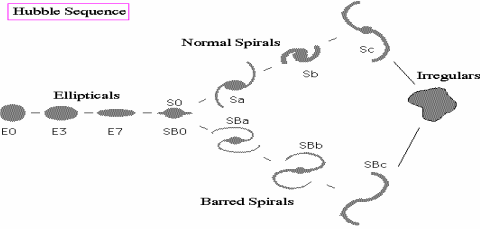


Chris Conselice

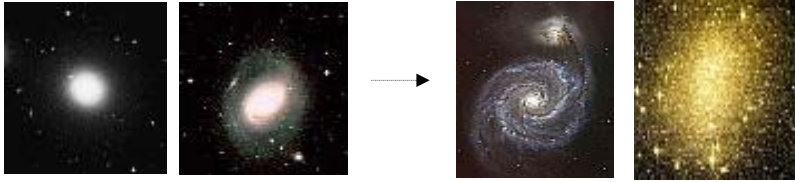
Hubble Types

98% of all nearby bright galaxies can be placed into a Hubble type



Hubble types are the $z = 0$ final state of bright galaxy evolution

Ellipticals have old stellar populations, spirals have both old and young components while irregulars are dominated by young stars



Old stars

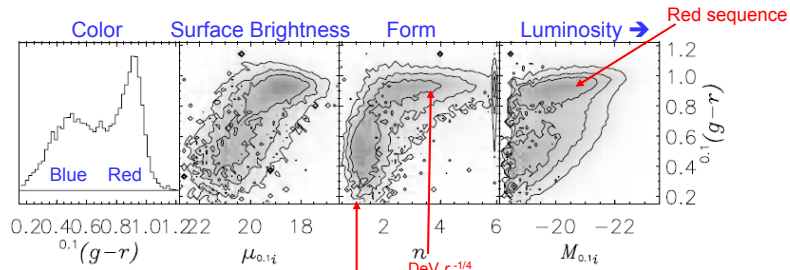
Young stars

A significant amount of star formation must have occurred in the past for Es, but some young stars clearly exist in spirals

Present day galaxies

- SDSS (Sloan Digital Sky Survey)
 - 10^6 targets, mostly galaxies, selected for spectroscopy
 - 10^4 deg² of sky
 - $m_r < 17.8$ mag

- Complete sample of 115,000 SDSS galaxies:

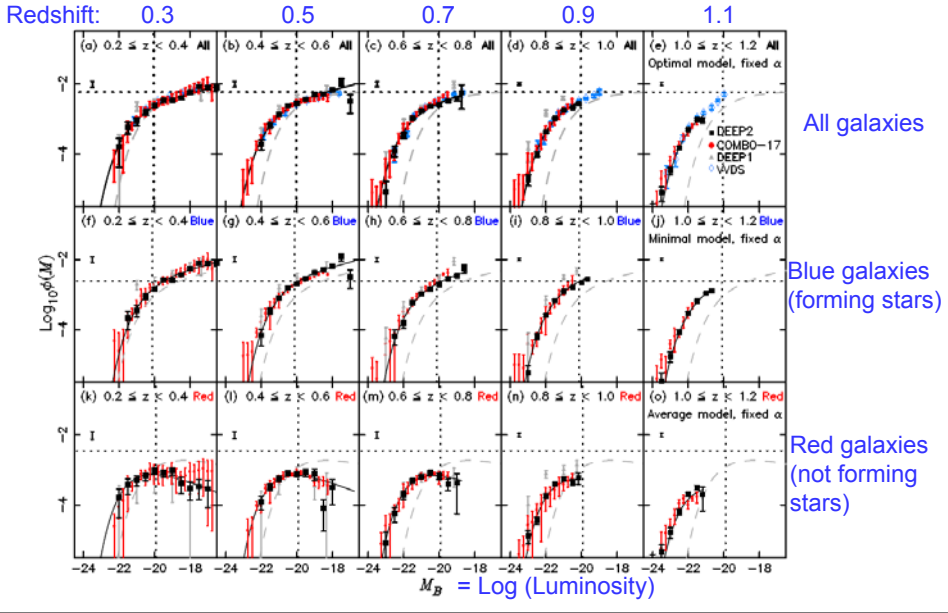


Blanton et al. 2005, ApJ, 629, 143

Exponential r^{-1}
Disks (spirals)

