Do galaxy global relationships emerge from local ones? The SDSS IV MaNGA surface mass density–metallicity relation

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ABSTRACT

We present the stellar surface mass density versus gas metallicity (Σ_*-Z) relation for more than 500 000 spatially resolved star-forming resolution elements (spaxels) from a sample of 653 disc galaxies included in the SDSS IV MaNGA survey. We find a tight relation between these local properties, with higher metallicities as the surface density increases. This relation extends over three orders of magnitude in the surface mass density and a factor of 4 in metallicity. We show that this local relationship can simultaneously reproduce two well-known properties of disc galaxies: their global mass–metallicity relationship *and* their radial metallicity gradients. We also find that the Σ_*-Z relation is largely independent of the galaxy's total stellar mass and specific star formation rate (sSFR), except at low stellar mass and high sSFR. These results suggest that in the present-day universe local properties play a key role in determining the gas-phase metallicity in typical disc galaxies.

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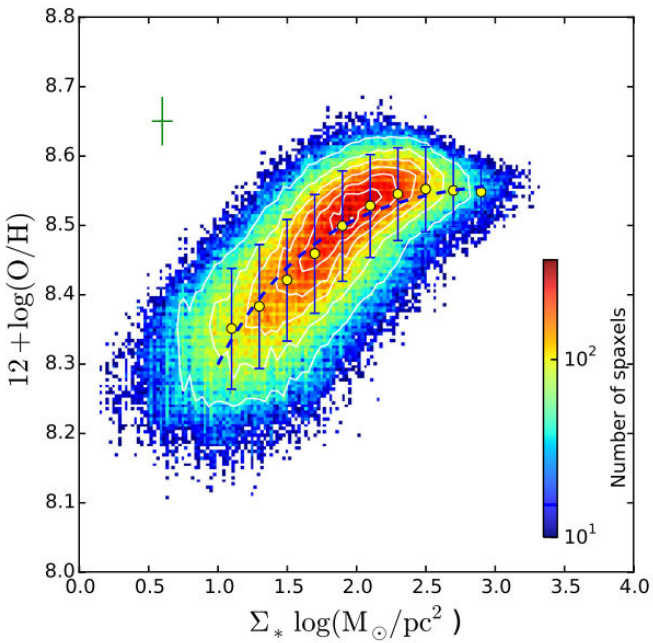

Figure 3. The distribution of the oxygen abundance for more than 507 000 star-forming spaxels against their stellar mass surface densities. These spaxels are extracted from 653 MaNGA galaxies considered as discs (see Section 2.1 for details). The colour bar shows the number of spaxels per bin in the Σ_*–Z space. The white outer contour encloses 80 per cent of the sample while each inner contours enclose ∼15 per cent less, consecutively. The yellow circles represent the median metallicity for spaxels with surface mass density within a bin width of 0.2 dex between $1.0 < \Sigma_* < 3$ dex. The blue error bars represent the standard deviation in metallicity for each of these bins. The dashed blue line represents the best-fitted curve for the yellow median circles.

