Understanding the link between dust geometry and star formation rate in galaxies

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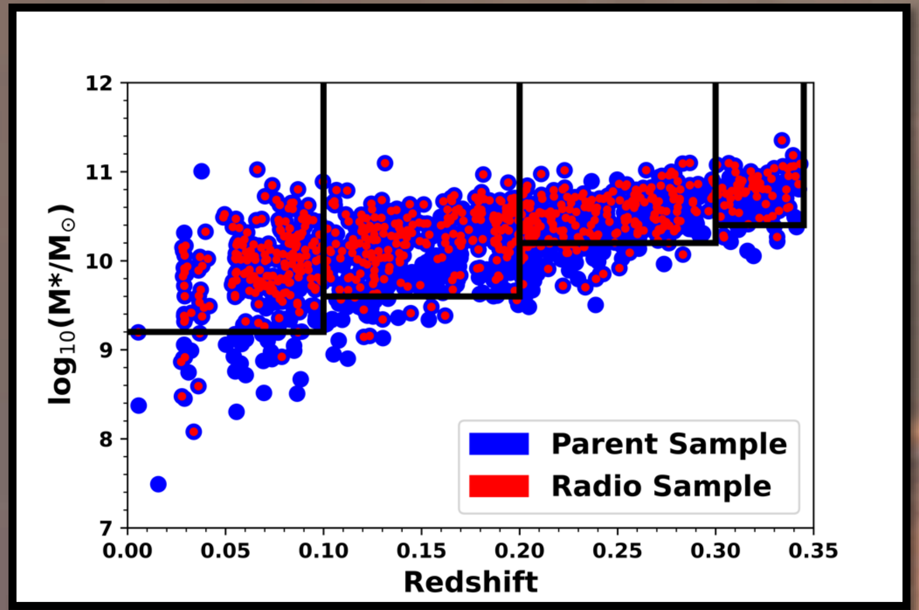
BACKGROUND

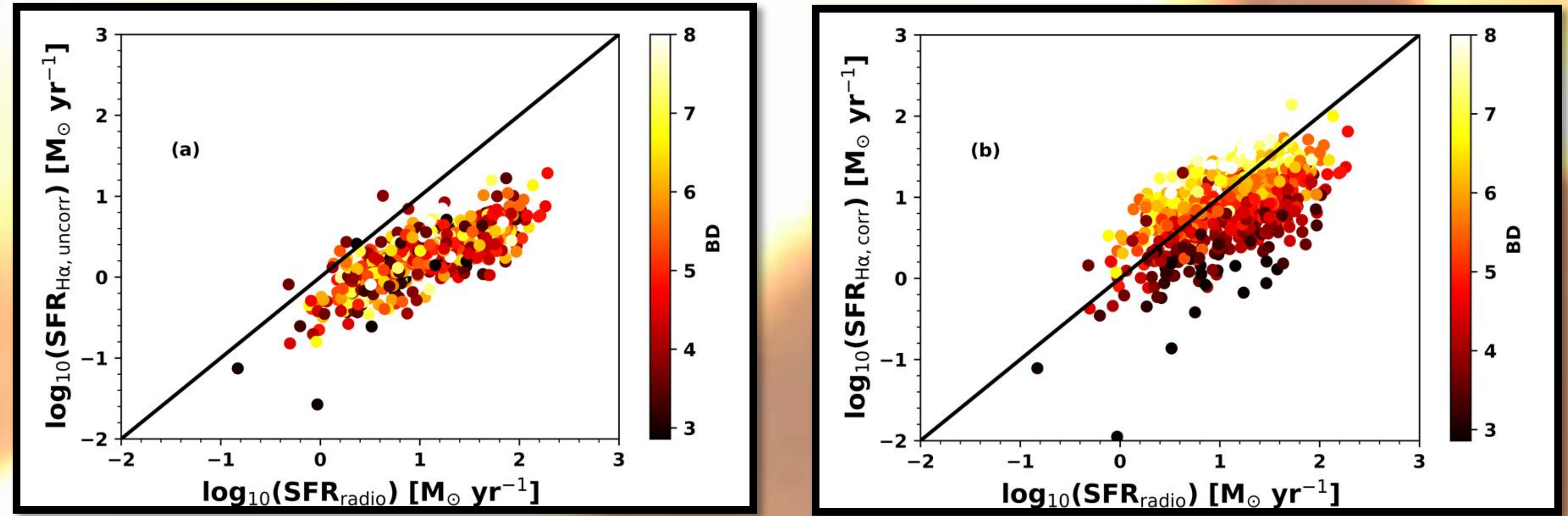
- We use early science data taken with the ASKAP telescope for the Evolutionary Map of the Universe (EMU, Norris+2021) survey in the Galaxy and Mass Assembly (GAMA, Driver+2022), G23 field due to the wealth of complementary photometric and spectroscopic data.
- We investigate the link between dust obscuration (Ahmed+2024a) and star formation rate (SFR) estimators using Hα luminosities, and radio luminosities. The ratio of SFRs estimated from radio luminosity and Hα luminosity corrected for dust attenuation using the Balmer decrement (BD) can be used as a probe of the degree of optically thick dust affecting Hα. We explore this by drawing on dust estimates using both the BD and the dust mass, demonstrating systematic underlying dependencies with the radio luminosity to Hα luminosity ratio (Ahmed+2024b, submitted).

