Should we support a new optical/UV space mission for 2015?

An Onion-inspired special report

Astronomer on the Street:

Well, yes!

I haven't heard anything yet that convinces me. Wait- you're not going to write that down??

- Absolutely! Here, have a book– take two! I have a whole box of 'em...

- I think we should go home and let the physicists figure it out.

- Sounds great! I'll take ten!

Sure, but I'm glad we have 10 years to figure out why.

Galaxies in Groups and Clusters

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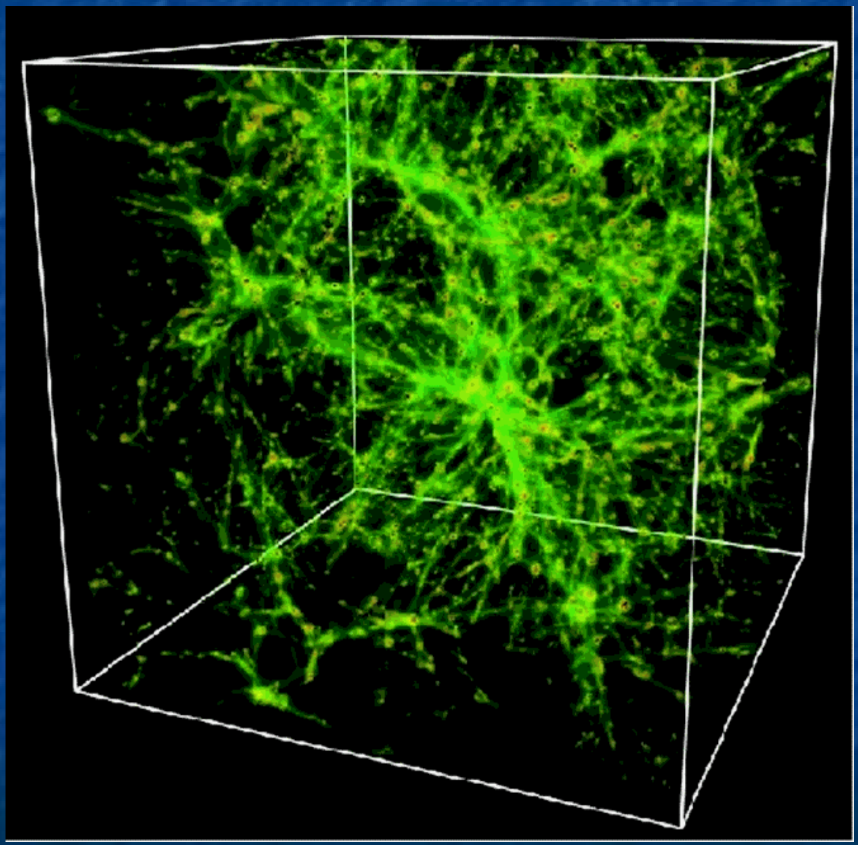
Why clusters?

