Local Galaxies

Fundamental relations for Ellipticals & dEs :

Color – magnitude relation : brighter Es are redder

Luminosity – metallicity relation : brighter Es are more metal-rich

Faber – Jackson relation : central velocity dispersion increases with luminosity

→ distance / mass determination

Kormendy's relations :

brighter Es have large effective radii

brighter Es have lower (average) surface brightness

Sphs (and GCs) do not follow Kormendy's relations

Fundamental Plane relations : effective radius – surface brightness – luminosity – central velocity dispersion

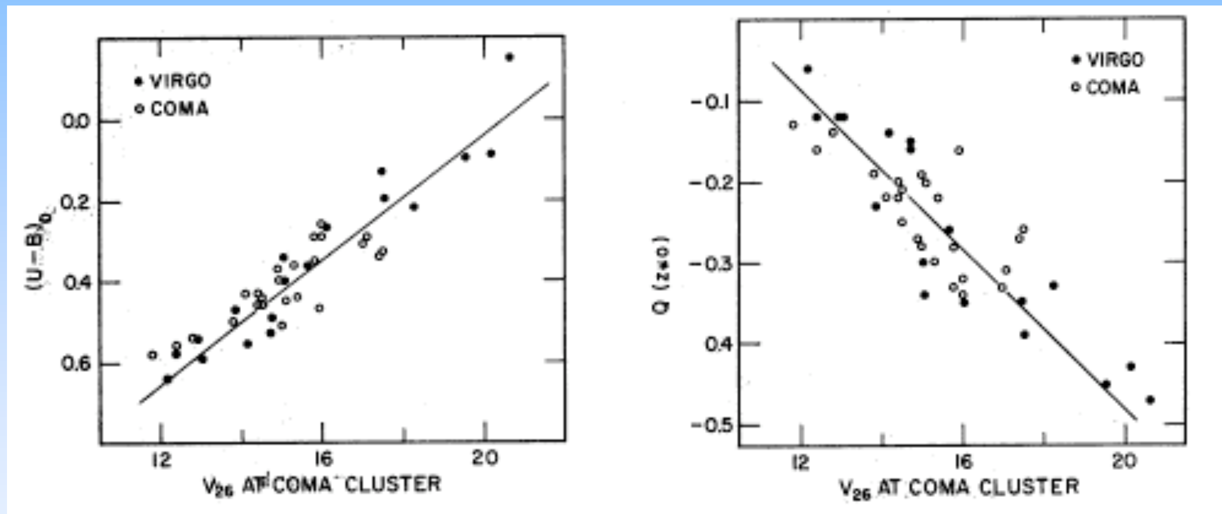
M/L increases with L

Local Galaxies

Fundamental relations for Ellipticals & dEs :

Color – magnitude relation : brighter Es are redder

(de Vaucouleurs 61, 72, fffff)



Local Galaxies

Fundamental relations for Ellipticals & dEs :

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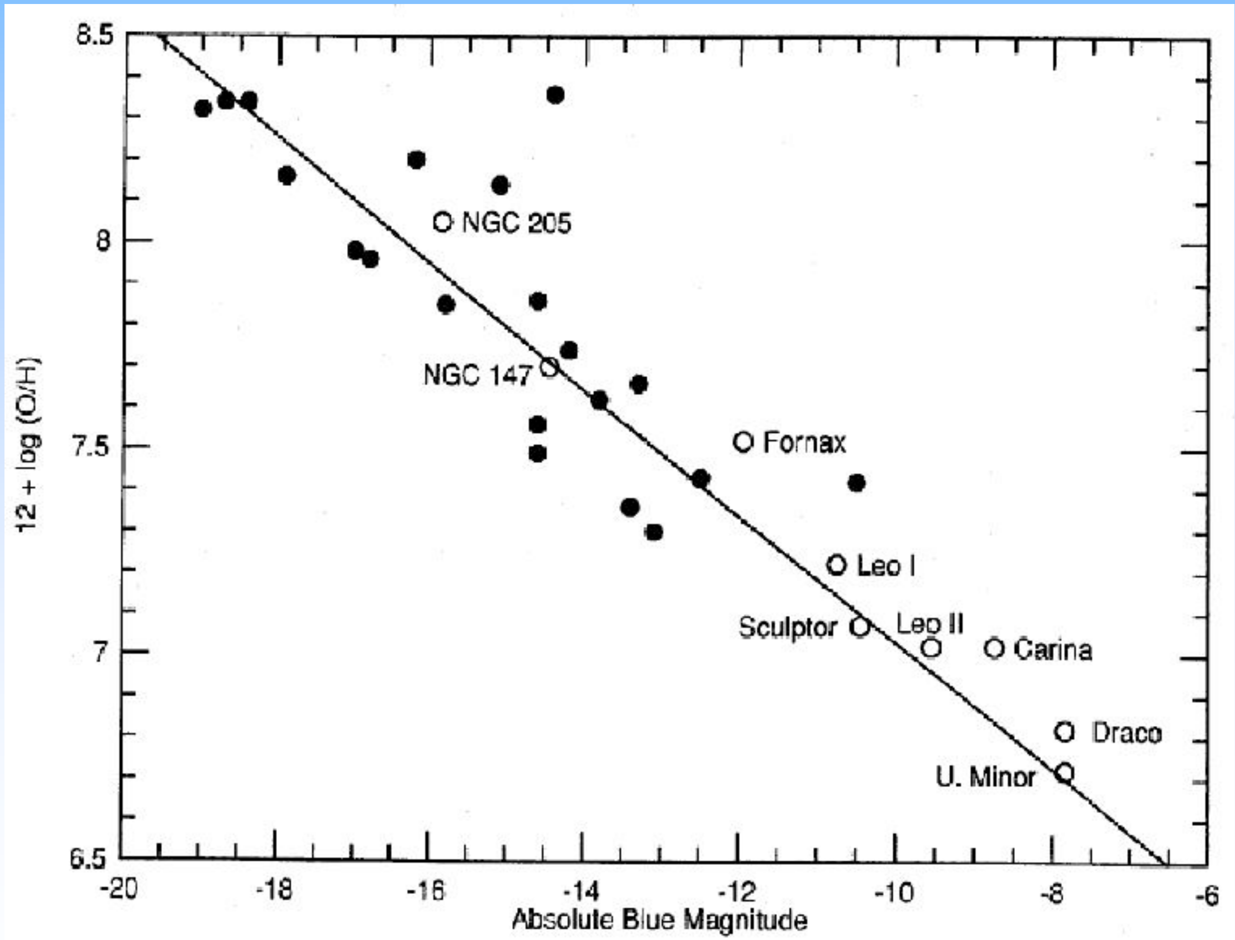


Vader 86,
Bica & Alloin 87,
Skillman 89

Local Galaxies

Fundamental relations for Ellipticals & dEs :

Faber – Jackson relation : central velocity dispersion increases with luminosity

(Faber & Jackson 76)

→ distance / mass determination

$L_V \sim \sigma^{\varepsilon}$, σ: central veloc. disp.

