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THE EVOLUTION OF METALLICITY AND METALLICITY GRADIENTS FROM $Z = 2.7 - 0.6$ WITH KMOS$^{3D}$

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ABSTRACT

We present measurements of the [N II]/Hα ratio as a probe of gas-phase oxygen abundance for a sample of 419 star-forming galaxies at $z = 0.6 - 2.7$ from the KMOS$^{3D}$ near-IR multi-IFU survey. The mass-metallicity relation (MZR) is determined consistently with the same sample selection, metallicity tracer, and methodology over the wide redshift range probed by the survey. We find good agreement with long-slit surveys in the literature, except for the low-mass slope of the relation at $z \sim 2.3$, where this sample is less biased than previous samples based on optical spectroscopic redshifts. In this regime we measure a steeper slope than some literature results. Excluding the AGN contribution from the MZR reduces sensitivity at the high mass end, but produces otherwise consistent results. There is no significant dependence of the [N II]/Hα ratio on SFR or environment at fixed redshift and stellar mass. The IFU data allow spatially resolved measurements of [N II]/Hα, from which we can infer abundance gradients for 180 galaxies, thus tripling the current sample in the literature. The observed gradients are on average flat, with only 15 gradients statistically offset from zero at $> 3\sigma$. We have modelled the effect of beam-smearing, assuming a smooth intrinsic radial gradient and known seeing, inclination and effective radius for each galaxy. Our seeing-limited observations can recover up to 70% of the intrinsic gradient for the largest, face-on disks, but only 30% for the smaller, more inclined galaxies. We do not find significant trends between observed or corrected gradients and any stellar population, dynamical or structural galaxy parameters, mostly in agreement with existing studies with much smaller sample sizes. In cosmological simulations, strong feedback is generally required to produce flat gradients at high redshift.

*Subject headings:* galaxies: high-redshift, galaxies: abundances, galaxies: evolution

Metallicity Gradientはフィードバックの指標になる
Gibson+13ではz=2で
- Normal feedback (SN Energyの10-40%が過熱に使われる)では-0.3dex/kpc
- Enhanced feedbackではフラットになる

と予想されている

KMOS-3D
- z=0.6-2.7
- 180天体（これまでの3倍のサンプル/5年サーベイの2年分）
- CANDELS-UDS, COSMOS, GOODS-S
- AGN fraction は~8%
- Seeing~0.55”

Mass Metallicity Relation
- ほかの結果と合致
- sSFRによっては変わらず
- 環境依存性はかすか。見えていない？

Abundance Gradients
- ほとんどフラット(Fig 6)
- 15/180が3シグマで傾きあり
- 中心のほうがlow metal (positive gradient) はほとんどいない

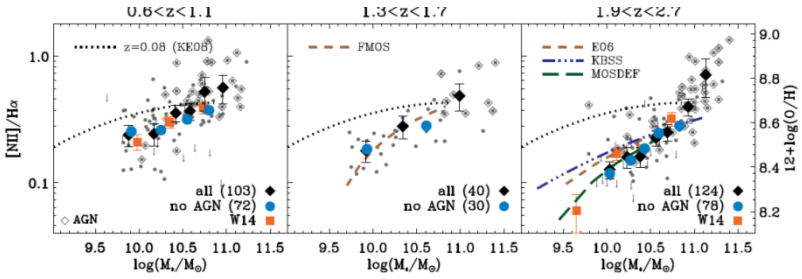
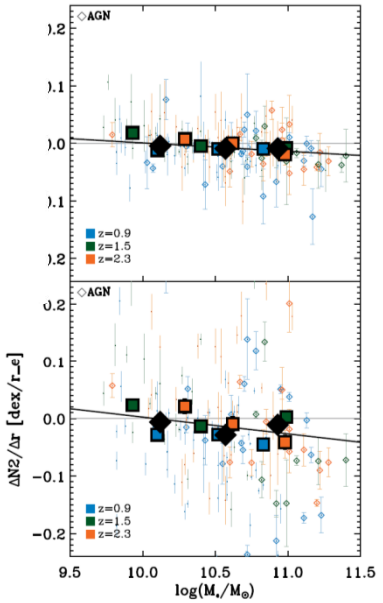



FIG. 2.— Galaxy-integrated [N II]/Hα ratios as a function of stellar mass for the KMOS$^{3D}$ sample. The right axis expresses galaxy



