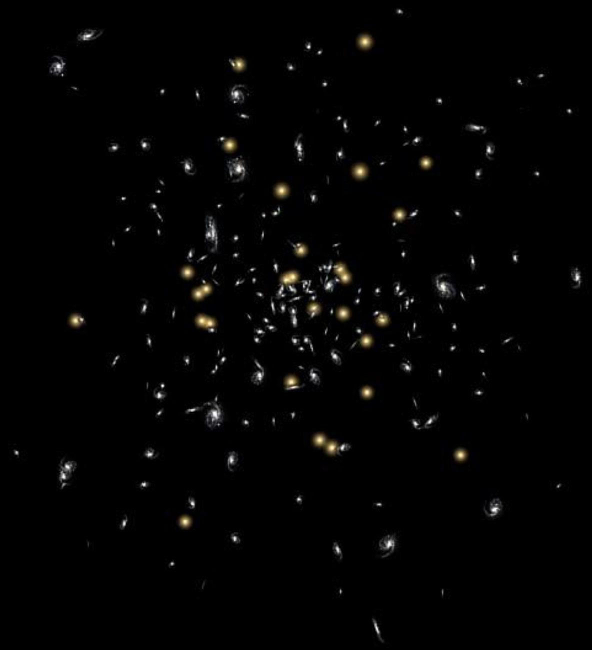






B. Moore

Cardiff Numerical Simulations Group (2009)



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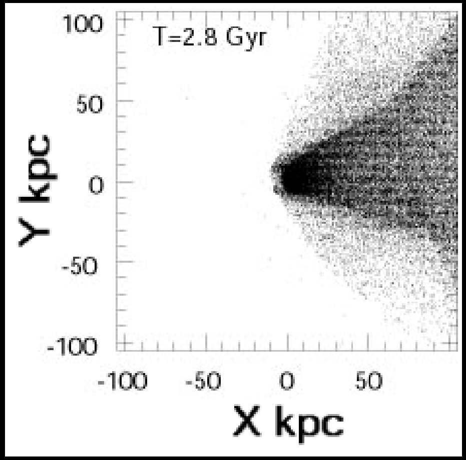