$M_r \sim \sigma^4 / (\rho_r\, r)$ → M/L increases with L

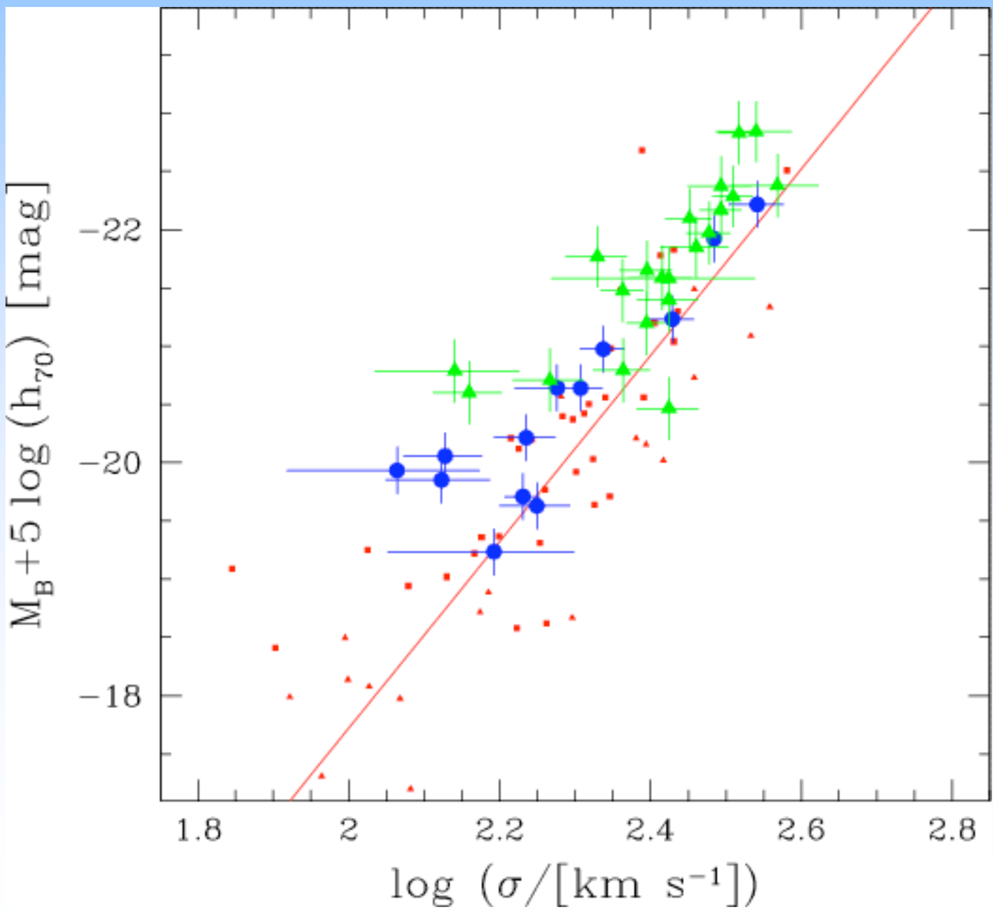
$\varepsilon \sim 4$ for bright gals
$\varepsilon \sim 3.2$ for faint gals
$\varepsilon \sim 5.4$ for cD gals

Local Galaxies

Fundamental relations for Ellipticals & dEs :

Faber – Jackson relation : central velocity dispersion increases with luminosity

(Faber & Jackson 76)



(Ziegler+05)

Local Galaxies

Fundamental relations for Ellipticals & dEs :

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brighter Es have larger effective radii

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.

Sphs (and GCs) do not follow Kormendy's relations

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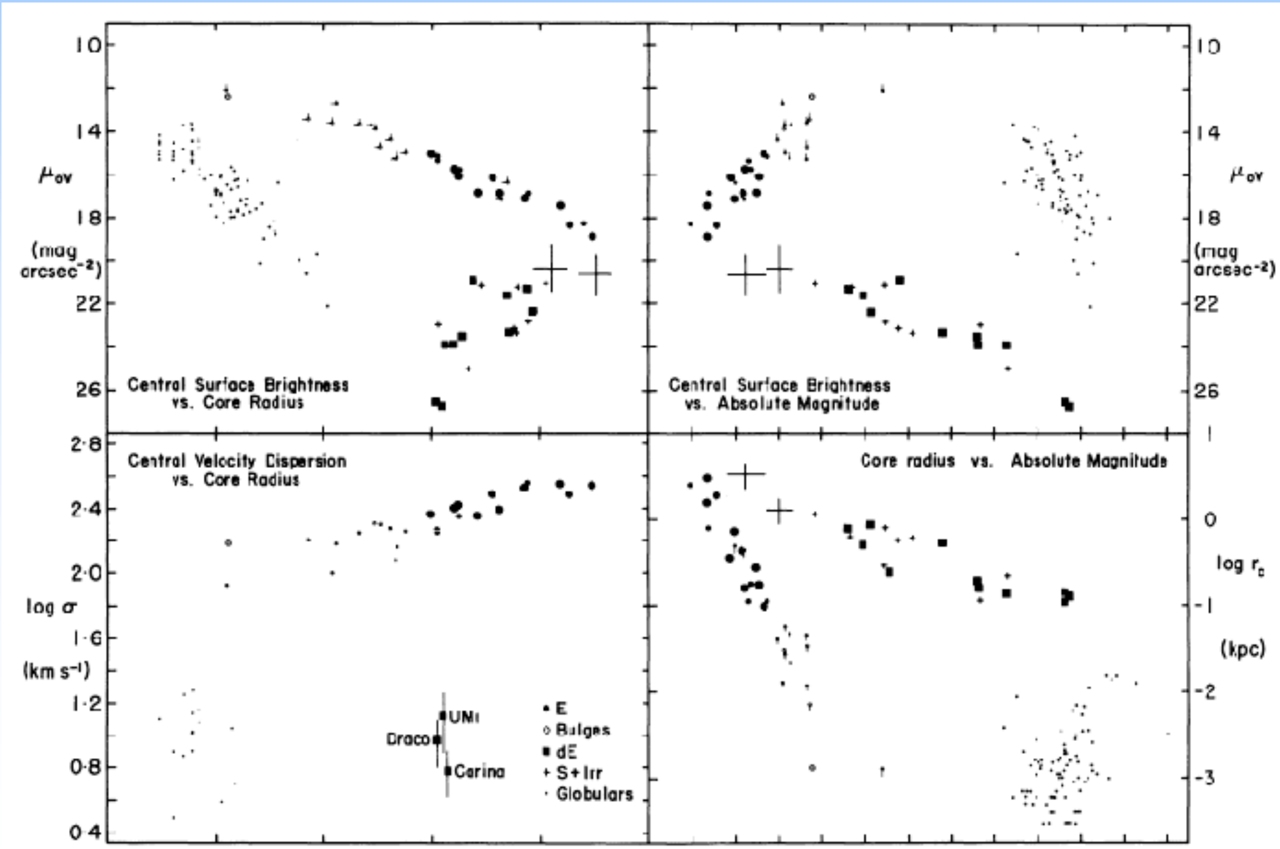