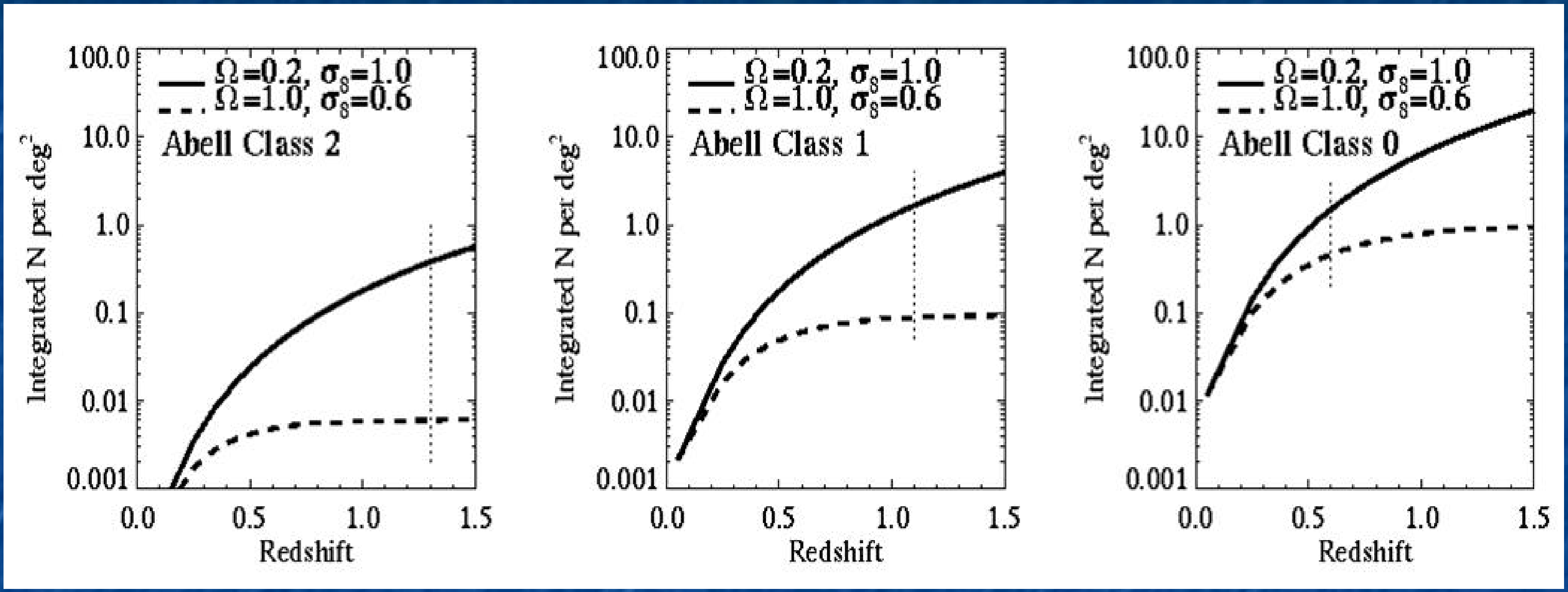


- Clusters mark intersections in the cosmic web
- Important laboratories for studies of phenomena on pc to Mpc scales

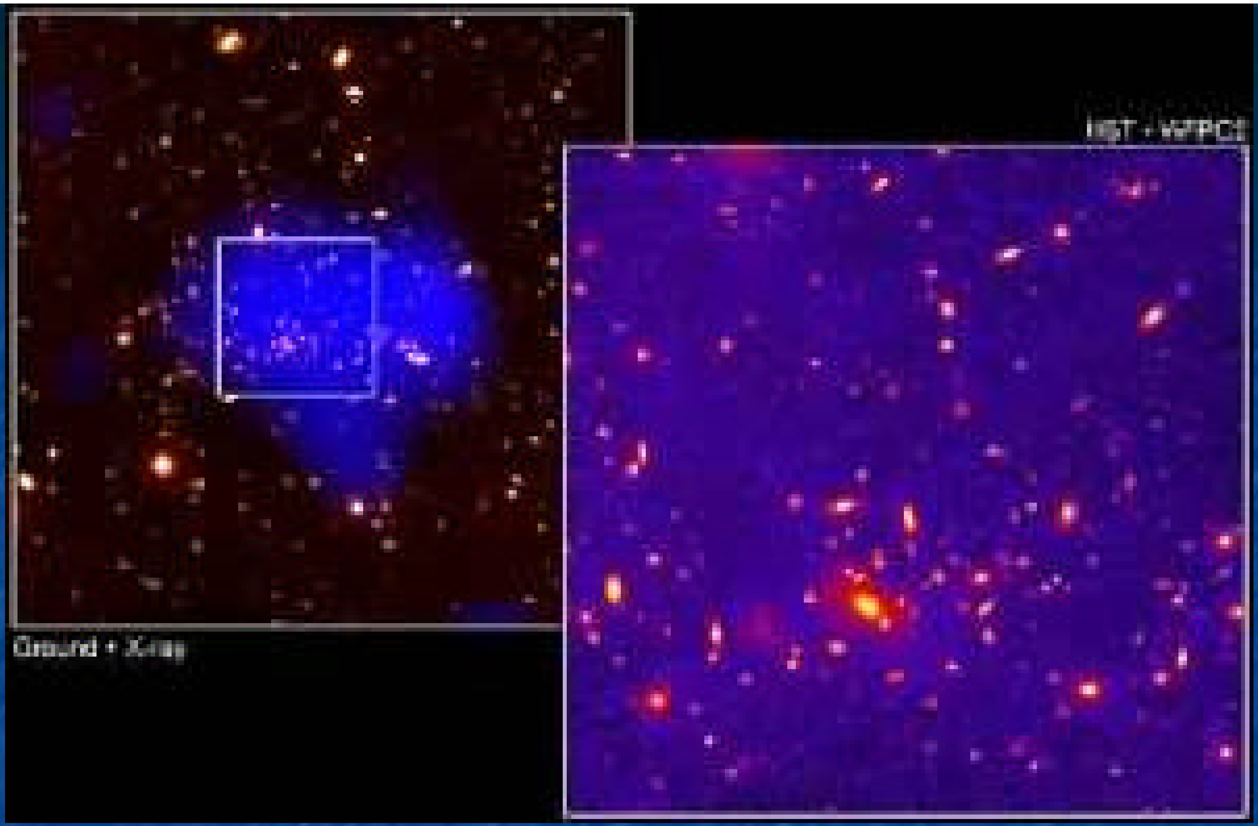
2000-2007: an explosion of new clusters from SDSS, X-ray, S-Z, lensing, deep optical imaging and spectroscopic surveys...

