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Z-FIRE: ISM PROPERTIES OF THE $Z = 2.095$ COSMOS CLUSTER

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ABSTRACT

We investigate the ISM properties of 13 star-forming galaxies within the $z \sim 2$ COSMOS cluster. We show that the cluster members have [N II]/Hα and [O III]/Hβ emission-line ratios similar to $z \sim 2$ field galaxies, yet systematically different emission-line ratios (by ~ 0.17 dex) from the majority of local star-forming galaxies. We find no statistically significant difference in the [N II]/Hα and [O III]/Hβ line ratios or ISM pressures among the $z \sim 2$ cluster galaxies and field galaxies at the same redshift. We show that our cluster galaxies have significantly larger ionization parameters (by up to an order of magnitude) than local star-forming galaxies. We hypothesize that these high ionization parameters may be associated with large specific star formation rates (i.e. a large star formation rate per unit stellar mass). If this hypothesis is correct, then this relationship would have important implications for the geometry and/or the mass of stars contained within individual star clusters as a function of redshift.

Clusterの星形成銀河の物理状態は？フィールドに比べてevolveしてる？
COSMOSーZFOURGEで発見されたz~2clusterで検証。

ZFIRE:Hi-z cluster spectroscopic survey in ZFOURGE by MOSFIRE
・8masks =. 180 spec-z => 57 cluster members at z~2
=> 8 objects have Ha/N2/Hb/O3 => 4 objects have S2
・それ以外に、フィールド銀河(+KBSSカタログ)でHa/N2/Hb/O3のサンプルと、S2のサンプル
・local sampleはSDSS
・Mstar=1e9-10Msol

BPT Diagram(Fig1)
- ISM Pressureが上がると右上へ
- 輻射場が固くなっても同様
- Ionization parameterが上がると、左上へ

BPT上ではフィールドもクラスターも同じところに来る

S2
- S2 doublet比で電子密度がわかる
- S2/Haもionization parameterが上がると減る
- S2/N2 vs O3/Hbでmetallicityとionization parameterが切り分けられる(Dopita+13)

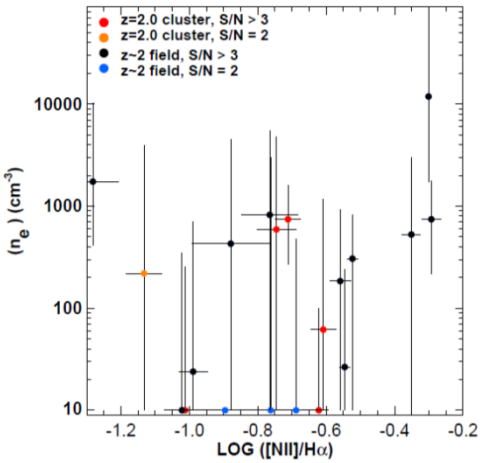

FIG. 4.— The [N II]/Hα ratio versus electron density for the COSMOS cluster (red circles), and field galaxies observed as part of the ZFIRE survey (black circles). Also shown are additional galaxies that would be added to our cluster sample and field sample if we were to apply the S/N limits of Steidel et al. (orange and dark blue circles, respectively).

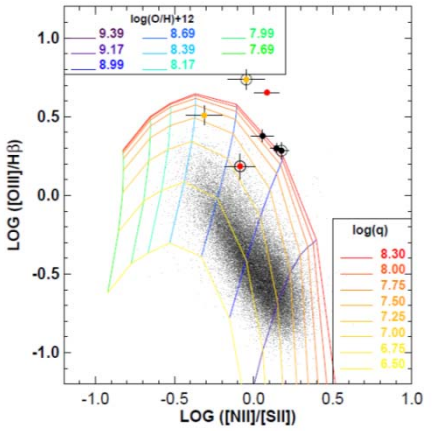

FIG. 5.— The [N II]/[S II] ratio versus [O III]/Hβ for the $z \sim 2$ COSMOS cluster for $> 3\sigma$ detections of [SII] (red circles) and for $\sim 2\sigma$ detections of [SII] (orange circles), compared with our $z \sim 2$ ZFIRE field galaxies (black filled circles) and the local SDSS sample (dots). The stellar mass range of the SDSS sample has been matched to the stellar mass range of our $z \sim 2$ galaxies ($9.5 < \log(M)/M_\odot < 11.0$). The colored curves show our theoretical photoionization models for a range of metallicity (blue-green lines), and ionization parameter (yellow-red lines), as indicated in the legends. The COSMOS cluster and field galaxies have larger ionization parameters than the majority of local SDSS galaxies. Galaxies with electron densities that could be as large as $n_e \sim 1000$ cm^{-3} within their errors are highlighted with a bold circular outline.

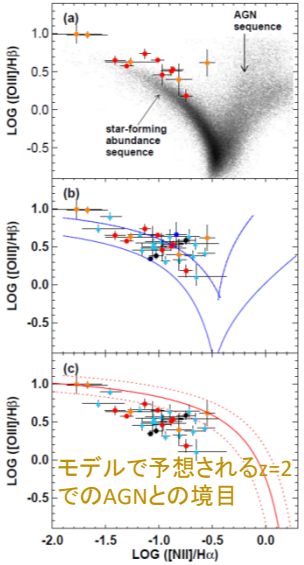

FIG. 1.— The [N II]/Hα versus [O III]/Hβ diagnostic diagram showing our COSMOS cluster (red circles) in comparison to the local SDSS sample (upper panel), our field comparison sample (middle panel), and the Kewley et al. (2013b) redshift-dependent classification line and error ranges (red solid line and dotted lines respectively, lower panel). The blue lines in the middle panel show the position of the local SDSS envelope for comparison. Field galaxies are colored according to sample, where pale blue corresponds to the KBSS-MOSFIRE field sample of Steidel et al. (2014), and black corresponds to field galaxies from our MOSFIRE observations with all strong-lines detected to $> 3\sigma$. Orange circles and dark blue circles show the additional galaxies that would be added to our cluster sample and field sample if we were to apply the S/N limits of Steidel et al.

電子密度
- 完全に電離していると、ISM Pressureはneに比例する
- [S2]6717/6731から出す（10/cc以上の時）
- 電子密度も、cluster/fieldの違い無し。

Ionization state (ionization parameter)
- O2/O3ができないので、N2/S2 – O3/Hbで
- N2/S2はmetallicity(O/H+12<8.69）とionization parameterが縮退している
- それをO3/Hbで解く
- Localではlog(q)=6-7.2
- Z=2では(field/clusterともに) log(q)>7.25
  - はみ出した二つは
    - AGNかも
    - Ne=10=>1000でも0.4dex上がる
  - Localに比べて有意に高い。これまでとconsisitent
  - 理由はまだわからない。Higher ne/larger escapefraction? Higer stellar temperature?
  - Log(q)=7.4と一番小さい人は、SSFRも小さかった。関係がある？

まとめ：環境はISMの物理状態には影響を与えない