Local Galaxies

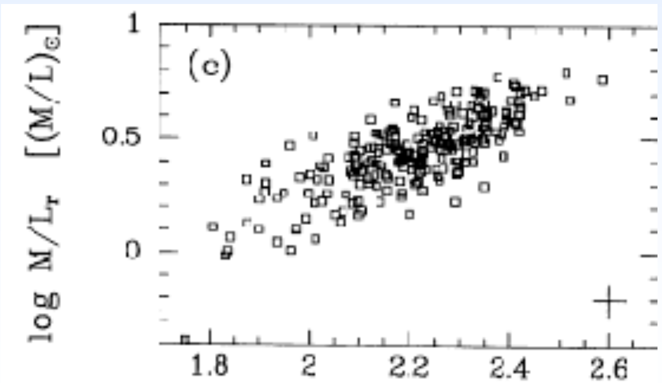
Fundamental relations for Ellipticals & dEs :

Fundamental Plane relations : effective radius – surface brightness – luminosity – central velocity dispersion

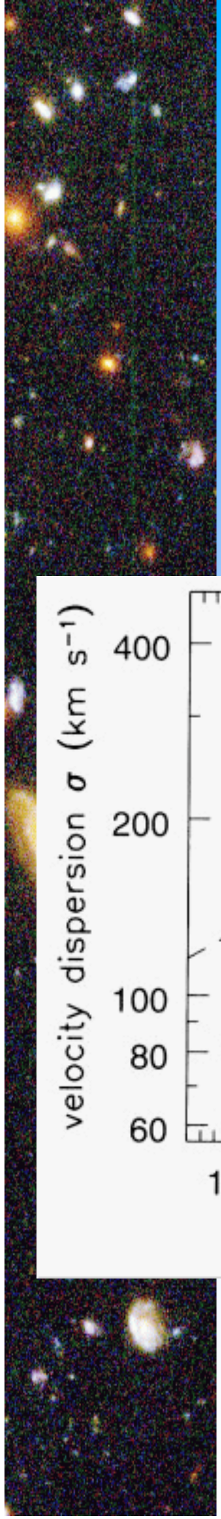
3 global parameters enough to describe structure of normal ellipticals, 2-dimensionally correlated: plane

$$L_V \sim \sigma_e^{a}\, I_e^{b} \qquad r_e \sim \sigma_e^{c}\, I_e^{d}$$

	a	b	c	d
Dressler+87	2.65	-0.65	1.33	-0.83
Djorgovski & Davis 87	3.45	-0.86	1.39	-0.90



M/L increases with L



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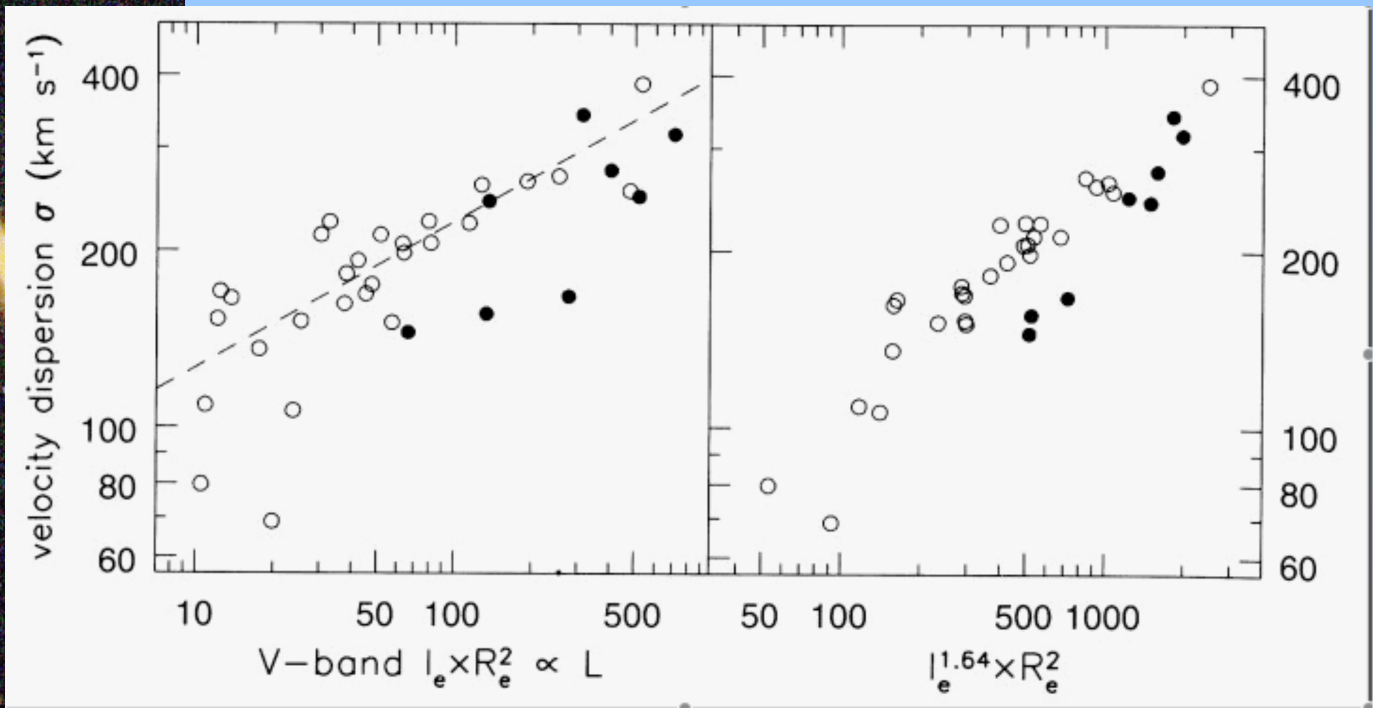

