The Hα concentration of local star-forming galaxies: implications for galaxy structure formation

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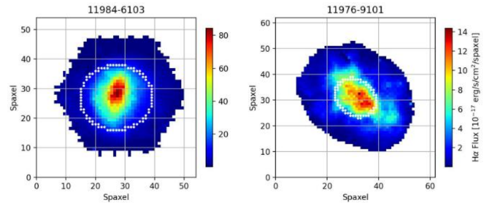
In this work, we present a study on the Hα emission line flux concentration of 3098 low-redshift star-forming galaxies (SFGs) using the MaNGA data available in the Data Release 17 from the Sloan Digital Sky Survey. We define the Hα flux concentration index ($C_{H\alpha}$) as $C_{H\alpha} = F_{H\alpha,0.8\,R_e}/F_{H\alpha,1.5\,R_e}$, where $F_{H\alpha,0.8\,R_e}$ and $F_{H\alpha,1.5\,R_e}$ are the cumulative Hα flux inside 0.8 and 1.5 r–band effective radius, respectively. We find that $C_{H\alpha}$ is strongly correlated with the luminosity weighted stellar age gradient. $C_{H\alpha}$ is also sensitive to environmental effects, in the sense that low-mass satellite galaxies below the star formation main sequence tend to have higher $C_{H\alpha}$. For central galaxies, we find that massive disk galaxies with enhanced star formation rate tend to have higher $C_{H\alpha}$, while such a phenomenon is not seen in the low-mass regime. We interpret this as evidence that compaction events more frequently occur in the high-mass regime, which eventually resulting in the buildup of prominent bulges in massive SFGs. Implications of these findings on galaxy structure formation are discussed.

Introduction

- Spatially resolved star formation properties
  → How galaxies grow and evolve
- IFS surveys → SFR radial profiles,
  But SF regions exhibit clumpy structures

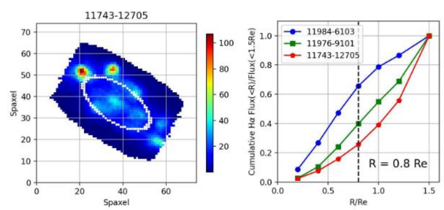
→ Hα concentration (like Schaefer+2017, Wang+2022 using SAMI IFS)

→ Usefulness of Hα concentration and scientific implication



Sample and Methods

- MaNGA IFS (Pan+2023)
  - $10^{9.0}M_\odot < M_* < 10^{12}M_\odot$
  - $0.01 < z < 0.15$
  - $b/a > 0.4$ (exclude edge-on)
  - $\log(sSFR/yr^{-1}) > -11.0$
- Hα concentration index $C_{H\alpha} = F_{H\alpha,0.8R_e}/F_{H\alpha,1.5R_e}$
  - 0.8Re is enough to avoid PSGF smoothing
  - At 0.8Re, different growth curve can be well separated



Comparison with Hα flux gradient and Luminosity-weighted age gradient

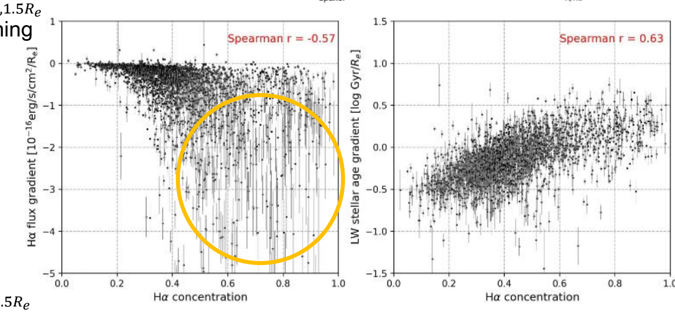
Hα flux gradient

- Large dispersion at high $C_{H\alpha}$
  - Uncertainty in Hα flux gradient (clump)
  - Hα flux gradient uses 0.5-2.0Re,
    But <0.5Re contributes 10-30% to $F_{H\alpha,1.5R_e}$

Luminosity-weighted stellar age gradient

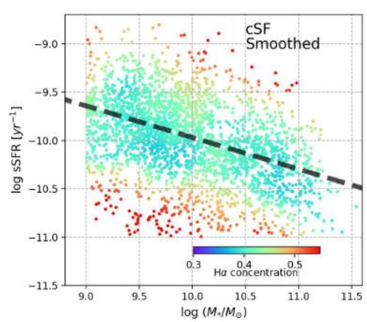
- Strong correlation
- $C_{H\alpha}$ traces not only current SF but also a longer SF pattern

→ Good indicator for studying the structure formation of galaxies



Hα concentration in SFMS

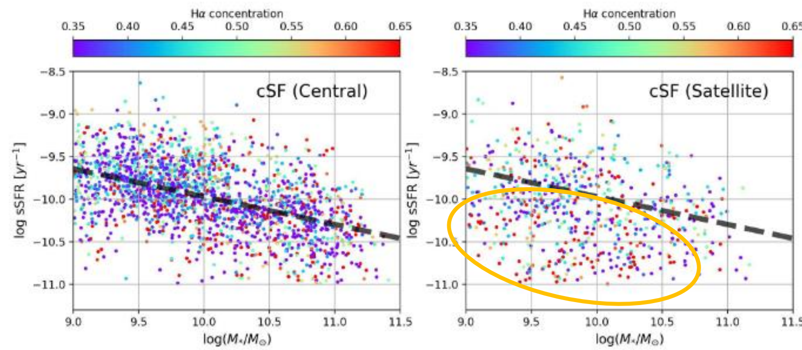
- Galaxies at the SFMS have lower $C_{H\alpha}$
  → Pure disk-dominated system
- Those in the upper and lower envelopes have higher $C_{H\alpha}$
  → Bulge-dominated system



Environment effect

- Low-mass satellite galaxies below SFMS tend to have higher $C_{H\alpha}$
  → Consistent with the previously suggested "outside-in" star formation quenching mode (starvation, ram pressure stripping)

→ CHα is a good indicator of SF distribution of galaxies



$C_{H\alpha}$ and SF enhancement in disk-dominated systems

- In the high mass regime, there is a dependence
  - More frequent "compaction" event: gas inflow by mergers or disk instabilities
- No clear dependence in low mass regime ($\log(M_*/M_\odot)<9.5$)
  - Efficient disk components build up due to high HI gas reservoirs?
  - inefficient disk growth in massive galaxies due to inefficient cool gas accretion?