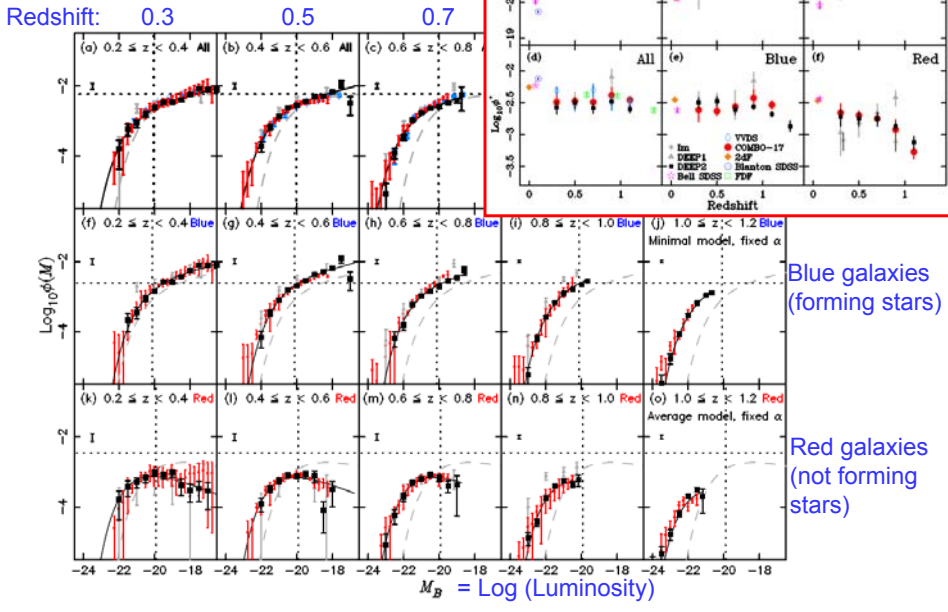
Looking back from the present day

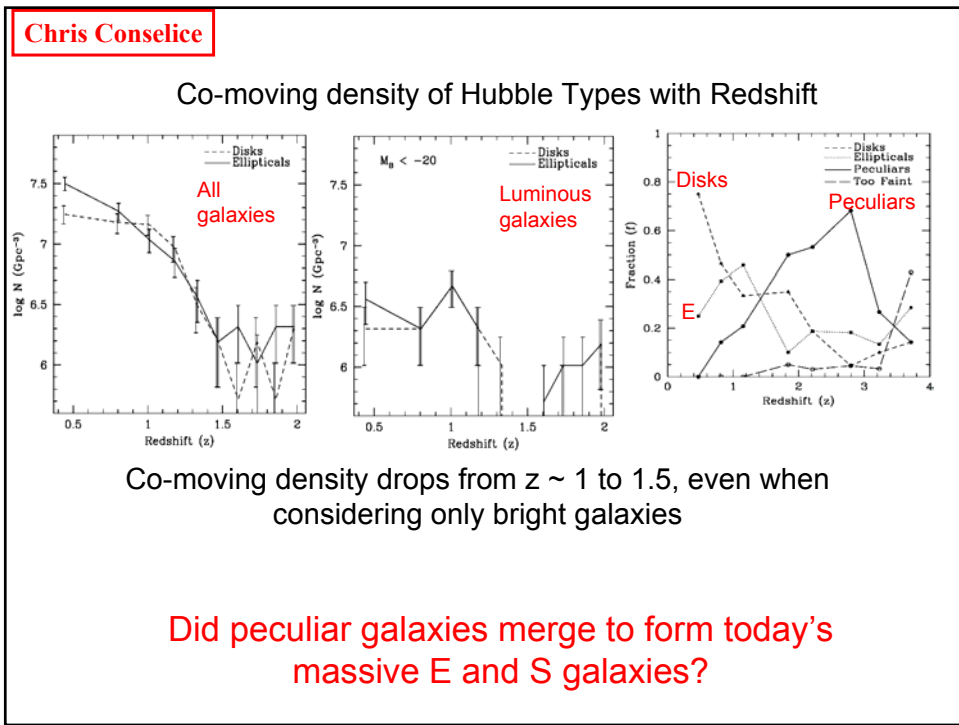
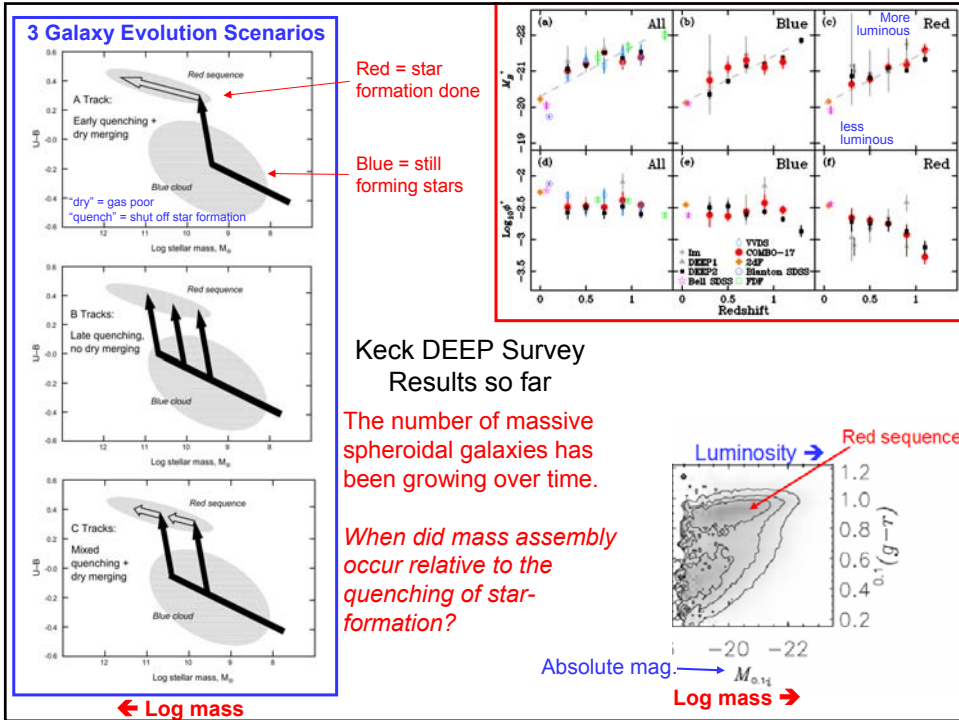
- Keck DEEP Survey - 39,000 galaxies