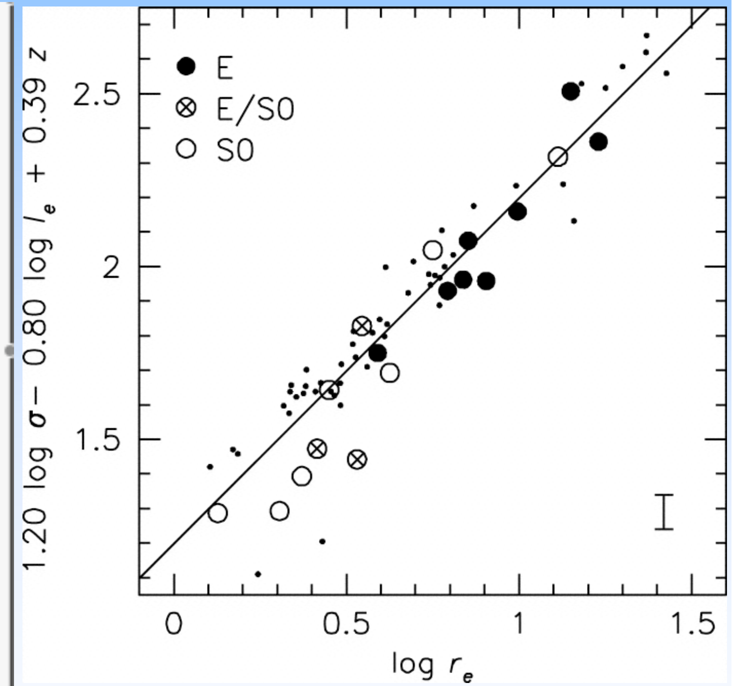

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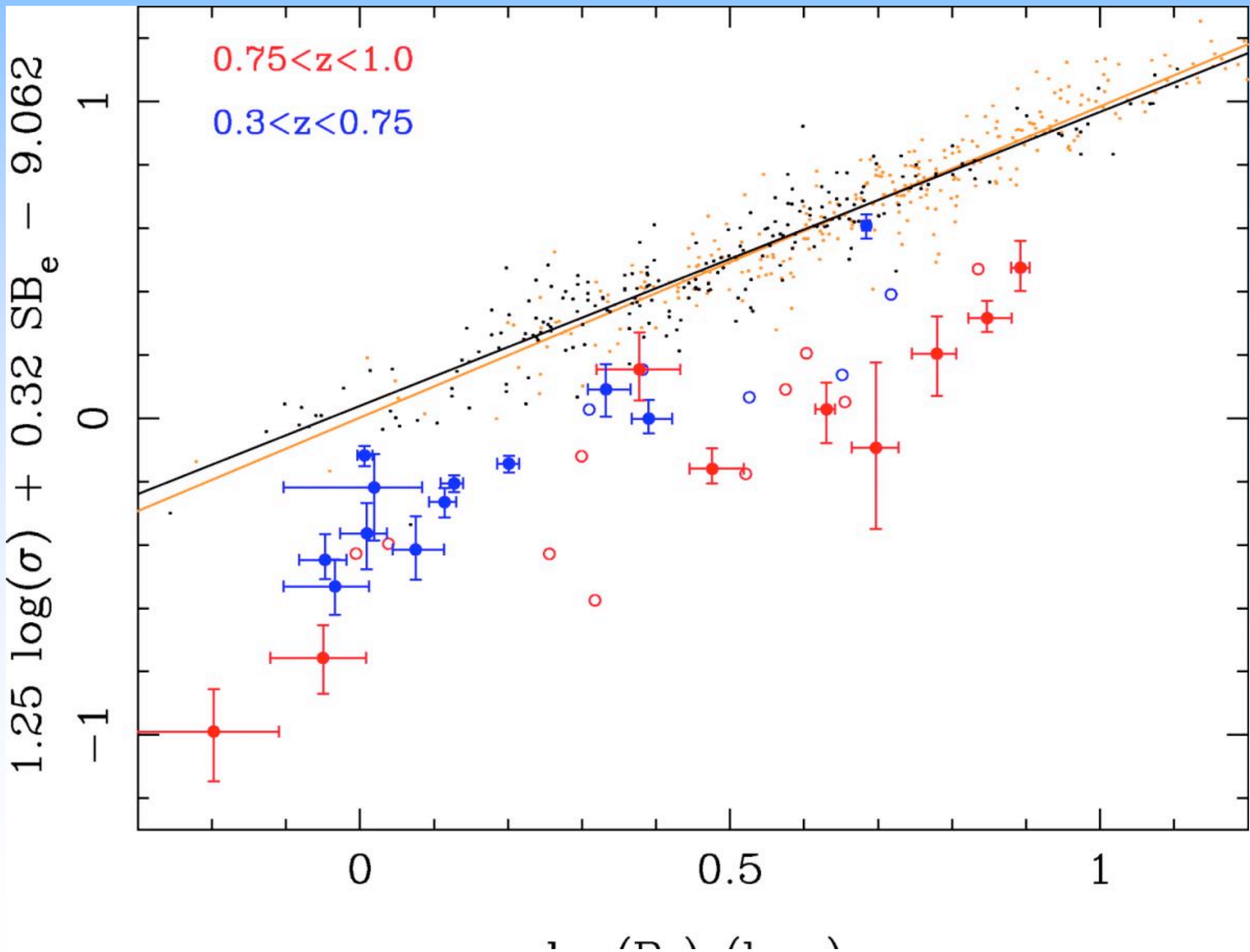


Redshift evolution

Local Galaxies

Fundamental relations for Spirals :

Luminosity – metallicity relation : for spirals and Irrs:
brighter Sps/Irrs have higher ISM metallicities