1. DATA



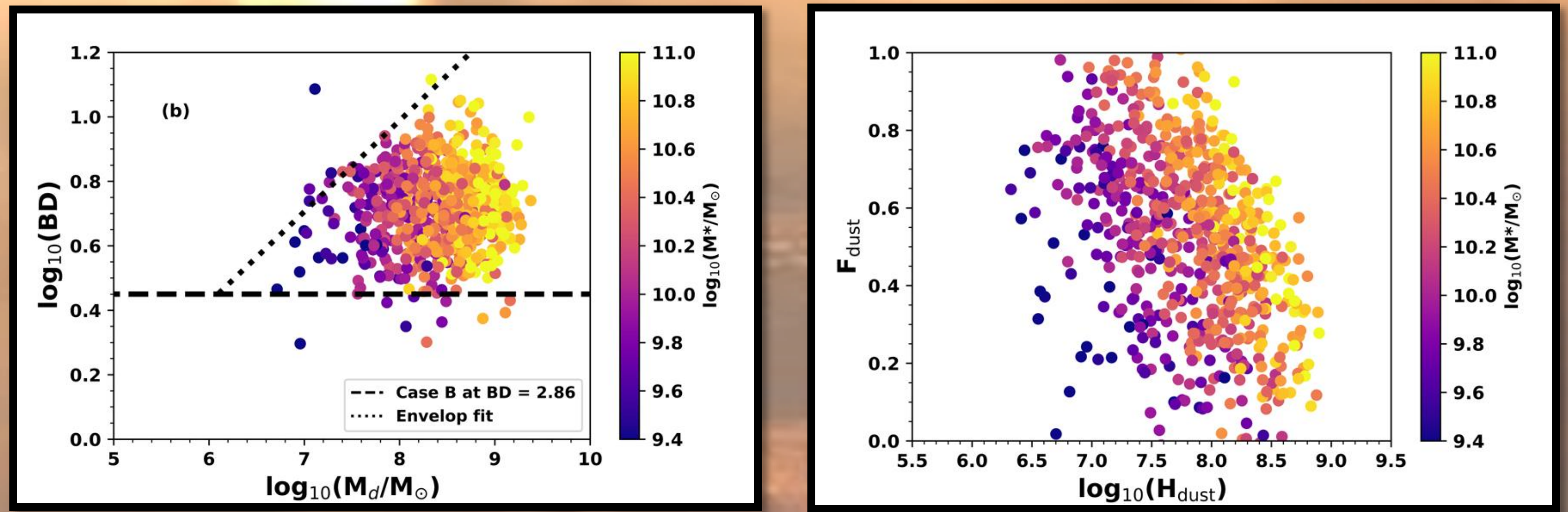
Distribution of stellar mass M^* of all galaxies in the sample as a function of redshift, illustrating the four volume limited samples with the optical parent galaxies (blue), and radio detections (red).