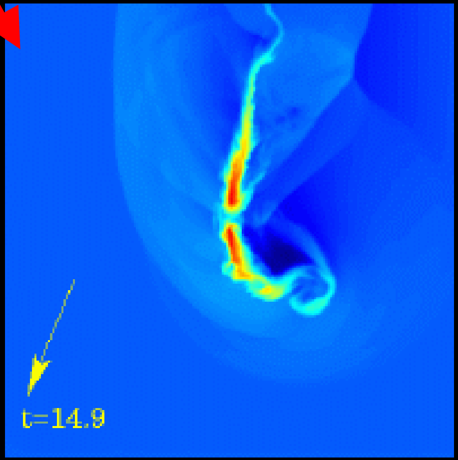
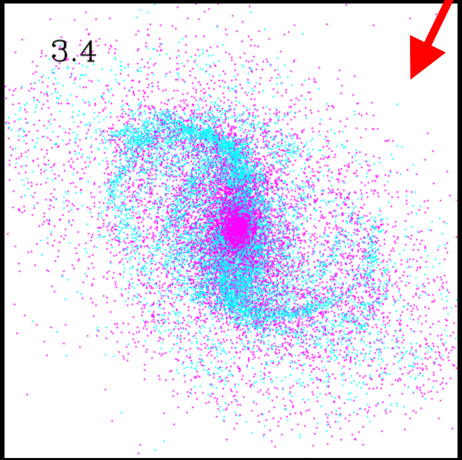
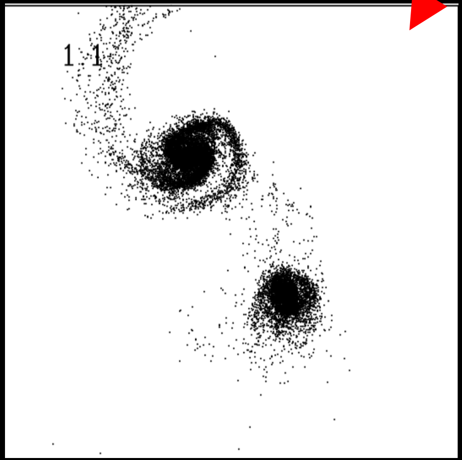
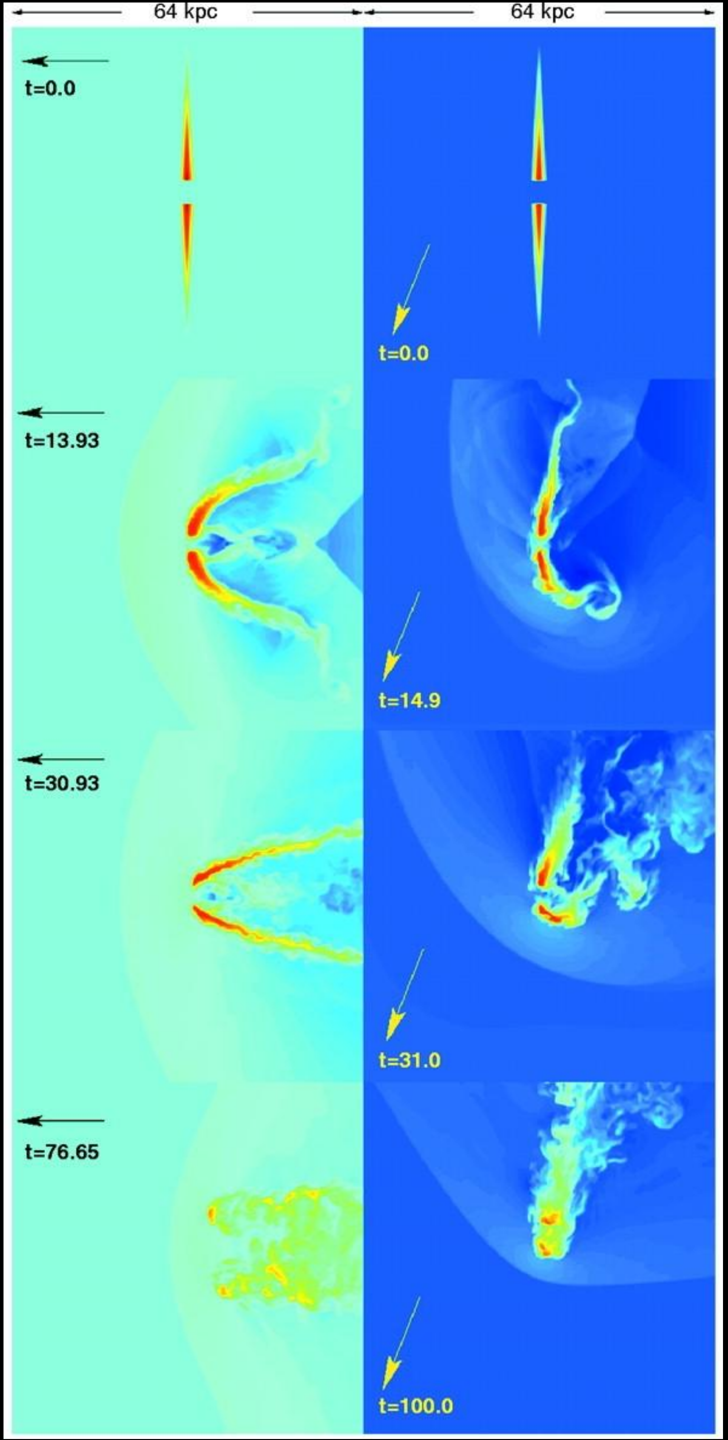