Tully – Fisher relation : brighter Sps have higher max. rotation velocities

→ distance / mass determination

rotational velocity ~ M(DM)

better correlation with NIR than with optical luminosities

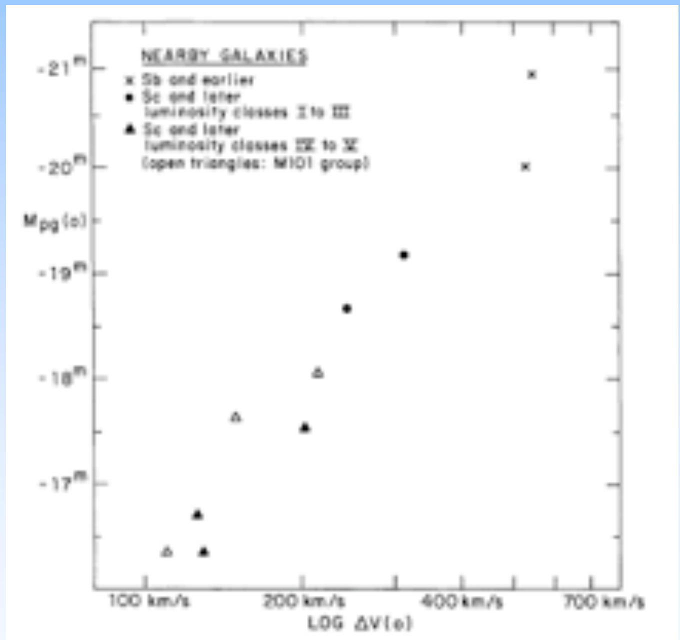
M(DM) increases with M(stars)

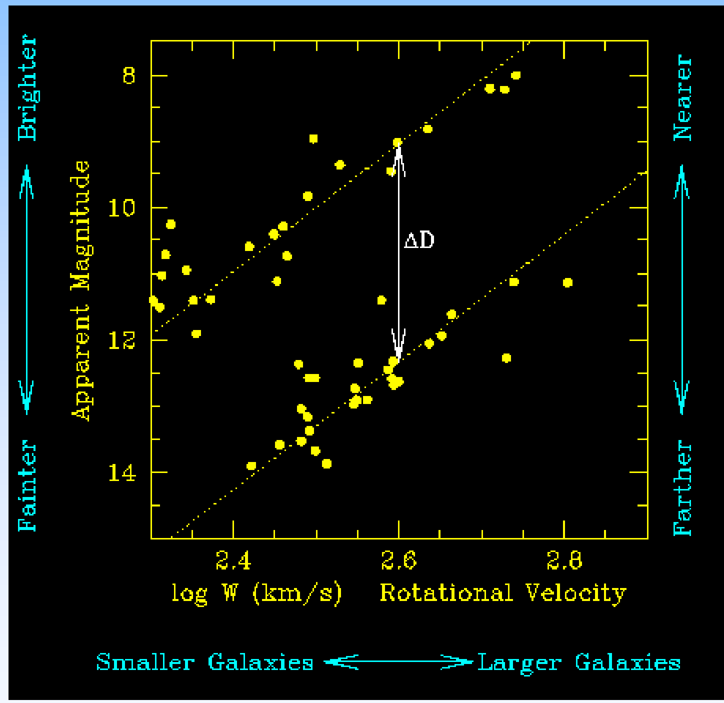
Local Galaxies

Fundamental relations for Spirals :

Tully – Fisher relation : brighter Sps have higher max. rotation velocities

Tully & Fisher 77





Fornax

Abell 1367

→ distance / mass determination

rotational velocity ~ M(DM)

Local Galaxies

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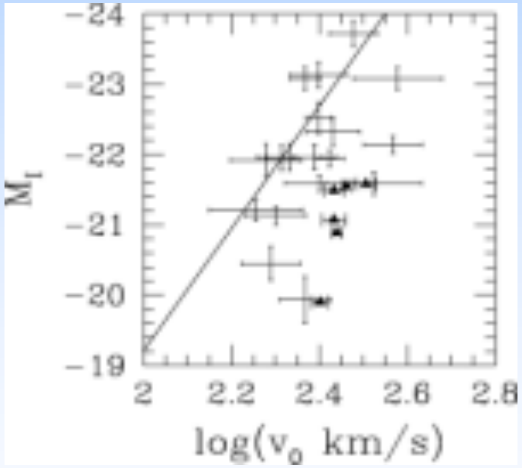
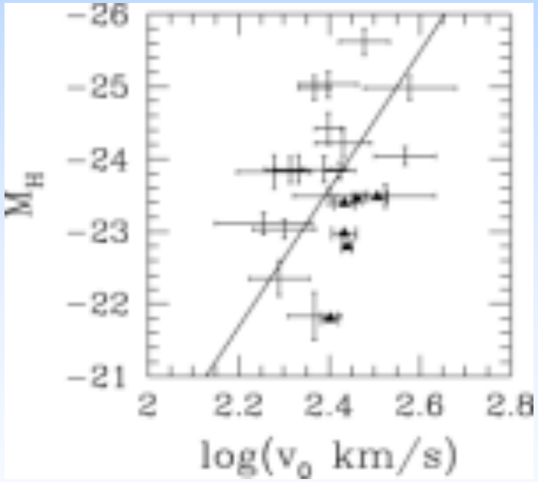
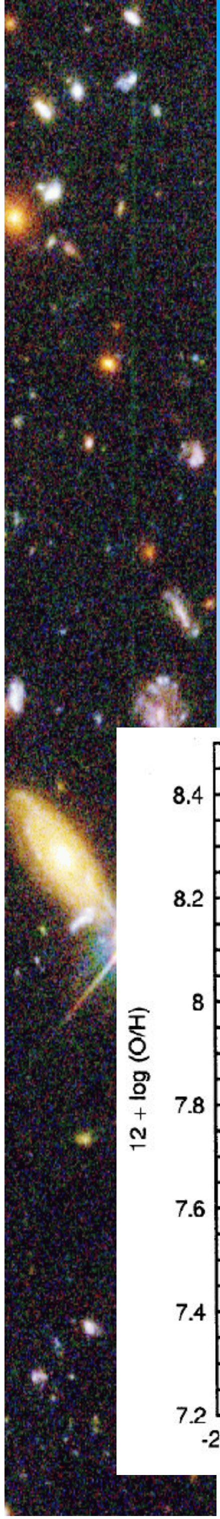




M(DM) increases with M(stars)