- For the first time we'll have a full sample of cluster types:
- Z=0 to the first clusters
- Full mass range from small groups to richest clusters
- Wide range of dynamical states, formation history

Clusters and cosmology



- Number densities of clusters of a given mass constrain cosmological parameters and specifically formation of large scale structure

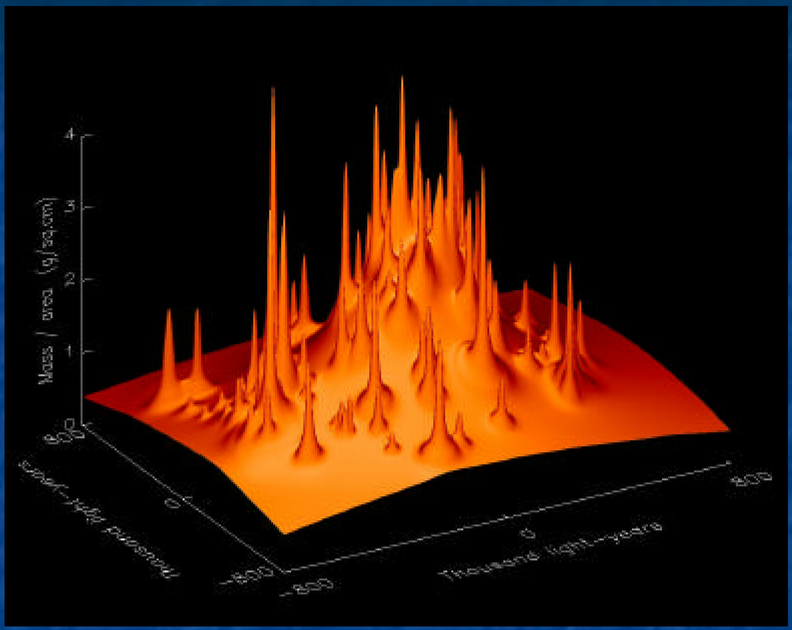


Donahue et al.

- Cluster contents include 100's of galaxies, hot X-ray emiting intra-cluster gas, dark matter
- Convenient "representative" samples of universal ratios?
- With cosmology "solved" in 2015, emphasis may be instead on variation in properties as a function of mass, substructures and detailed cosmic evolution of systems

Determining Mass and Mass Distributions

- Dynamical and X-ray studies:
- Require equlibrium, assumptions about projection and isotropy
- Difficult to apply to less massive systems
- Lensing masses measure projected mass without requiring equilibrium

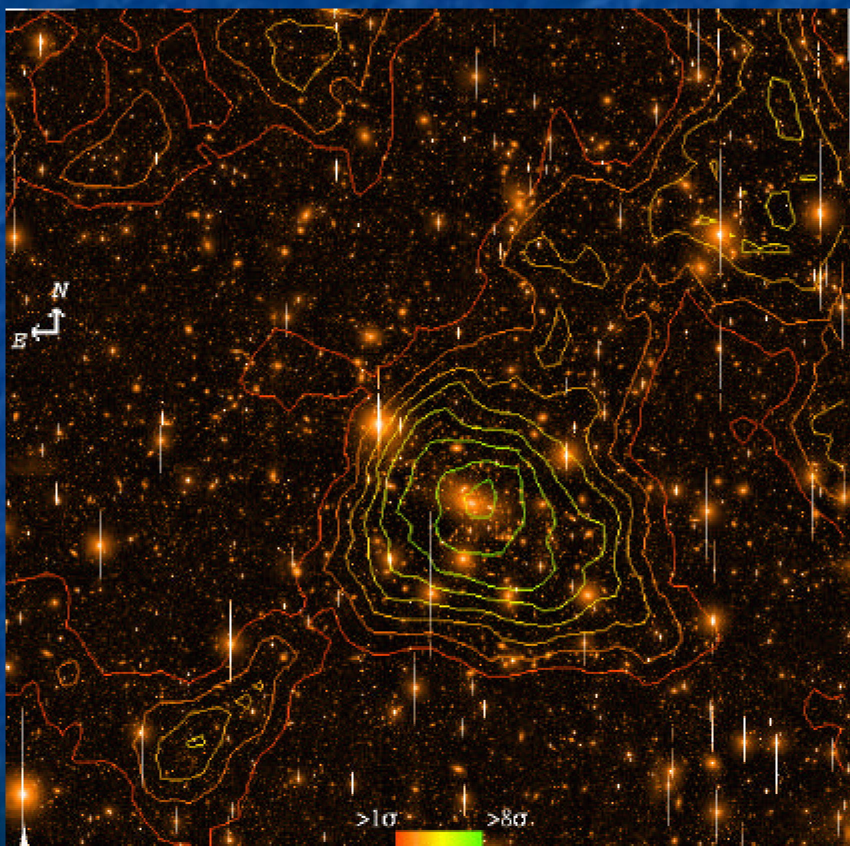


Strong lensing constrains core masses and in cases where we see multiple images of a single source can be used to model complex mass profiles, including individual galaxy haloes inside cluster potential