Looking back from

- Keck DEEP Survey - 39,000

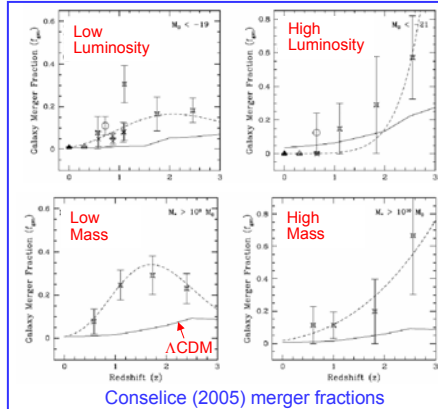
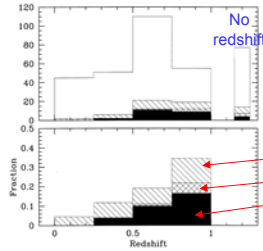
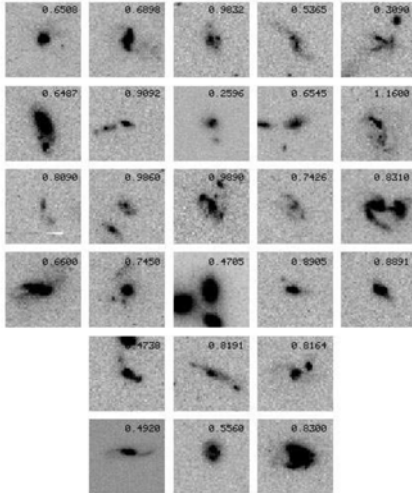




Are these high redshift peculiar galaxies mergers?

LeFevre et al., 2000, MNRAS, 311, 565

- 285 galaxies.
- HST images, CFHT spectra.
- Merger fraction increases with redshift



Merger Processes

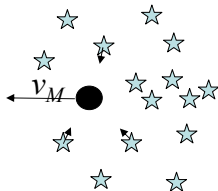
- **Dynamical Friction** - A slow accretion process.
 - Massive body moving through uniform distribution of stars
 - Pulls stars in behind it.
 - Creates high-density wake.
 - Gravitational pull from wake slows down massive body.
 - If massive body is in orbit in a galaxy, it will gradually spiral into the center.