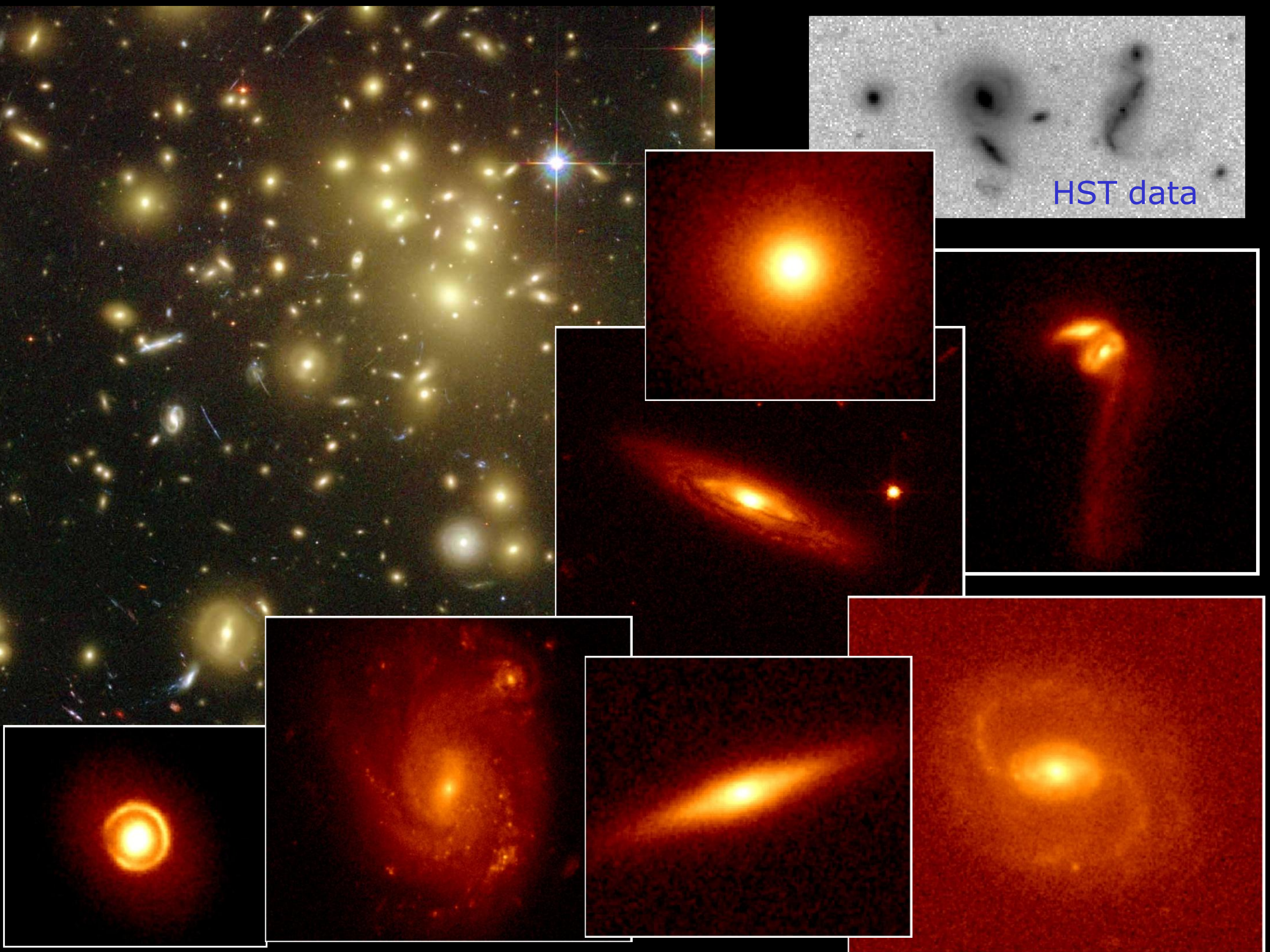


Ram Pressure:

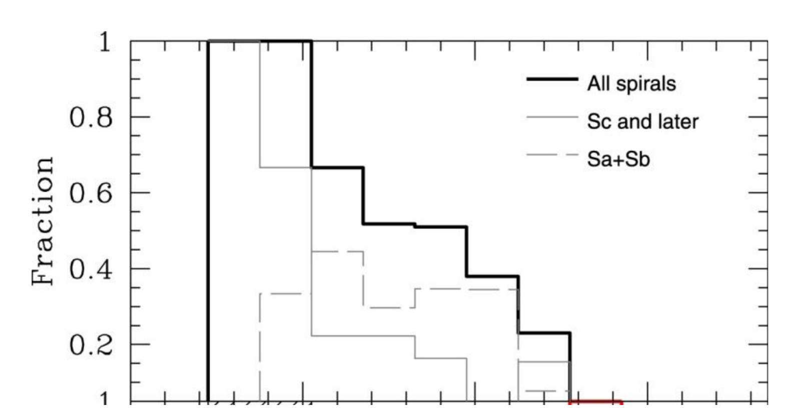
Gas disk interacting with hot intracluster medium

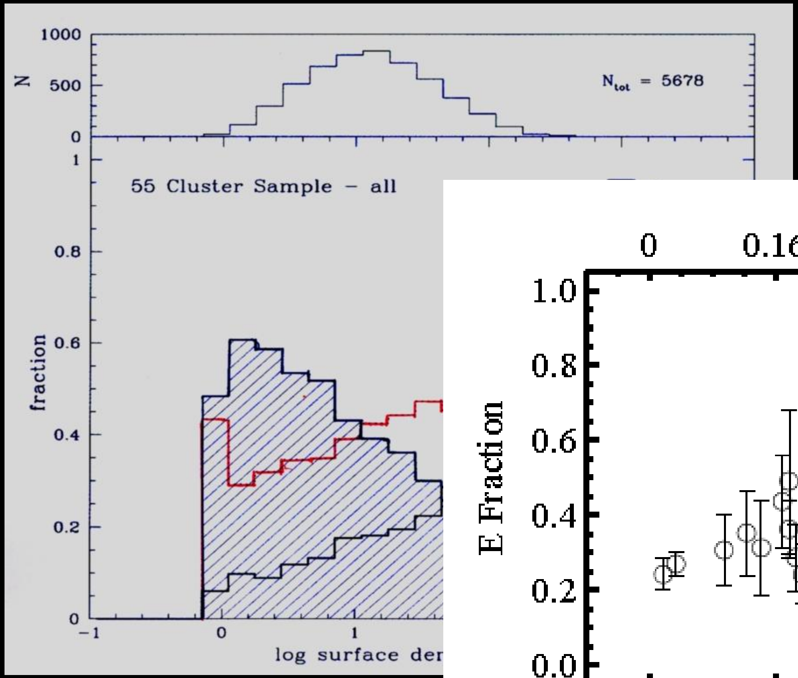
Cardiff Numerical Simulations Group (2009)