2. STAR FORMATION RATE (SFR)



Motivated by Hopkins+2001, we use a novel approach to minimise the discrepancy between the SFR measurements derived from radio and uncorrected Hα luminosities in panel (a) and BD - corrected Hα luminosities in panel (b) for the radio sample, colour coded by BD.

4. DUST GEOMETRY



Distribution of BD as a function of dust mass M_d, colour coded by M^* for the radio detections. The horizontal dashed line is the nominal Case B value of BD = 2.86. The dotted line is the empirical envelope for the BD. To link the BD and the M_d, we introduce two novel dust parameters calculated as

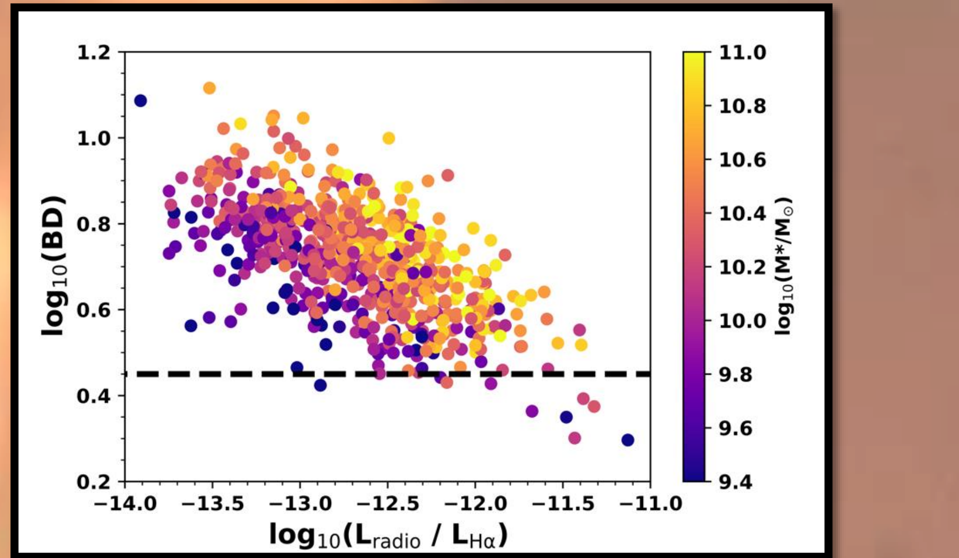
$$F_{dust} = \frac{\log BD - \log(2.86)}{\log BD_{ENV} - \log(2.86)}$$

$$\log H_{dust} = 10^{1.0578}\frac{\log M_d}{BD^{2.303}}$$

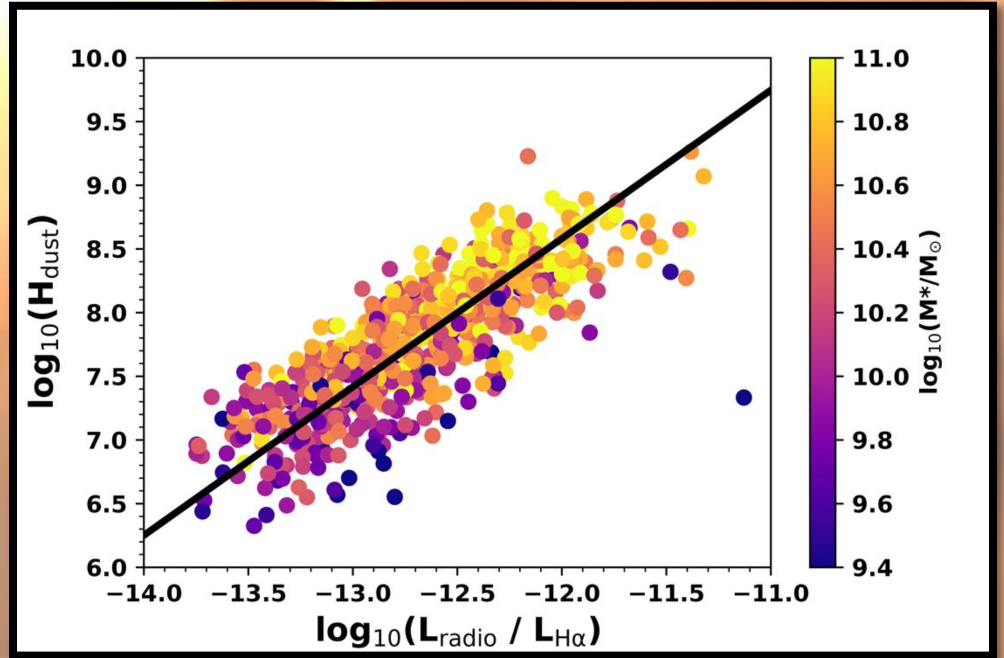
F_{dust} is the dust geometry as a proportion of a foreground screen or distributed dust. It quantifies the vertical positioning of the BD between the nominal Case B value and the empirical envelope. H_{dust} is a different approach which explicitly links both the BD and M_d.

