THE ORIGIN OF THE MASS-METALLICITY RELATION:INSIGHT FROM 53,000 STAR-FORMING GALAXIES IN THE SLOAN DIGITAL SKY SURVEY

Tremonti et al.(2004)

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◆ purpose

Stellar mass and metallicity are significant parameters of physical properties of galaxies.

「stellar mass」・・・ the amount of gas locked up into stars
「metallicity」 ・・・ the imprint of star evolution

So, understanding how these quantities evolve with time and in relation to one another, we will physical process of galaxy evolutions. And we present a new benchmark for the model of galaxy evolution in our SDSS sample.

◆ introduction

- feedback

The influence of the galactic wind and supernovae for ISM usually called “feedback”. The galactic wind is related to the sequence of galaxy chemical evolution because it act to flow metals out of galaxies.

- the new techniques

We used new techniques to derive the quantity of stellar-mass and metallicity.

◆ sample

The number of a part of sample from SDSS which is to study large-scale structure (DR2) = 211,165

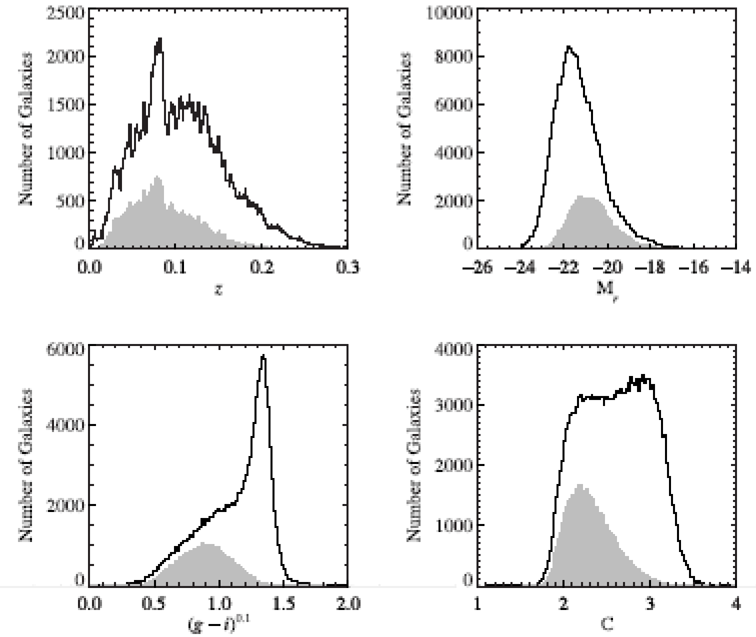
<requirement>

1. Redshift is $0.005<z<0.25$
2. The light of galaxy into the fiber is more than 10% of total light of the galaxy.
3. The emission line of Hα, Hβ and [NII]λ6584 are detected more than 5σ.
4. $\sigma(m_z) < 0.15$[mag], $\sigma(H\delta_A) < 2.5$[Å], $\sigma(D_n(4000)) < 0.1$
5. [OIII] is detected more than 3σ ,and [NII]/Hα < 0.4 if [OIII] < 3σ.
6. The errors σ of stellar mass and metallicity derived from likelihood distribution are less than 0.2[dex].

◆ sample

→The numbers of our sample = 54,300 star-forming galaxies

- band pass
  = u, g, r, i, z (3800-9200 Å)



- concentration parameter C

  = a substitution of Hubble type

define :
The radius fraction of galaxy light at 50% and 90% in r-band. The boarder is about 2.6 with early-type and late-type galaxies.

$$C = \frac{r_{90,r}}{r_{50,r}}$$

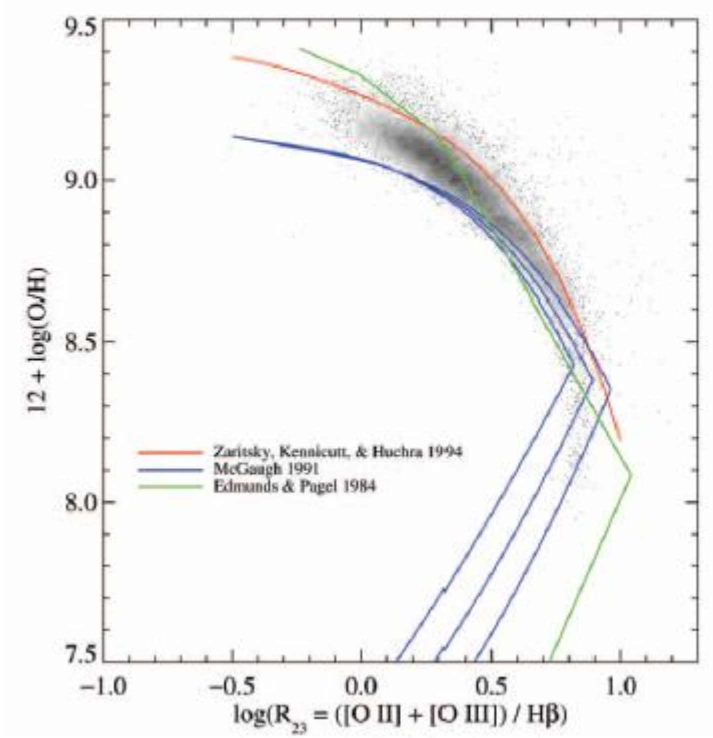
◆ measuring method of metallicity

- a representation as metallicity ･･･ 12+log(O/H)

In ISM studies, Oxygen have been adopted as metal .For examples, it is the most abundance, it displays strong lines in optical.

