The Hα star formation main sequence in cluster and field galaxies at $z \sim 1.6$

arXiv.2009.07861

Julie Nantais[1],* Gillian Wilson[2], Adam Muzzin[3], Lyndsay J. Old[4], Ricardo Demarco[5], Pierluigi Cerulo[5], Michael Balogh[6,7], Gregory Rudnick[8], Jeffrey Chan[2], M. C. Cooper[9], Ben Forrest[2], Brian Hayden[10,11], Chris Lidman[12,13], Allison Noble[14], Saul Perlmutter[10,11], Carter Rhea[15], Jason Surace[16], Remco van der Burg[17], and Eelco van Kampen[17]

ABSTRACT

We calculate Hα-based star formation rates and determine the star formation rate-stellar mass relation for members of three SpARCS clusters at $z \sim 1.6$ and serendipitously identified field galaxies at similar redshifts to the clusters. We find similar star formation rates in cluster and field galaxies throughout our range of stellar masses. The results are comparable to those seen in other clusters at similar redshifts, and consistent with our previous photometric evidence for little quenching activity in clusters. One possible explanation for our results is that galaxies in our $z \sim 1.6$ clusters have been accreted too recently to show signs of environmental quenching. It is also possible that the clusters are not yet dynamically mature enough to produce important environmental quenching effects shown to be important at low redshift, such as ram pressure stripping or harassment.

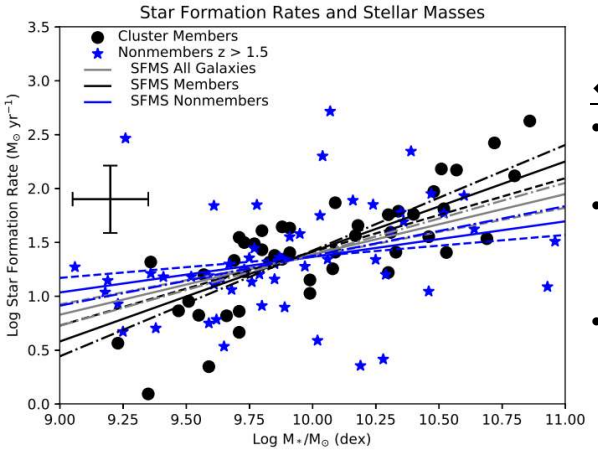

Figure 3. Individual SFRs versus stellar mass for star-forming galaxies meeting our selection criteria in the three clusters (black circles) and the field (blue stars). The values for field galaxies are corrected for estimated evolution of the SFMS with redshift. Also shown are least-squares, unweighted linear fits to the collective (gray), field (blue), and cluster (black) distributions, and typical individual uncertainties (black error bars below the legend text). The 68% uncertainty margins to the linear fits are shown as dashed (lower slope/upper intercept) and dash-dot (upper slope/lower intercept) lines for the combined sample (gray), field (blue), and clusters (black).

←SFMSの比較

- Cluster（●）はfield（★）よりややsteep (3.3σ)。
- Lowest/higest 5%を除くと両者の分布は近づく(2σ)。
- cluster+fieldのSFMSの上下にいる数を比べると、同程度（誤差の範囲内）。

環境による星形成の抑制はいつ効き始めるのか？

- 現在では形態-密度関係（高密度では早期型）やSFR-密度関係（高密度ではlow sSFR）が見られるが、高密度環境での星形成抑制はいつ頃どのようなメカニズムで働くのか？
  - Ramp pressure stripping, harassment, slow tidal interaction, strangulation (starvation)。
  - Bulge growth, AGN feedback
- z~1の観測では、少なくともrich clusterでは既にpassive銀河がfieldより多いという結果。
- 環境による星形成抑制が見られるのはいつ頃からなのか？
- Spitzerで観測した既存のz~1.6銀河団3つ (561銀河) をMOSFIREで分光
  - うち370銀河についてHa redshiftを取得 → SFR(Ha)。
- SFMS上でfieldとの違いを比較。

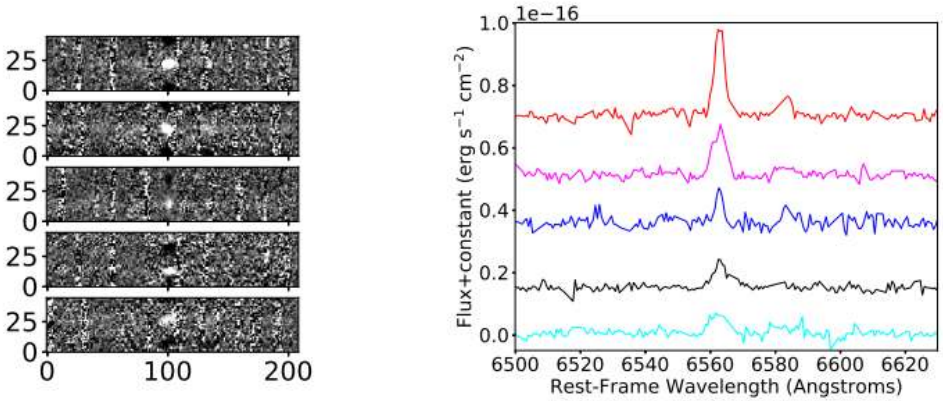

Figure 1. Left: Cutouts of two-dimensional reduced spectra of five cluster members from SpARCS0330, with clear Hα emission lines of different intensity and shape. Right: One-dimensional extractions, shown with rest-frame wavelengths and on a common flux scale, of the same five cluster members shown in the same order as the left panel.

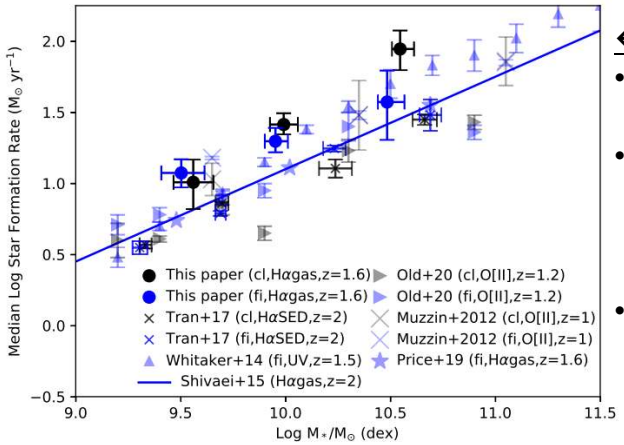

Figure 4. Comparison of our binned results (members as black circles and nonmembers corrected for star formation rate evolution with redshift as blue circles) with selected values from the literature, designated in the legend below the plot. Our SFRs are similar to many other works using optical emission lines, with some works finding substantial differences between cluster members and field galaxies and others finding little to no difference like our study. Some of the differences found in other studies are smaller than our uncertainties at the corresponding stellar masses.

←他研究との比較

- clusterとfieldに違いが無いという結果(x, X)と一致。
- Fieldを比べると、Whitaker(▲)とは同等だが、Shivaei(—)やPriceより(★)より少し上。
- dustやAGNの影響がより大きい[OII]を使ったOld+20とも同等。

- passive fractionがfieldと大きく変わらない（Nantais+17 ）。
  →z~1.6ではenvironmental quenchがまだ効いていない
- 銀河団を形成してから（銀河が落ち込んでから）あまり時間が経っておらず、fieldとの違いが現れていないと考えられる。
- z~1.6では、low-mass cluster levelでさえ、SFR-密度関係は見られない。
- 星形成の抑制より先に現れるであろう形態変化やNIR分光によるpassive銀河同定などが解明の鍵を握るだろう。