Gladders, Ellingson & Hoekstra 2002

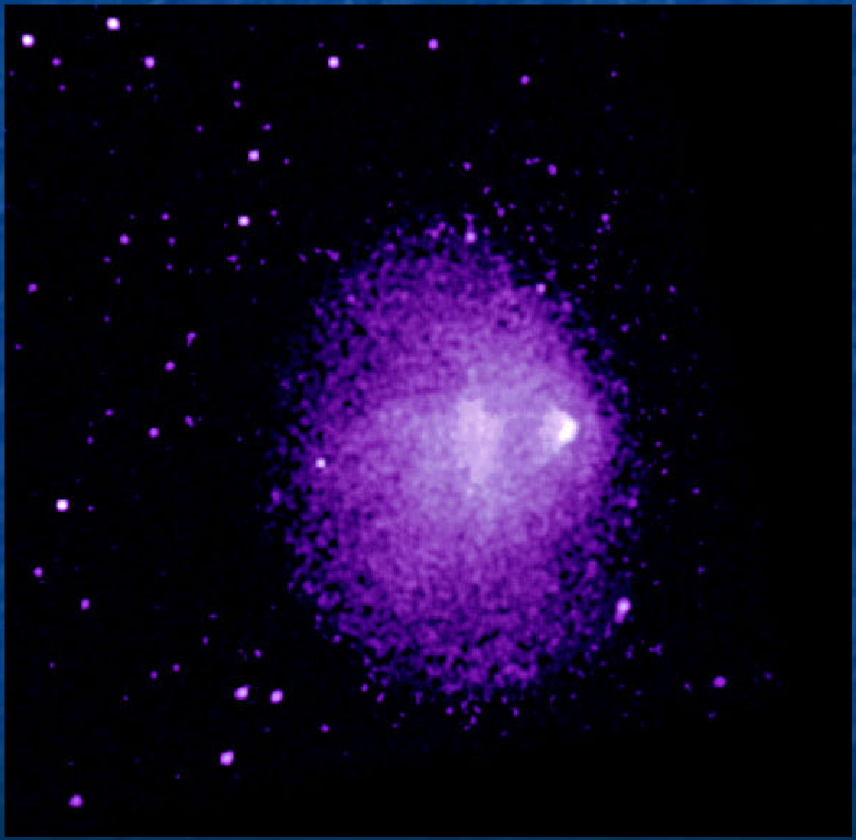
- Lensing of multiple objets by the same potential offers geometric solutions to cosmology
- Magnification from lensing offers a close, if distorted, look at very high z galaxies
- Systems like these are rare but increasing in number

Weak lensing mass maps



- Weak lensing is especially attractive: can map mass distributions to large radii, into the field
- Requires deep high resolution images over a wide field (10 ’+)
- Can be done from ground (?) but with difficulty

Fischer et al.