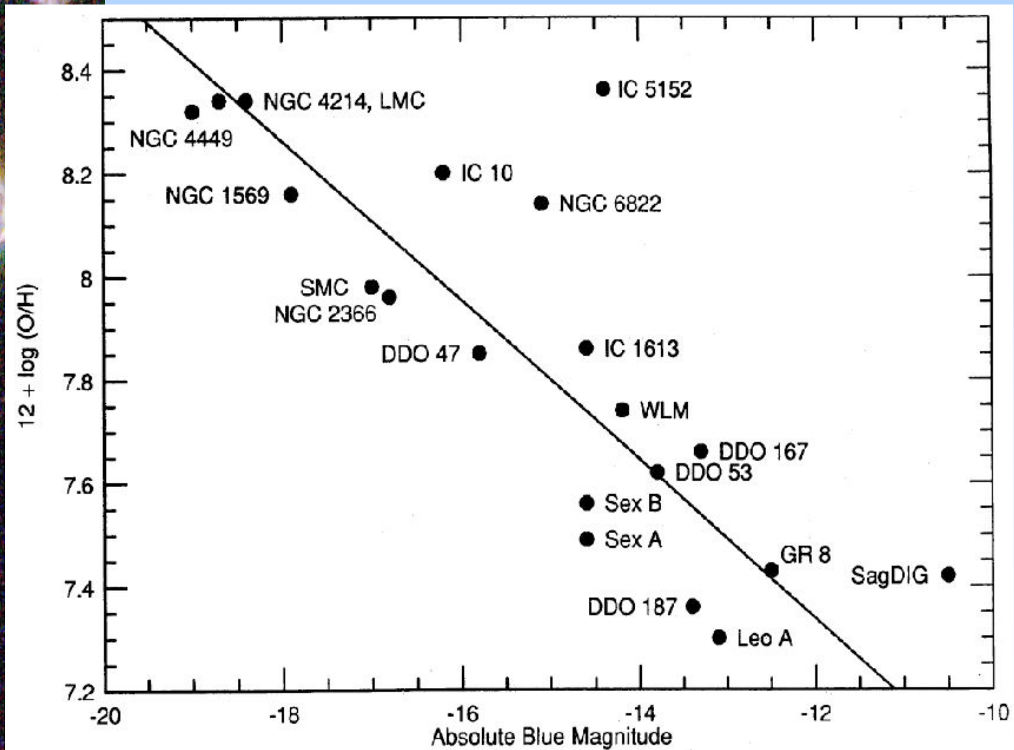
Local Galaxies

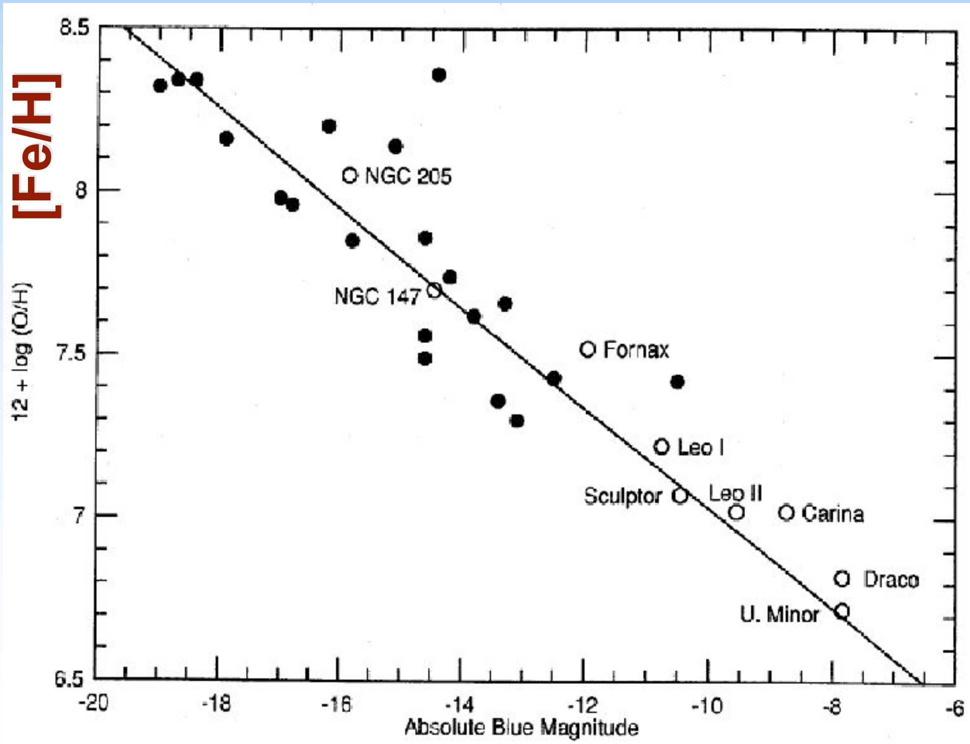


Fundamental relations for Spirals :

Luminosity – metallicity relation : for spirals and Irrs:
brighter Sps/Irrs have higher ISM metallicities
similar to relation for ellipticals (stellar metall.)

(Skillman 89)





Local Galaxies

Luminosity function for galaxies : Schechter 1976

Schechter LF : $\Phi(L) = (\Phi^*/L^*)(L/L^*)^{\alpha} \exp(-L/L^*)$

L^* : characteristic luminosity

$M_B^* = -19.7 + 5 \log h$

Φ^* : (local) normalisation = $1.6 \cdot 10^{-2}\ h^3\ \mathrm{Mpc}^{-3}$

difficult to determine !

α : faint end slope

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

$$\phi(M)dM = \frac{2}{5}\phi^*(ln 10)\left[10^{\frac{2}{5}(M^*-M)}\right]^{\alpha+1} exp\left[-10^{\frac{2}{5}(M^*-M)}\right]dM$$

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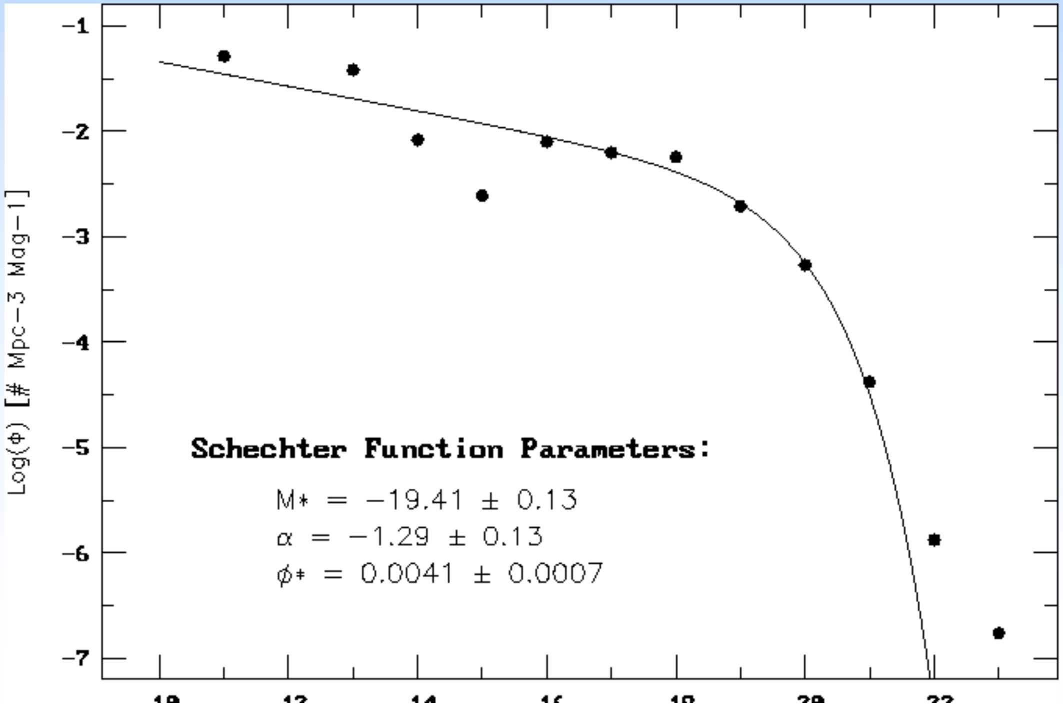