To measure metallicity, we used the empirical relation among metallicity and relative flux of each strong emission lines.

R_{23} = ([OII]λ3727+[OIII]λλ4959,5007)/Hβ



◆ measuring method of metallicity

This time, we adopt the method using approach outlined by S. Charlot et al.(2004).

→There is the model regard to contribution of HII region and defuse ionized gas based on simultaneous fits most prominent emission lines.([OII],Hβ,[OIII],[NII],Hα,[SII])

But all emission lines are not detected always, finally we fit its relation analytically in figure 3.

$$12 + \log(O/H) = 9.185 - 0.313x - 0.264x^2 - 0.321x^3$$

($x = R_{23}$)

◆ measuring method of stellar-mass

The galaxy's stellar mass can not be measured directly, because of the mass-to-luminosity ratio depends strongly on the star forming history and metallicity.

Therefore, we import Kauffmann's method which relies on spectral indicator of the stellar age and when starburst occurred.

Then, we can restriction to star forming history by 4000 angstrom break and stellar Balmer absorption.(insensitive reddening and only weakly depend on metallicity)

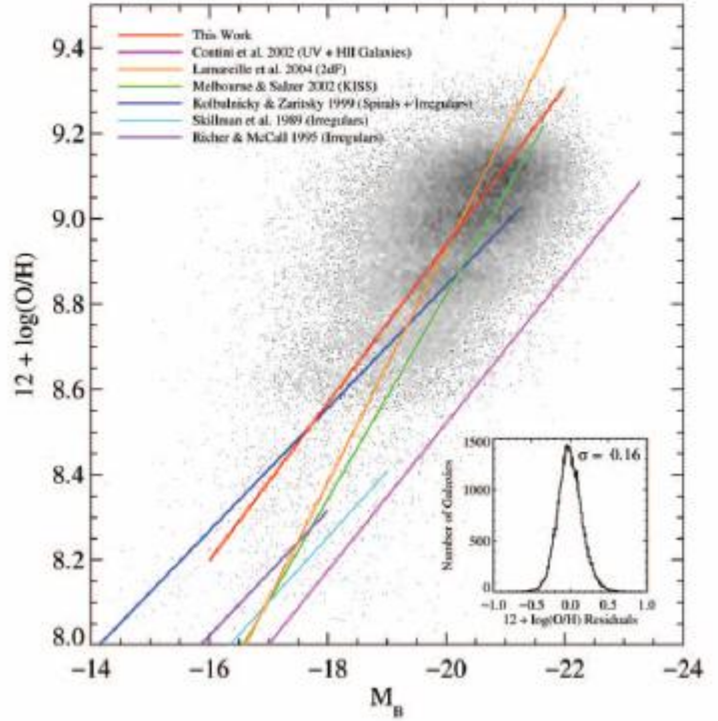
⇒So, we can assign M/L ratio using a baysian analysis with values of $D_n(4000)$ and $H\delta_A$.

◆ result 1. : the luminosity-metallicity relation

Stellar mass is difficult to measure directly, almost previous researches focused on the luminosity at first instead of mass.

12+log(O/H)

= -0.185(±0.001)M_B+5.238(±0.018)



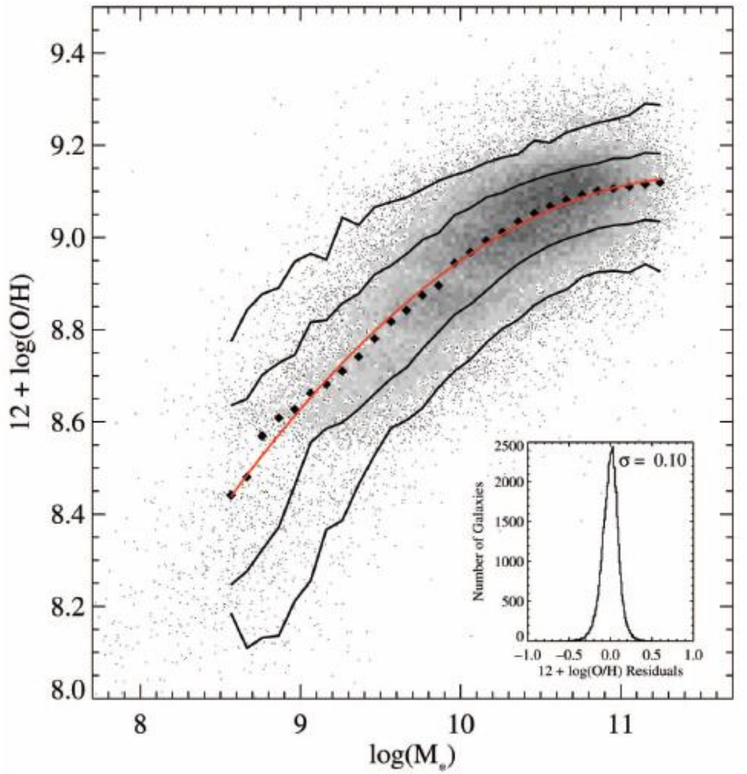
Their are not simply compared with each other from the those difference of observational band, fitting method, metallicity calibration, sample selection.