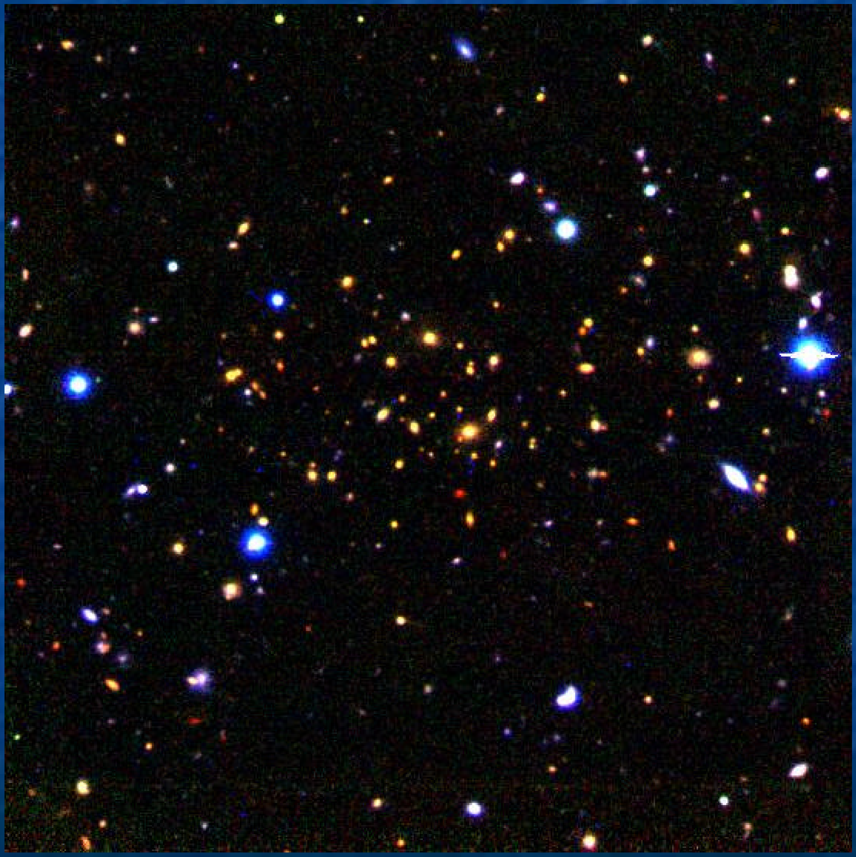


- Hot gas mass distributions, temperatures, metallicities from X-ray emission
- Massive clusters are "closed boxes" so intracluster gas reflects integrated feedback from galaxies
- Present Lx-Tx distributions suggest additional energy input: early star formation, AGN?
- QSO absorption lines: trace the surrounding cosmic web?

- Combination of accurate mass maps and gas/galaxy/metal distributions will test efficiency of galaxy formation and measure galactic feedback for different mass overdensities and galaxy populations

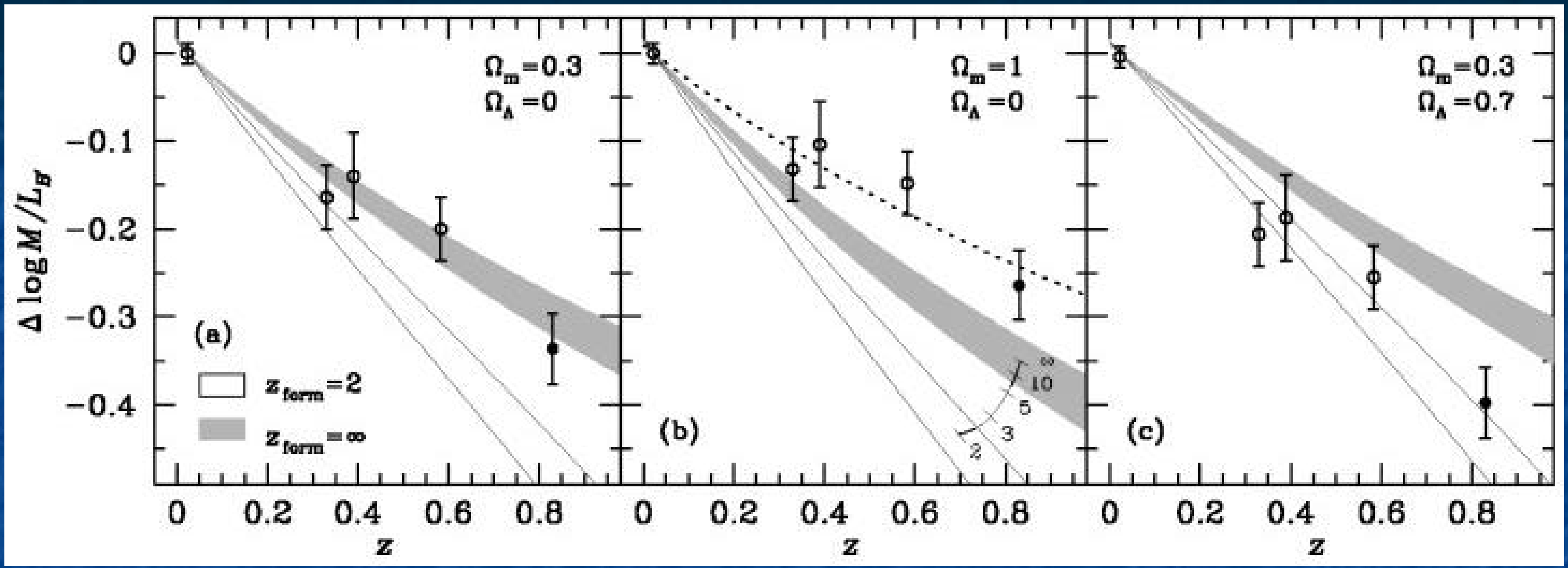
- Clusters will not be as useful as fundamental cosmological probes, but will provide a link between mass structure and the visible universe