Σ_*-Z関係：
BPT図でSFと判定したspaxelの星質量面密度と金属量。

銀河ごとにspaxelを足し合わせてM_*-Z関係を算出すると、先行研究とよく合う（Fig.6）。

銀河の M_*-Z 関係はより local な Σ*-Z 関係から成り立っているのだろうか？

- SDSS MaNGA disk銀河について、空間分解（~2.5" ~ 2.5kpc）した星質量-金属量関係を導出。

星質量毎のΣ_*-Z関係：　　**sSFR毎のΣ_*-Z関係：**

Dense Σ_* ~ 銀河の内側領域と解釈すると、これらの分布はinside-out metal enrichmentとして説明できるかもしれない。

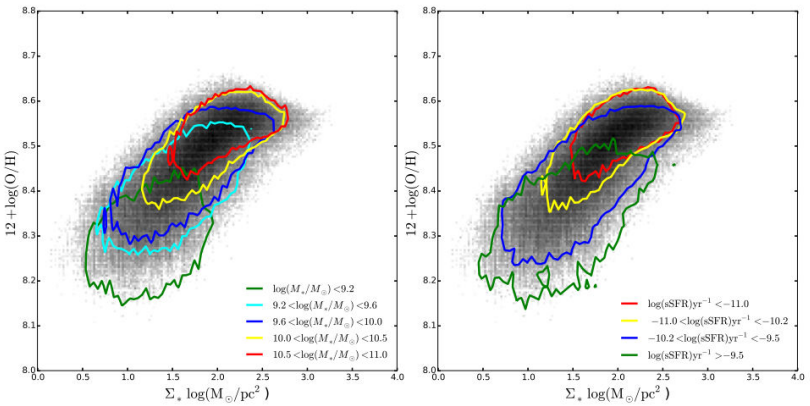

Figure 7. Σ–Z relation distribution divided at different total stellar mass and total sSFR bins (left- and right-hand panels, respectively). In each of the stellar mass/sSFR bins the contours encloses 80 per cent of the sample. Except for the lowest mass bin, the size of each stellar mass bin is ∼0.4 dex, ranging from 9.2 to 11.0. The sSFR is divided in four different bins from low (log (sSFR) < −11 log (yr^{-1})) to high (log (sSFR) > −9.5 log (yr^{-1})) values. For reference, we plot in grey colourscale the distribution presented in Fig. 3.

Fig3の多項式フィットからのズレ：
lowest M_*、highest sSFRで外れる → （浅いポテンシャルから）outflowでmetalが出ていっている？

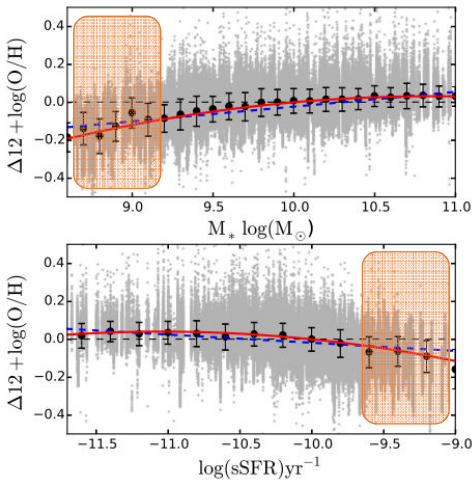

Figure 8. Scatter of the Σ_*–Z relation with respect to the total stellar mass. Black points represent the median value at different bins (0.1 dex for the total stellar mass). In both panels, the solid-red and dashed-blue curves represent a quadratic and linear fit of the median scatter metallicities, respectively. Black dashed line represents zero-scatter in the Σ_*–Z relation.

（上）Stellar massの動径分布：
（下）上から（Σ*-Z関係で）予想されるZと実測Zの差：

Outflowで metal-poor ?

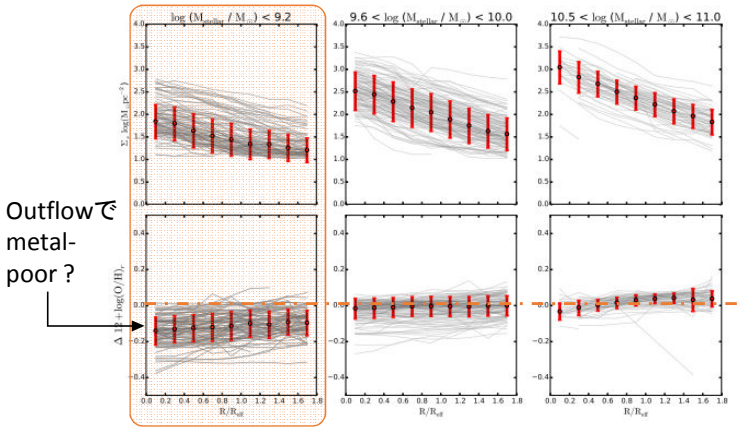

Figure 9. Top: radial distribution of the surface mass density for disc galaxies at different total stellar mass bins in effective radius units. The mass bins are the same used in Section 3.4. Grey lines represent individual gradients in radial bins of 0.2 R_{eff}. For each radial bin red point and error bar represent the median and standard deviation, respectively. Bottom: radial distribution of the difference between the observed metallicity and the value derived from the best-fitted curve of the Σ_*–Z relation for the same mass bins within the range of Σ_* where the fitting was performed. Red points and error bars represent the median and standard deviation for a given radius. Except for the lowest mass bin, the derived metallicity gradient is consistent to the observed one.

- Σ_*-Z関係から、M_*-Z関係とmetallicity gradientをおおよそ再現することが出来た。
- 今後、full MaNGA sample (~8倍) を用いて、stellar age等も含めて詳細にchemical evolutionを調べる。