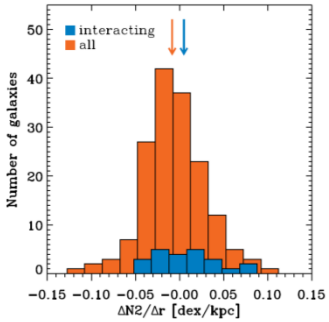




FIG. 9.— Comparison of the full sample of KMOS$^{3D}$ ΔN2/Δr

FIG. 6.— Observed metallicity gradients as a function of stel-

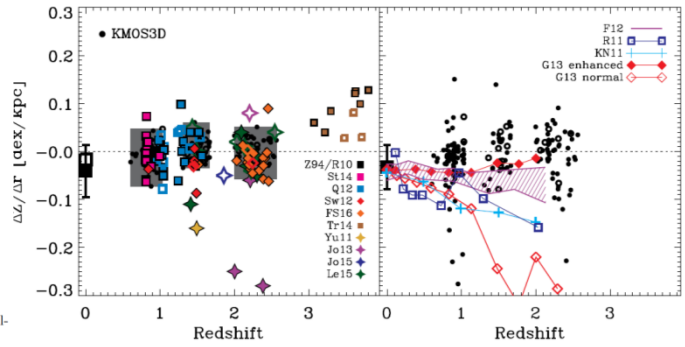



FIG. 10.— The left panel compiles the KMOS$^{3D}$ results with all the abundance gradients measured at high redshift from the literature.

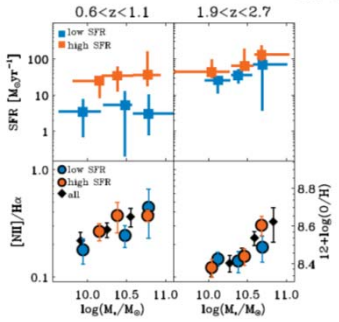



FIG. 3.— The effect of star formation on metallicity, using the

Fig 10:ほぼフラットなmetallicity gradient
- 強いフィードバックが必要
- あるいは中心へのcold inflowでもいい？
- interactionでかき回されてるわけではない？(Fig 9)

ただし、バイアスされている可能性あり
- beam smearing
- Shockによる銀河の外側でのNIIのenhancement

まとめ：つよいフィードバックが必要そう

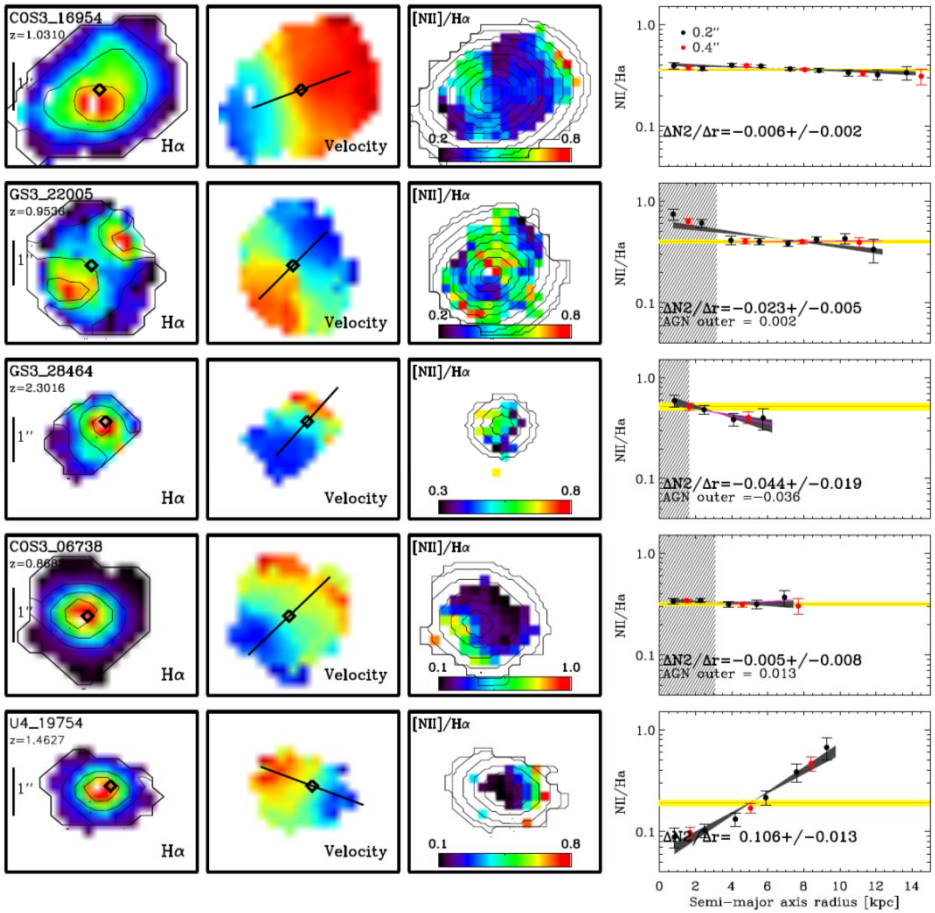



FIG. 11.— Illustration of how abundance gradients are measured for five example galaxies. The three panels on the left show the Hα,