Clusters and Galaxy Formation



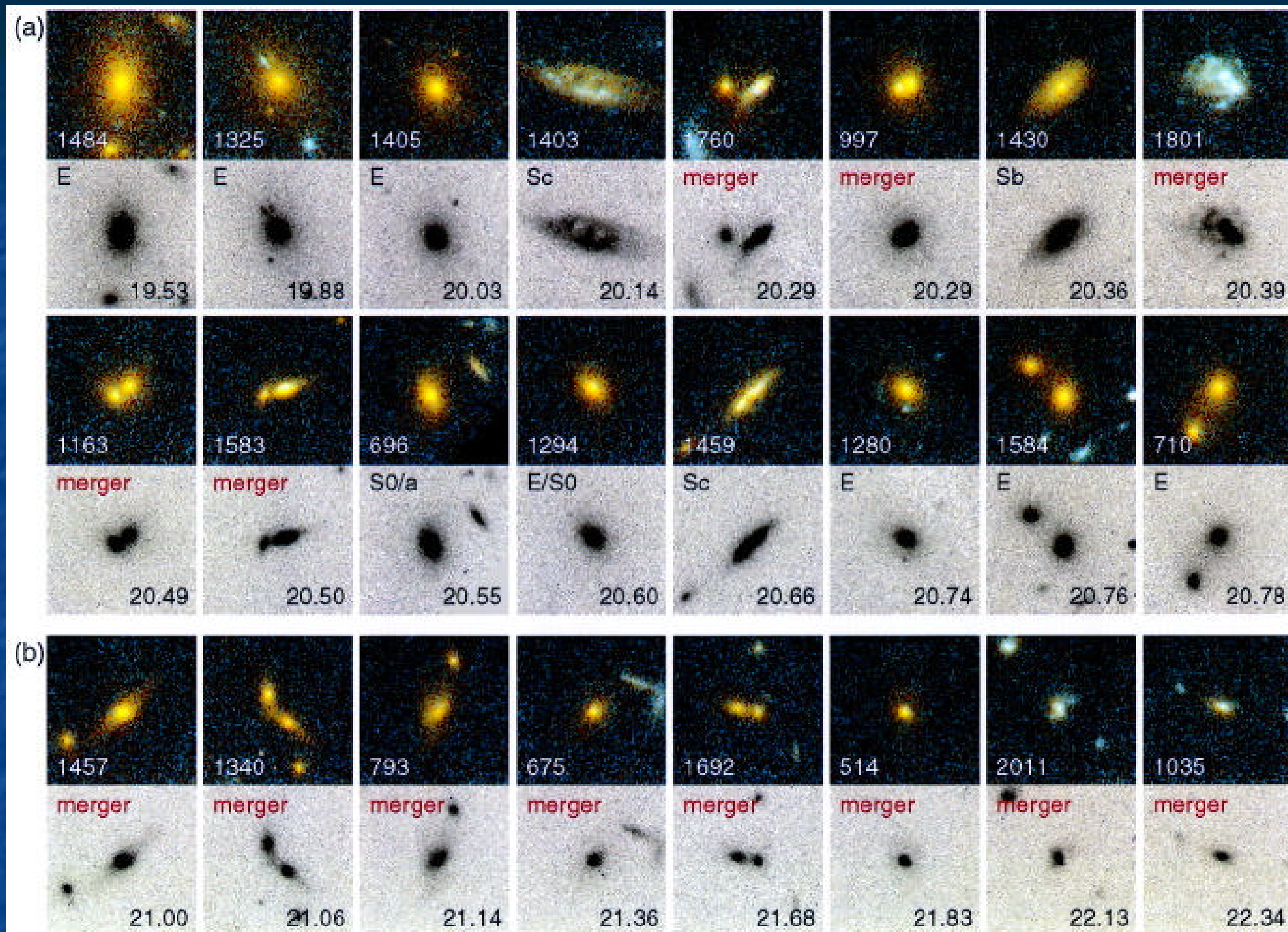
- Clusters probably represent the sites of the first born galaxies
- Also are convenient fields for looking at many coeval galaxies simultaneously

Z=0.97;
Barrientos et al.
2002



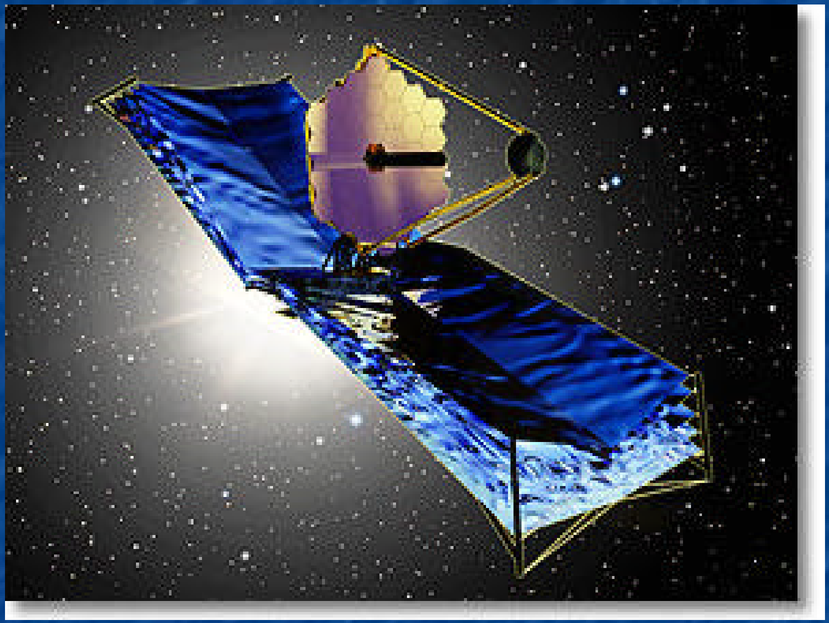
Van Dokkum et al. 1998

- Detailed information about galaxy structure + velocity information from 8-10m class telescopes yield M/L ratios of galaxies
- Indications are that galaxies formed at z> 2, have evolved "passively" since z~1



