Balmer Decrements and Nebular-Stellar Reddening in JADES Galaxies at 2.7 < z < 7

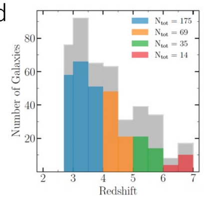
Shreya Karthikeyan et al, [arXiv:2603.11338]

1. Introduction

- Dust attenuation
  - greatly influences SED of galaxies by absorbing and scattering UV/optical light.
  - different tracers
    - Balmer decrement $H\alpha/H\beta$: H II region (nebular reddening $E(B-V)_{gas}$)
    - SED fitting or UV/optical colour : whole galaxy (stellar reddening $E(B-V)_{star}$)
  - Scaling relations
    - correlation btw $E(B-V)_{gas}$ and stellar mass $M_\star$
      - This holds out to $z \sim 2$ (i.e. non-evolution).
      - despite evolving ISM conditions
    - correlation btw $E(B-V)_{star}$ and metallicity Z out to $z \sim 2$ (Shivaei 2020)
      - $Z \uparrow \rightarrow \frac{dust}{gas}, \frac{dust}{metal} \uparrow \rightarrow$ strong attenuation
  - differential reddening $\Delta E(B-V) := E(B-V)_{\rm gas} - E(B-V)_{\rm star}$
    - $E(B-V)_{gas} > E(B-V)_{star}$ (Calzetti 00)
      - nebular region experience additional localized attenuation from birth-cloud dust
      - This effect is weaker at $z \sim 2$ than local universe
- This study
  - investigate those relations for higher redshift
  - examine reddening dependencies on SFR, $M_\star, Z$

2. Data, Method

- JADES NIRCam, NIRSpec
  - Apply SED fitting to NIRSpec spectra and NIRCam photometry (PROSPECTOR) $\rightarrow E(B-V)_{star}, SFR_{100Myr}, M_\star$
  - Emission line fitting $\rightarrow H\alpha, H\beta, [OIII] \ldots \rightarrow E(B-V)_{gas}, Z$
  - 425 objects in total, $\in 2.7 < z < 7$



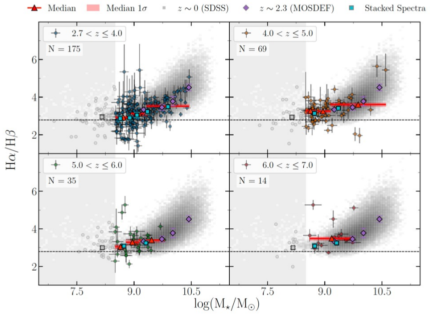
$$E(B-V)_{\rm gas} = \frac{2.5}{k(\lambda_2) - k(\lambda_1)} \log_{10}\left(\frac{R_{\rm obs}}{R_{\rm int}}\right) \quad (1)$$

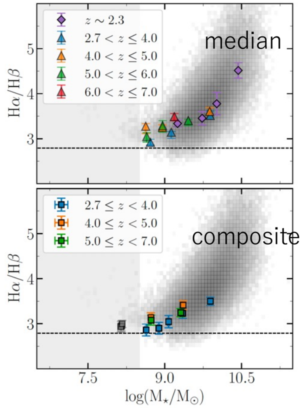
$$R_{\rm obs} = (F_{\lambda 1}/F_{\lambda 2})_{\rm obs} \text{ and } R_{\rm int} = (F_{\lambda 1}/F_{\lambda 2})_{\rm int}$$

- Stacked composite spectra
  - "Balmer decrement stacks" and "metallicity stacks"

3. Results

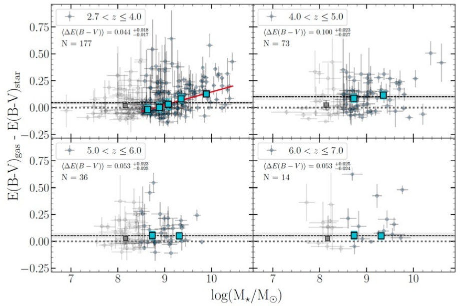
$H\alpha/H\beta$ vs $M_\star$





- positive correlation for $2.7 < z < 5.0$
- For $z > 5$, not statistically significant
- little or no evolution out to $z \sim 7$

$\Delta E(B-V)$ vs $M_\star, SFR_{100Myr}$



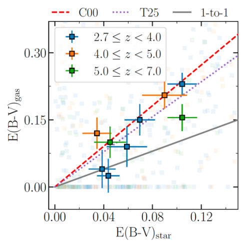
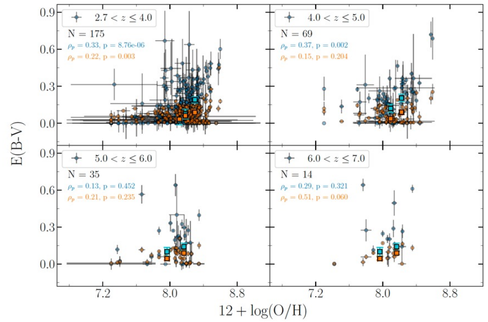


Figure 7. Comparison of $E(B-V)_{\rm gas}$ and $E(B-V)_{\rm star}$ from stacked spectra. The low-opacity squares plot individual galaxies. The red dashed line indicates the Calzetti et al. (2000) relation; the purple dashed line the Tsujita et al. (2025) relation. The solid grey line is the one-to-one relation.

- positive correlation btw $\Delta E(B-V)$ and both $M_\star, SFR_{100}$ for $2.7 < z < 4.0$
  - consistent with MOSDEF result at $z \sim 2$ (Reddy 2015, Lorenz 2023)
- For $z > 4$, no evidence for mass, SFR-dependence.
- They offer prescriptions to transform $E(B-V)_{star}$ to $E(B-V)_{gas}$.



$E(B-V)$ vs Z

- positive correlation btw $E(B-V)_{gas}$ and Z for $2.7 < z < 5.0$
- modest or little correlation btw $E(B-V)_{star}$ and Z

4.Discussion

$H\alpha/H\beta$ vs $M_\star$

- Non-evolution
  - the "effective" dust column scales with galaxy's assembled stellar mass
  - At higher redshift, dust distribution might be more patchy or κ_λ might be lower.

Nebular reddening vs Stellar reddening

- At $z > 5$, little deviation btw two attenuation
  - classical two-component (birth cloud and diffuse ISM dust) model weakens at high redshift
  - dust associated with SFG regulates both nebular and stellar attenuation
  - three-component model
    - dust in SFG
    - dust in ~kpc-scale clumps
    - diffuse dust (negligible)

Metallicity

- stronger correlation btw $E(B-V)_{gas}$ and Z than $E(B-V)_{star}$
  - differs from MOSDEF results (Shivaei 2020)
    - because of different SED fitting assumption or strong-line calibrations , .. ?
  - simply interpreted that nebular reddening is closely tied to enriched gas in HII regions

$$A_\lambda \simeq 1.086 \times \kappa_\lambda \times \left(\frac{M_{\rm dust}}{M_{\rm gas}}\right) \times \Sigma_{\rm gas}. \quad (8)$$

$$\log\left(\frac{M_{\rm dust}}{M_{\rm gas}}\right) = a \times [12 + \log({\rm O/H})] + b$$