Force on massive body is

$$f_d \simeq C \frac{G^2 M^2 \rho}{v_M^2} \Rightarrow t_c = \frac{2\pi v_M r_i^2}{CGM}$$

$$r_{\max} = \sqrt{\frac{t_{\max} CGM}{2\pi v_M}}$$

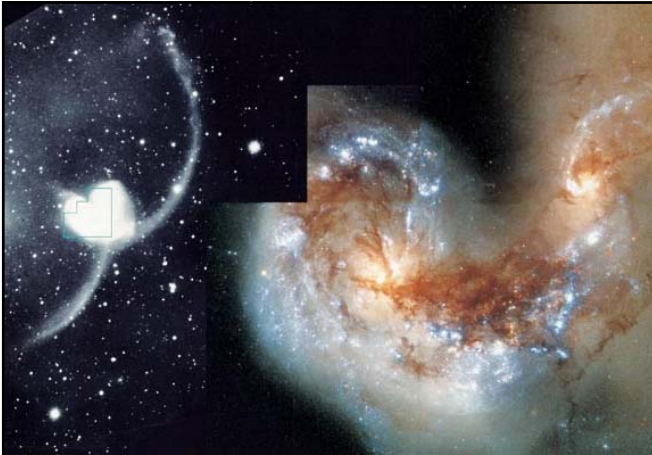
[CO eqn. 26.3]



r_i = initial distance from center of galaxy.

t_c = time to spiral into center due to dynamical friction.

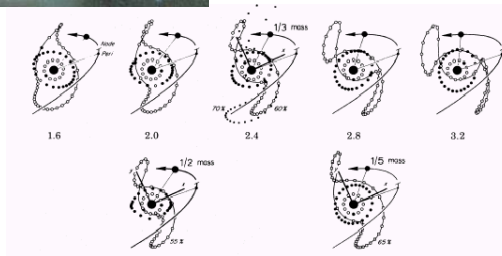
r_{\max} = max radius for capture within age of universe.
(= 4 kpc for M31 and $t = 13$ Gyr)



The Antennae Galaxies

NGC 4038
NGC 4039

- **Galaxy collisions – “impacts”.**
 - Numerical simulations
 - Toomre & Toomre, 1972, ApJ 178, 623.
 - Tidal tails, etc.



Galaxies NGC 2207 and IC 2103



Hubble Heritage

Do collisions between spirals make ellipticals?

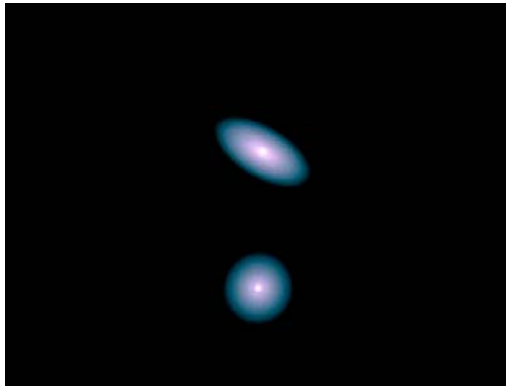
The Milky Way Meets Andromeda

2.5 million ly away

Approaching at 500,000 km/hr

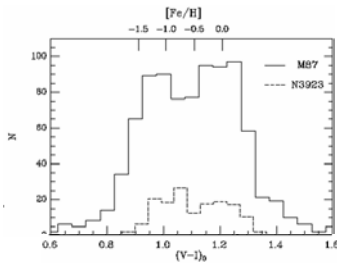
→ Collision in 3 billion yrs

Movie lasts 1.3 billion yrs.

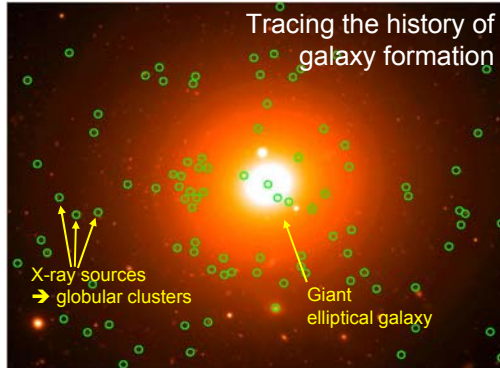
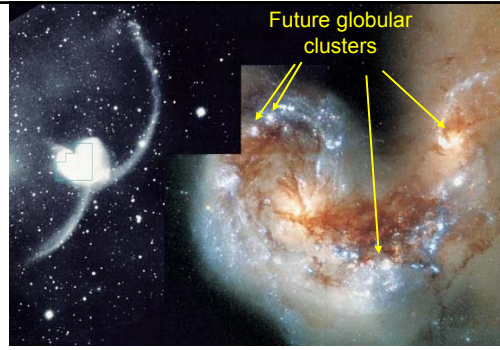


Globular Clusters as Merger Tracers

- Galaxy collisions → bursts of star formation.
- Product includes globular clusters.
- E galaxies have several different generations of globular clusters.



Zepf & Co.



Globular Clusters as Merger Tracers

- > 60% of E-galaxies show bimodal or more complicated distributions of GC's.
- Need images in many colors to separate effects of age and metallicity.