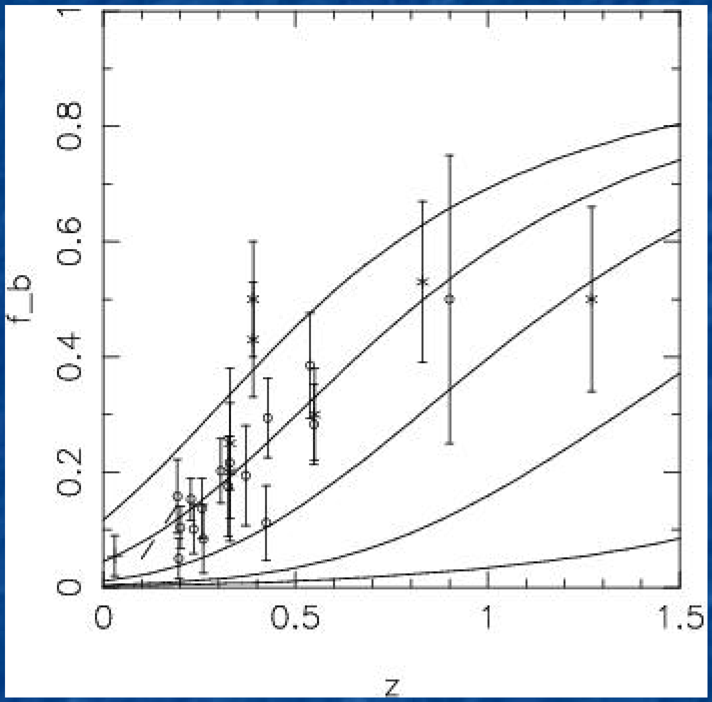
Van Dokkum et al. 2000

- "Red mergers" at z~0.8 suggest that stars form before morphology of galaxy is finished. Is this generally true?



- NGST is the logical follow-up to trace galaxy formation at $z > 2$, but lower-z counterparts are still necessary to link high redshift galaxies to the present
- Star formation is most visible < 1 micron for
  $z < 1.5$
- Will NGST deliver diffraction-limited images to 0.6 microns?

Cluster Galaxy Evolution at z< 1



Model curves for (top to bottom) 2.5,2,1.5,1.0,0.5 Gyr timescale for transformation of red to blue galaxies

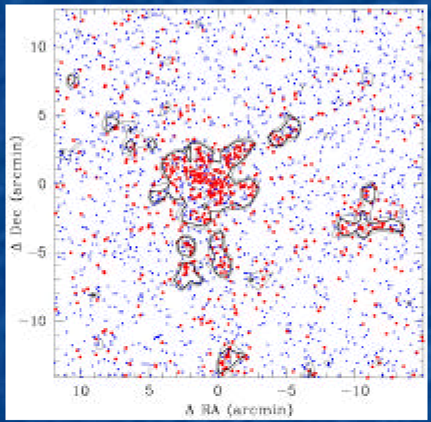
- Still a lot of action at moderate redshifts

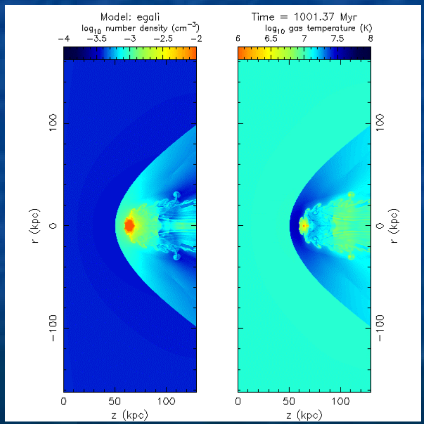
(e.g. "Butcher Oemler effect")

- Ongoing infall of star-forming field galaxies into clusters- cosmology drives changes in star formation
- Important to understand cluster-cluster variation in terms of recent merging history

