

12h

# Galaxies, Large-scale structure & the IGM

Spiral galaxies

Galaxy population statistics

Clusters & groups of galaxies

Galaxies at high redshifts

2-pt correlation functions

Probing the matter distribution using weak  
lensing

The Gunn-Peterson test

Quasar absorption line systems

September 13, 2022

University of Rochester

16h

0.14

0.12

0.10

Redshift  $z$

0.08

0.06

0.04

0.02

0.00

0.00

0.02

0.04

0.06

0.08

0.10

0.12

0.14

0.14

0.12

8h

0.4

0.5

0.6

0.7

0.8

0.9

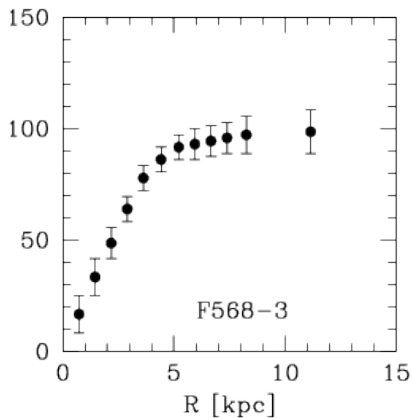
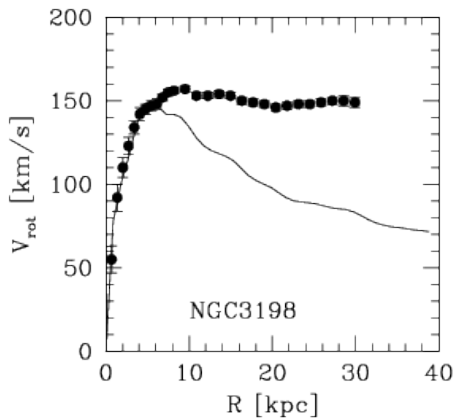
1.0

# Spiral arm patterns

Grand design v. flocculent system



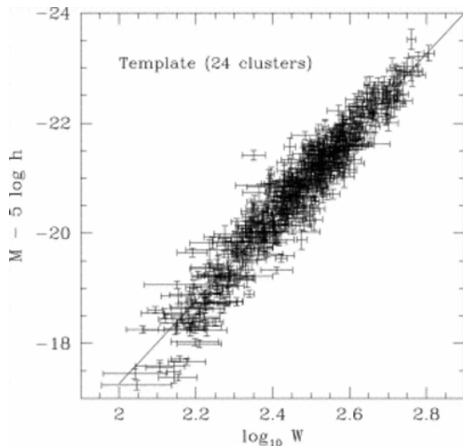
# Spiral galaxy kinematics



# Tully-Fisher relation

$$L = AV_{\max}^{\alpha}$$

where  $V_{\max}$  is the asymptotic rotational velocity.



*Giovanelli et al. (1997)*



# Lenticular (S0) galaxies

NGC 4526 & NGC 4150



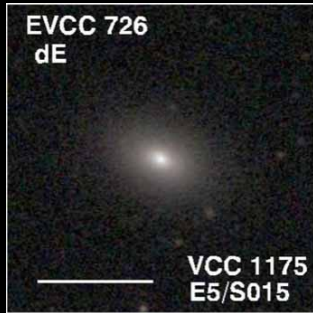
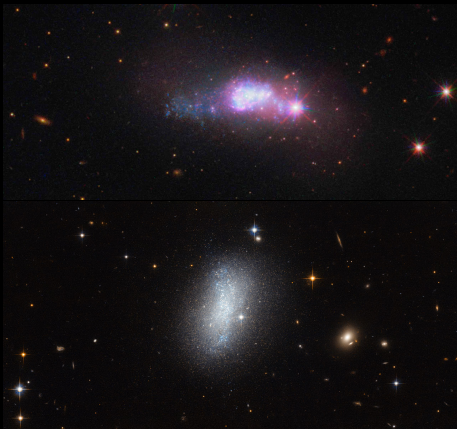
# Irregular galaxies

Large and Small Magellanic Clouds

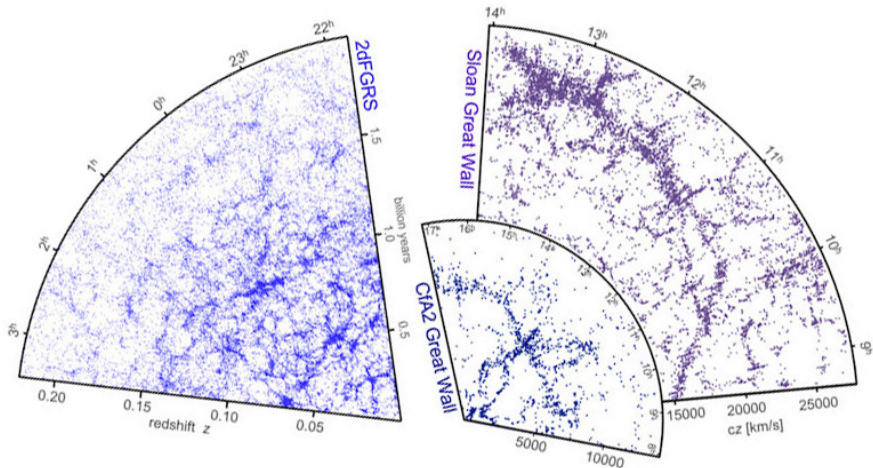


# Dwarf galaxies

Gas-rich (dIrr) & Gas-poor (dE and dSph)