Local Galaxies

Local luminosity functions for galaxies :

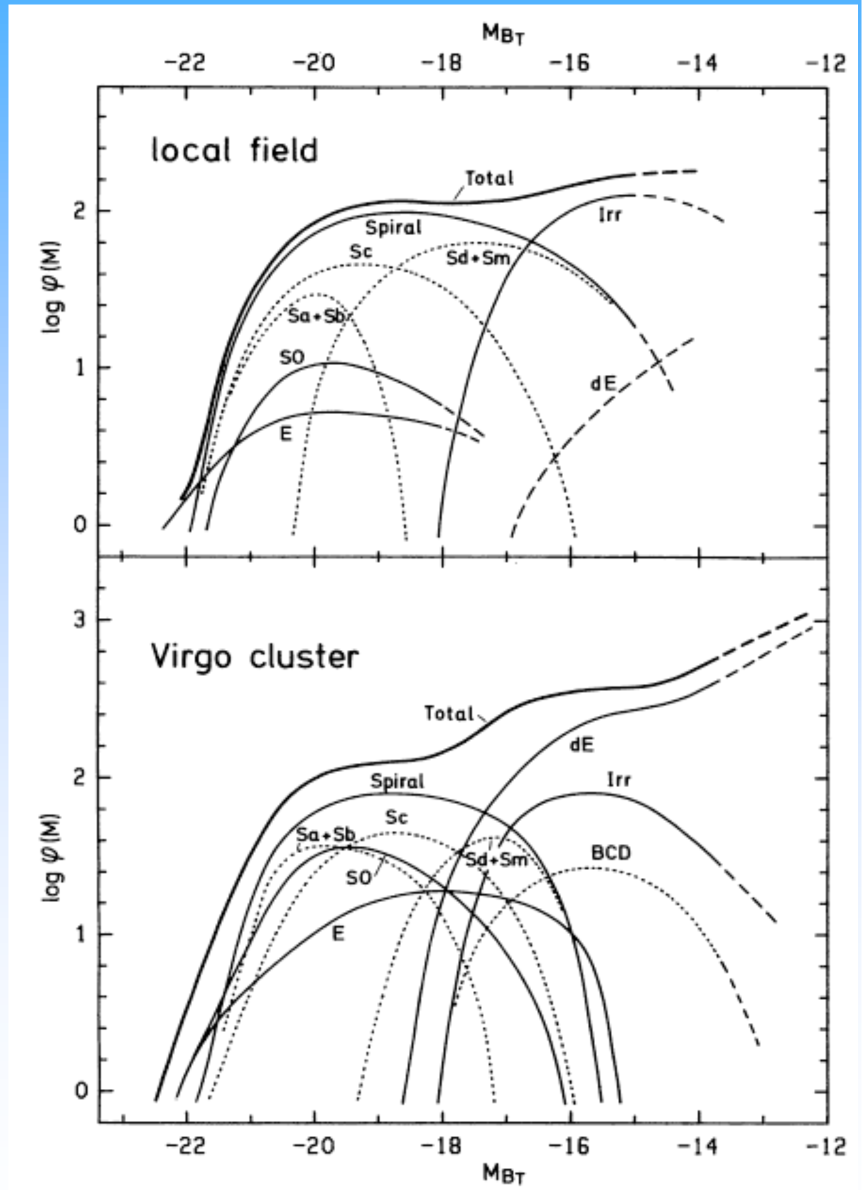
field galaxies

break-down

into types

cluster galaxies:

steep faint end slope



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difficult to determine !

α : faint end slope

low luminosity galaxies dominate by number
high luminosity galaxies dominate the light
in the local universe

M_B^* (E) < M_B^* (Sa) < M_B^* (Sb) < M_B^* (Sc) < M_B^* (Sd)
-21.5 -19.7 -18.9 -18.8 -17.7
with considerable overlap in Virgo (Sandage+85)

Local Galaxies

Luminosity function for galaxies : Schechter 1976

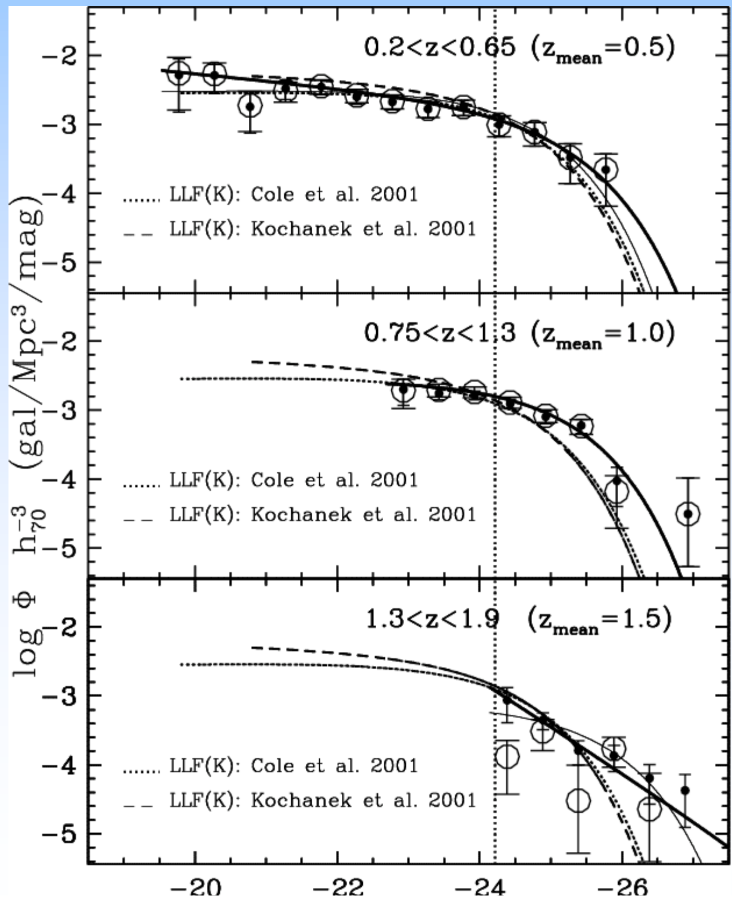
Schechter LF : $\Phi(L) = (\Phi^*/L^*)(L/L^*)^{\alpha} \exp(-L/L^*)$