But it is probable that physical correlation between stellar mass and metallicity is exist.

◆ result 2. : the mass-metallicity relation

The result is a right figure.
It seem to be rough linear relation between 10^8.5[M*] to 10^10.5[M*], and in upper range the slope to be flat.
This relation presented a polynomial of form.

$$12 + \log(\mathrm{O/H}) =$$
$$-1.492 + 1.847(\log M^*) - 0.08026(\log M^*)^2$$



The most prominent feature is tightness of mass-metallicity relation.（1σ = at low mass :0.2 to high mass:0.07）

◆ the origin of the mass-metallicity relation

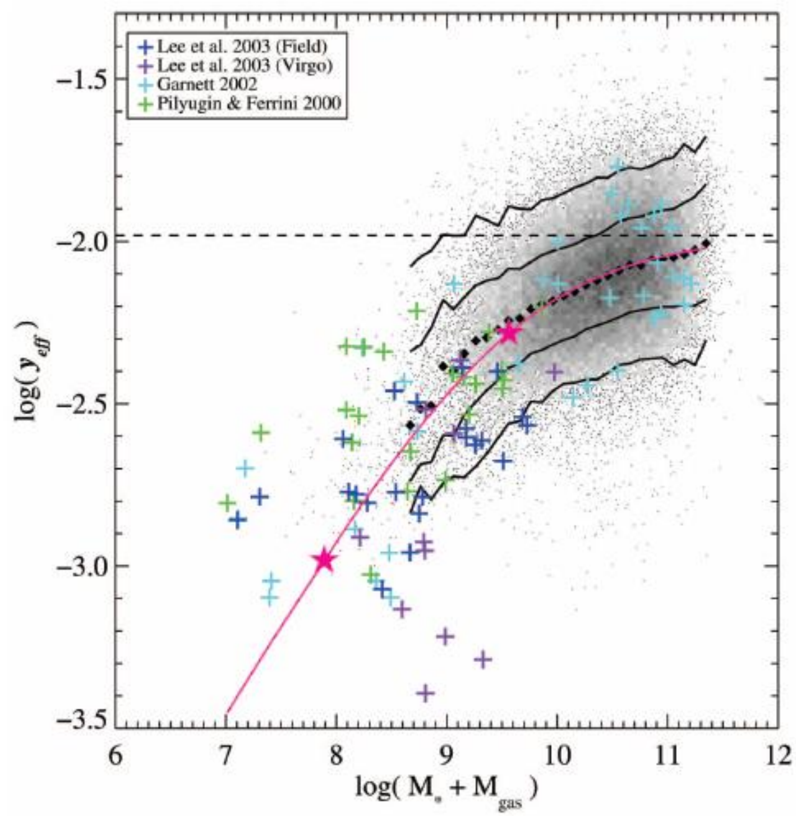
We find that galaxy mass have a significant role in galaxy chemical evolution from the mass-metallicity tight relation, however we don’t know whether the sequence is one of 「enrichment」or「depletion].

Now we adopt under equation.

$$Z = y_{eff} \times \ln(\mu_{gas})$$

Z : metallicity
y_{eff} : effective yield
μ_{gas} : gas mass fraction

$$y_{eff} = y_0/(1+(M_0/M_{baryon})^{0.57})$$



◆ the origin of the mass-metallicity relation

At lower mass value the slope is steep, and start to be flat when the M_{baryon} value over 10^9.5[M*].

In low-mass galaxies, gravitational potential of galaxy is proportional relation to preservation metals.

So, the main factor of this relation is mass loss by galactic wind.

$$y_{eff} = y_0/1 + (M_0/M_{baryon})^{0.57}$$

Using this equation to fit relation,

$$y_0 = 0.0104, M_0 = 3.67 \times 10^9 [M*]$$

Considering this result, the escape velocity is less than terminal velocity of outflow(about 300-900[km/s]), metal ejection will occur.

◆ summary

- We find that there is a tight correlation between Stellar-mass and gas-phase Metallicity of our sample.

- The relation is relatively steep from $10^{8.5} \sim 10^{10.5}[M_{solar}]$,but flattens above $10^{10.5}[M_{solar}]$ at high metallicity.

- The origin of this relation is seemed to be both the role that galactic winds carry out metals into intergalactic mediums and of the weak gravitational potential of low-mass dwarf galaxies.