**Dissecting the SFR-M* relation at z ~ 2**

**Implications for SFR diagnostics at high redshift**

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**Introduction**

Star formation rate (SFR) is one of the most fundamental quantities for constraining the physics of galaxy formation and evolution. The past decade has seen a multitude of studies that trace SFRs out to high redshift and examined their correlation with other galaxy properties, such as stellar masses (M*). The correlation between SFR and M* suggests that galaxies assemble their stellar mass in a relatively steady process, as opposed to a rapid starburst mode.

At redshift z ~ 2, universe was at its peak of star-formation activity and galaxies were at the process of assembling most of their stellar mass. Therefore, studying the SFR-M* relation at that epoch is crucial for better understanding the galaxy evolution processes. Previous efforts to constrain the SFR-M* relation at z ~ 2 have inconsistent results regarding the slope, normalization, and scatter of the relation. These studies cannot be easily compared with each other as they adopt different samples and different SFR indicators.

In the MOSDEF survey, we have access to multiple SFR diagnostics for a large and comprehensive sample of galaxies at z ~ 2 that can be used to resolve some of the discrepancies between the previously derived SFR-M* properties. These SFR diagnostics include:

- Robust dust-corrected SFR(Hα, Hβ) from near-IR spectroscopy
- Obscured SFR(IR) from Spitzer and Herschel mid- and far-IR photometry
- Unobscured SFR(UV) as well as SFRs derived from SED fitting, from UV to near-IR photometry

**The MOSDEF Survey**

The MOSFIRE Deep Evolution Field (MOSDEF) survey is a large program with MOSFIRE near-IR spectrometer on the Keck I telescope, to observe the stellar, gaseous, metal, dust, and black hole content of ~1500 galaxies at 1.37z ≤ 3.80. The MOSDEF sample is selected based on rest-optical (H-band) magnitudes and is observed in five CANDELS fields: AEGIS, COSMOS, GOODS-N, GOODS-S, and UDS.

* Survey website: http://mosdef.astro.berkeley.edu

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**SFR-M* in MOSDEF and other studies**

In Shivaei et al. (2015b), we explored the relationship between dust-corrected SFR derived from Hα, Hβ and stellar mass derived from SED fitting for 216 galaxies at z ~ 2 (right figure). We measured a log(SFR)-log(M*) slope of 0.6 ± 0.1.

In the right plot, relations from other studies are shown with colored lines. Clearly, there is a discrepancy between the slope of the SFR-M* relation derived from different studies. The comparison suggests that studies that use Hα SFRs measure systematically shallower slopes compared to those that adopt IR inferred SFRs.

**Questions:** How does choosing different SFR diagnostics affect the slope of the SFR-M* relation? What conditions must be met for various SFR diagnostics to be valid?

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**Comparison of SFR diagnostics:**

1. **How accurate does Hα trace SFR at z ~ 2?**

As galaxies at z ~ 2 were more star-forming compared to now, it has been argued that Balmer lines may miss optically thick star-forming regions at these high redshifts. In order to investigate this possible bias, we compared the MOSDEF SFR(Hα,Hβ) with independently measured UV-to-far-IR SFRs derived from panchromatic SED fitting (right two models).

**Result:** In Shivaei et al. (2016), we showed that Hα luminosity, once corrected for dust attenuation using the Balmer decrement, does not underestimate the SFR even for the most dusty and star-forming galaxies in our sample (SFRs ~ 250 M* yr⁻¹).

2. **How accurate does 24µm trace SFR at z ~ 2?**

SpitzerMIPS 24µm is commonly used as an indicator of total IR luminosity (LIR) and SFR at high redshift, as it traces 7.7µm PAH emission at z ~ 2. To explore the robustness of this SFR diagnostic at different ISM environments, we investigated the relative strength of 7.7µm luminosity, traced by MIPS 24µm, to SFR(Hα,Hβ) as well as to IR luminosity, derived from HerschelPACS 100 and 160µm bands, as a function of metallicity (left plot) and ionization state (middle and right plots). There is a clear trend between 7.7µm intensity and metallicity, ionization state, and as a consequence the stellar mass. This result implies that PAH molecules are effectively destroyed by harder radiation fields in low metallicity environments.

**Result:** The commonly-used conversions of LIR to L_Hα (horizontal lines in the plots above) are only consistent with more massive and metal-rich galaxies.

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Right figure demonstrates that using a single conversion from rest 7.7µm to L_Hα (diamonds) underestimates SFRs at low masses, and hence, results in a steeper slope of the SFR-M* relation. In contrast, blue stars that are calculated from our mass-dependent conversion of L_7.7µm to L_Hα (Shivaei et al. 2016, in prep), are in a very good agreement with SFR(Hα,Hβ) (red circles) and with a shallower slope of the SFR-M* relation.