Φ^* : (local) normalisation = $1.6 \cdot 10^{-2}\ h^3\ Mpc^{-3}$

difficult to determine !

large volume : bright galaxies ok, faint galaxies incomplete

small volume: faint galaxies complete, bright galaxies poor statistics



redshift evolution :

Local Galaxies

Galaxy mix :

field : normal (=big) galaxies >70% Sps
~20% Es
<10% S0s

dwarf-to-normal galaxy number ratio : $\alpha \sim -1.1$

galaxy clusters : >70% S0s
~20% Es
<10% Sps

dwarf -to-normal galaxy number ratio : $\alpha \ll -1.1$

→ transformation of galaxy types

Chemical Evolution : Gas & Stars

Big Bang : H, He, (...., Li)

all heavy elements (> H, He := astrophys. „metals“)

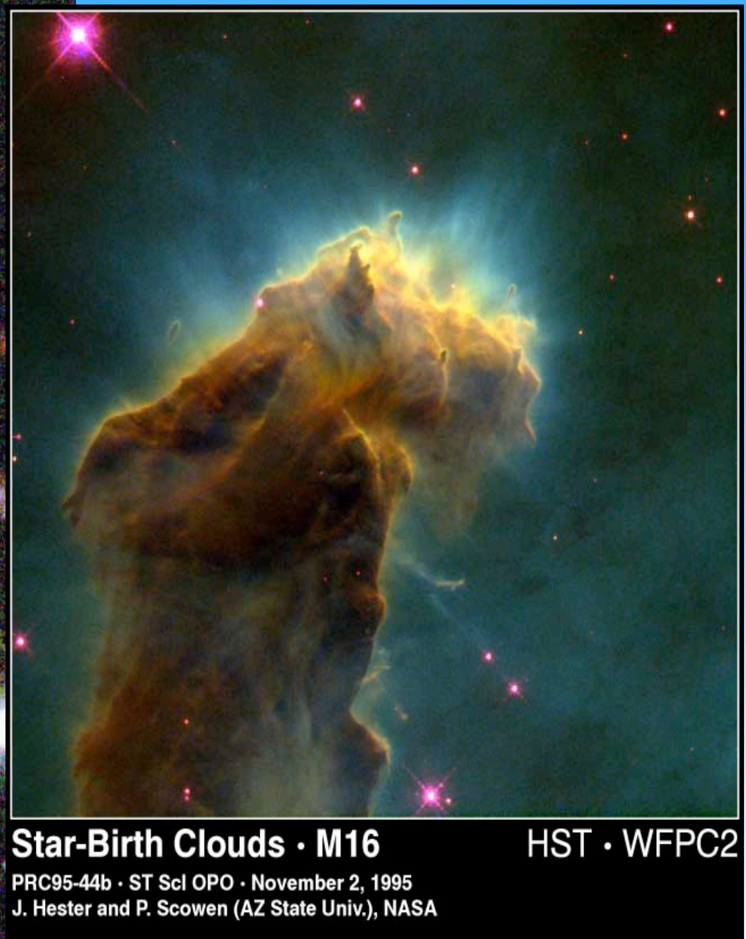
- ☞ **fusioned within stars,**
- ☞ **get back into gas phase through stellar winds, PN, SNe**
- ☞ **built into later stellar generations**

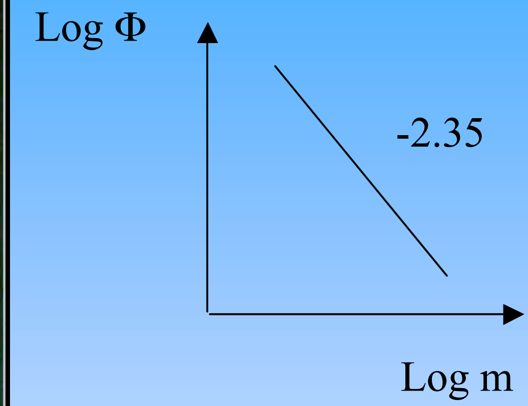
Chemical abundances in the gas determined by

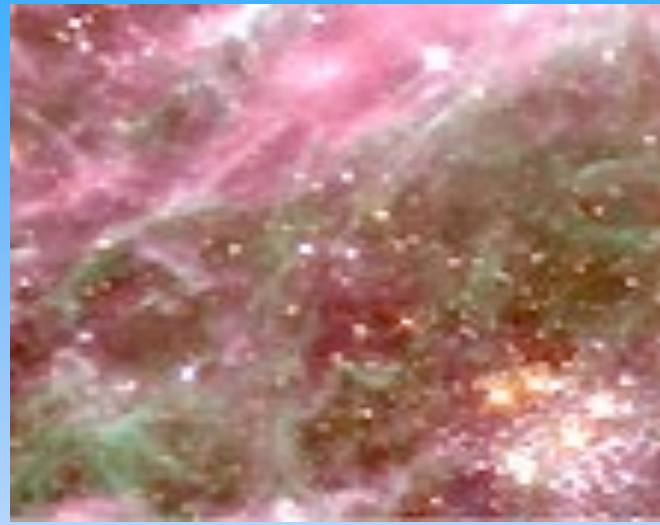
→ **Stellar Initial Mass Function**
→ **Star Formation History of the galaxy**
→ **Stellar lifetimes & yields (mass, composition)**
→ **In- & outflow of gas**

→ $Z^{Gas}(t)$, $X_i^{Gas}(t)$ **from modified Tinsley (68ff) equations**
+ SNIa contributions

Chemical & Spectral Evolution of a Galaxy
GALEV







Normalisation :

$$\int_{ml}^{mup} m\cdot\Phi(m)dm = 1$$

Stellar population :

→ Stellar Initial Mass Function (Salpeter 1955, Kroupa+ 1993ff)

→ Stellar evolutionary tracks, lifetimes, yields

→ Star Formation History of the galaxy