# Large galaxy redshift surveys



# Galaxy luminosity function

Schechter function:

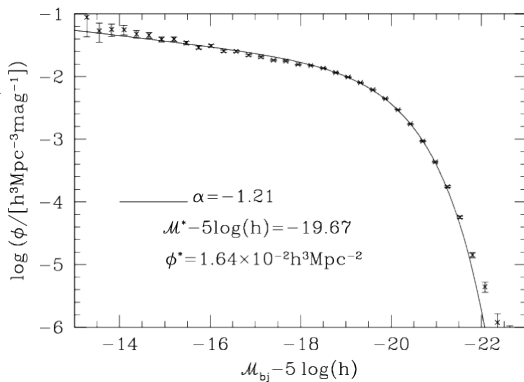
$$\phi(L)dL = \phi^* \left( \frac{L}{L^*} \right)^\alpha e^{-L/L^*} \frac{dL}{L^*}$$

where

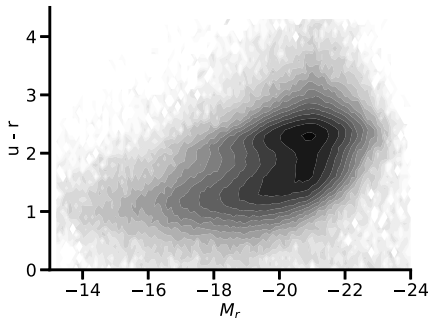
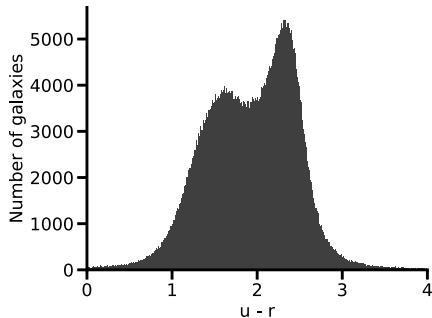
$L^*$   $\equiv$  characteristic  
luminosity

$\alpha$   $\equiv$  faint-end slope

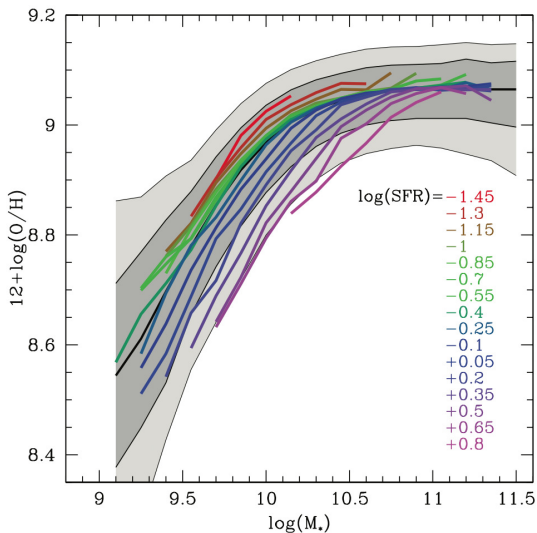
$\phi^*$   $\equiv$  overall  
normalization



# Color distribution

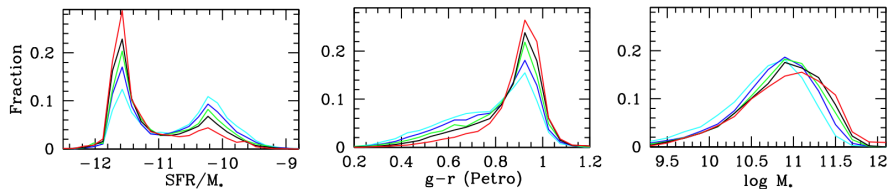


# Mass-metallicity relation



*Mannucci et al. (2010)*

# Environmental dependence



*Kauffmann et al. (2004)* - Colors correspond to galaxy density: red being the highest, and cyan being the lowest.



# Virgo cluster



# Coma cluster



# Galaxy cluster number density

$$n(r) \propto \frac{1}{r^\gamma (r + r_s)^{3-\gamma}}$$

where

$r_s \equiv$  cluster scale radius

$\gamma \equiv$  logarithmic slope of inner profile

Typically,  $\gamma \sim 1$  and  $r_s \sim 0.2R_{\text{cluster}}$ .