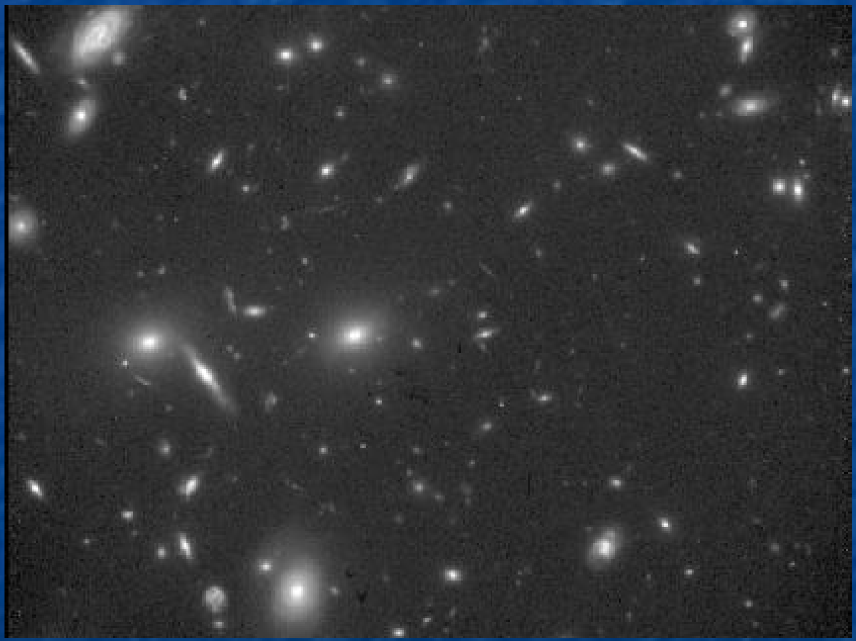
Environmental disasters

Kodama et al. 2002)



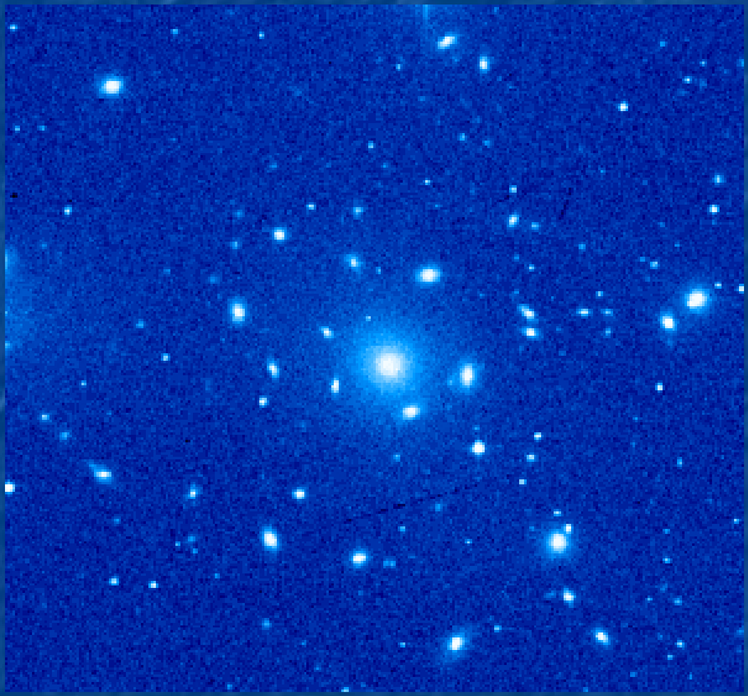


- Galaxy interactions- mergers, starbursts? Do these happen in infalling groups BEFORE entering the clusters? Need both extensive spectroscopy for dynamic/stellar popss and high resolutinn images
- Cluster-specific mechanisms: Tidal disruption by the cluster potential, ram-pressure stripping by the hot intra-cluster gas.
- Affects on outer regins of cluster galaxies? we should find numerous qsos behind cores of lensing clusters which would allow us to measure the sizes of galaxy mass and gaseous halos



- HST is marginally adequate to measure detailed disk properties at z~0.5.
- Dwarfs may be most susceptible to environmental processes
- Tracing the morphologies of galaxies in an unbroken sequence from formation epochs to the present will require a larger aperture and higher resolution capability

Clusters at low redshift: Back to the future?



- Low redshift galaxies can proxy for high-z: Coma continues to be of great interest in interpreting z=1-3
- Resolved stellar populations in Coma: constrain star formation & enrichment history
- Dozens of quasar sightlines at V=22- galaxy halos?

e.g. Bower et al. 1993, Caldwell & Rose 1997
Poggianti et al. 2001, Moore et al. 2002

Summary: what can t be done by HST/NGST/very large ground-based AO telescopes?

- ?Weak lensing/mass distributions over wide fields; 10 ’ FOV, ?? resolution
- Morphologies of star forming galaxies over a wide range of environments, 10 ’FOV, < 0.02 ” resolution
- UV absorption from galaxy halos in a variety of environments, intergalactic gas
  - Detailed look at stellar populations in low-z clusters- Coma!