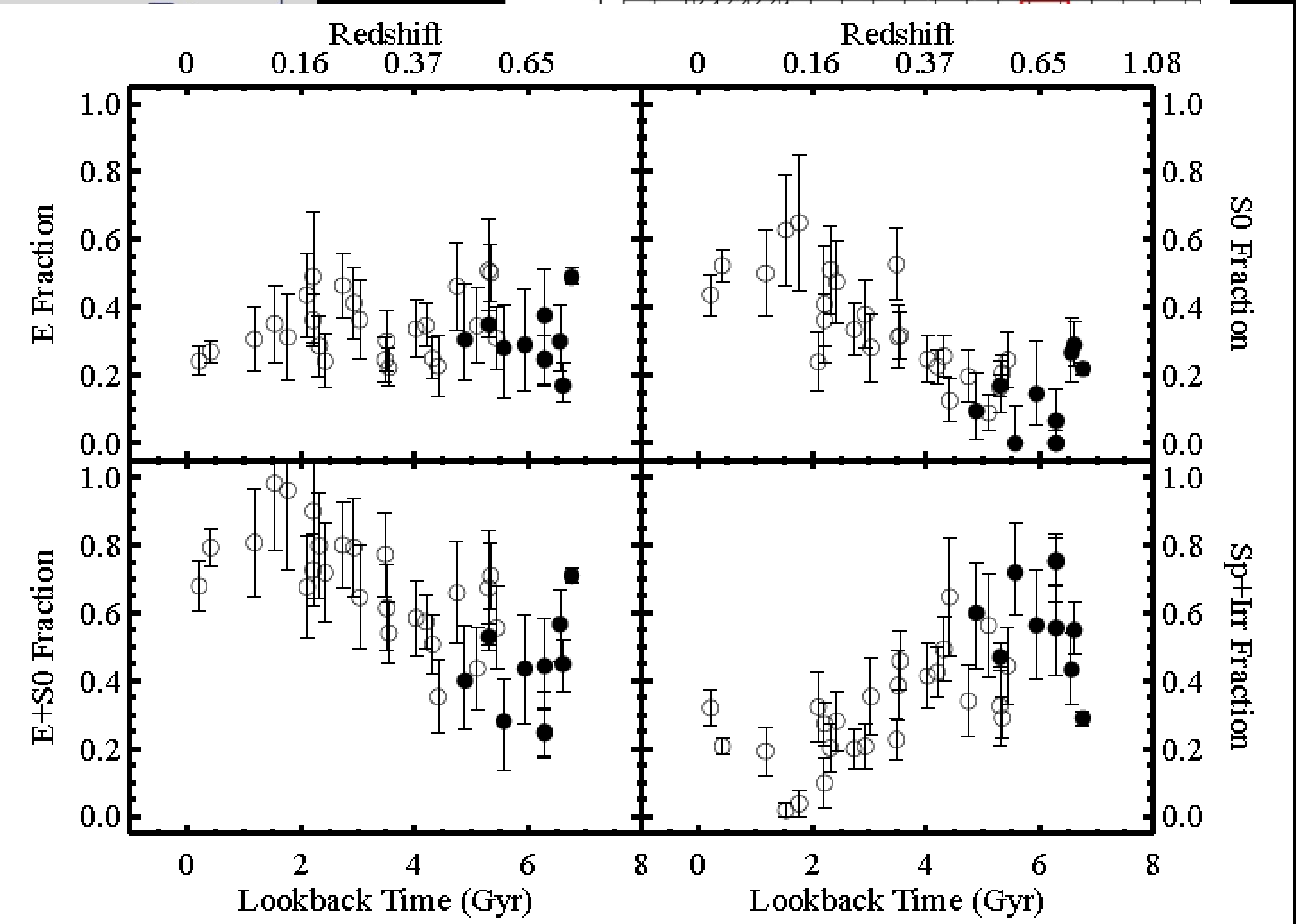
Quilis, Moore & Bower (2000)


HST data

Dressler et al. (1997)
Desai et al. (2007)
Poggianti et al. (2008)







Morpholo
relatio

Summary

- Galaxy formation and evolution need to be studied in a cosmological context – galaxies do not form or live in isolation.
- The environment plays a very important rôle in the development of galaxies and their morphology.
- Clusters of galaxies are excellent laboratories to study environmental effects.