3. Hα DEFICIT

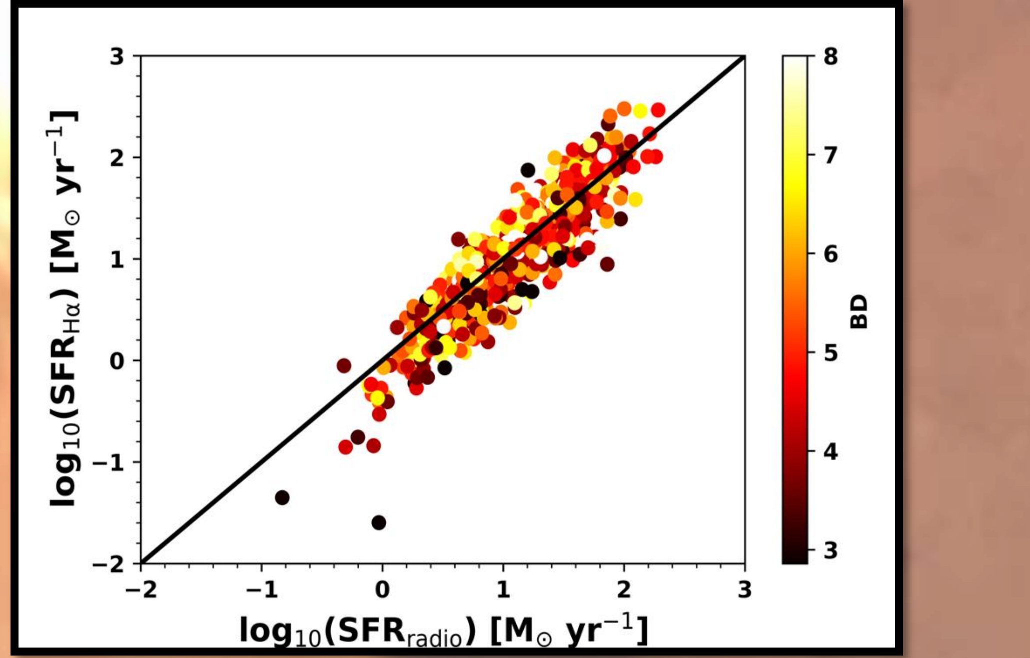
The distribution of BD as a function of Hα deficit, which we define as the ratio of the radio and Hα luminosities, colour coded by M^*. This highlights the BD dependence as the SFR discrepancy increases.



5. IMPROVED SFR



Distribution of H_{dust} as a function of Hα deficit, colour coded by M^*. The correlation is significantly tighter compared to that of the correlation between Hα deficit and BD alone.



The relation in the previous figure has been used to recalibrate the Hα SFR. This figure shows the updated comparison between the radio and improved Hα SFR. The line is the one-to-one relation and the correlation is significantly tighter.

SUMMARY

- We introduce two novel parameters H_{dust} and F_{dust} to quantify the properties of dust in galaxies.
- We establish a tight correlation between H_{dust} and Hα deficit, establishing this parameter as a clear tracer of optically thick dust to define an improved estimate of Hα luminosity, and hence Hα SFR.

References

- Ahmed, U. T., et al. 2024b (submitted)
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- Norris, R. P., Marvil, J., Collier, J. D., et al. 2021, PASA, 38, e046
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