Distributions of dust and stars inside star-forming galaxies at z=1.5

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Image Credit: NASA / ESA / HST

Why does dust distribution in galaxies matter?

1. Dust is still a missing piece in current major galaxy hydrosimulations (need spatial resolution < 10 pc).
2. Dust influences several processes of galaxy formation (metal distribution, launching winds, gas cooling).
3. **Future galaxy formation models need to apply/match realistic dust distribution from observation.**

Credit: ESO

Outline

1. Using IRX-beta relation to understand dust distribution.

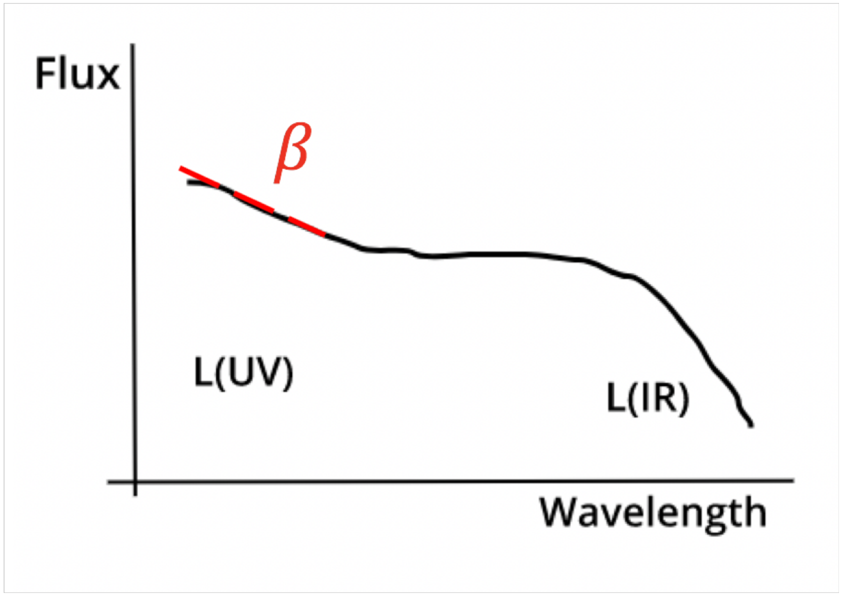
2. Dust distribution in massive star-forming galaxies.

3. Dust distribution in low-mass star-forming galaxies.

Credit: ESO

1. Using IRX and β to understand dust distribution

IRX: L(IR)/L(UV) β: slope of UV spectrum



1. Galaxies with no dust:

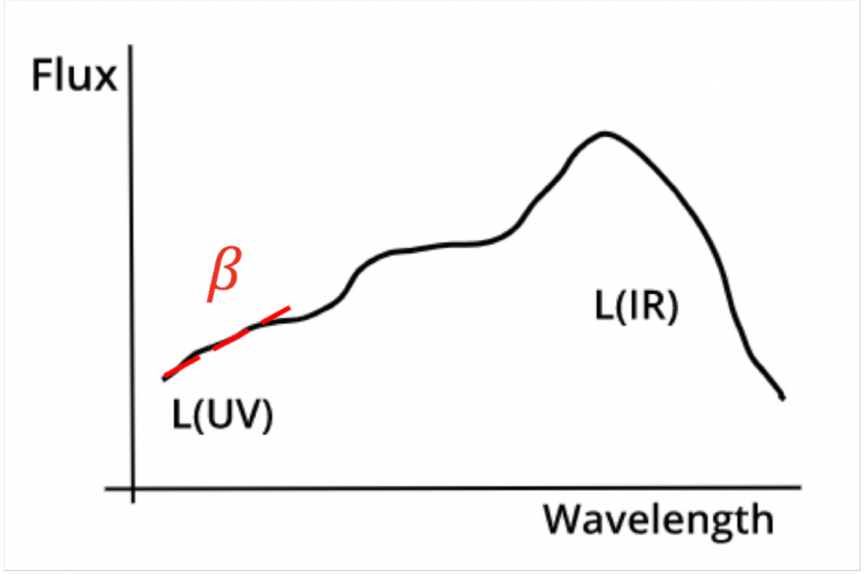
Low IRX value

Small (more negative) β value

2. Galaxies with much dust:

High IRX value

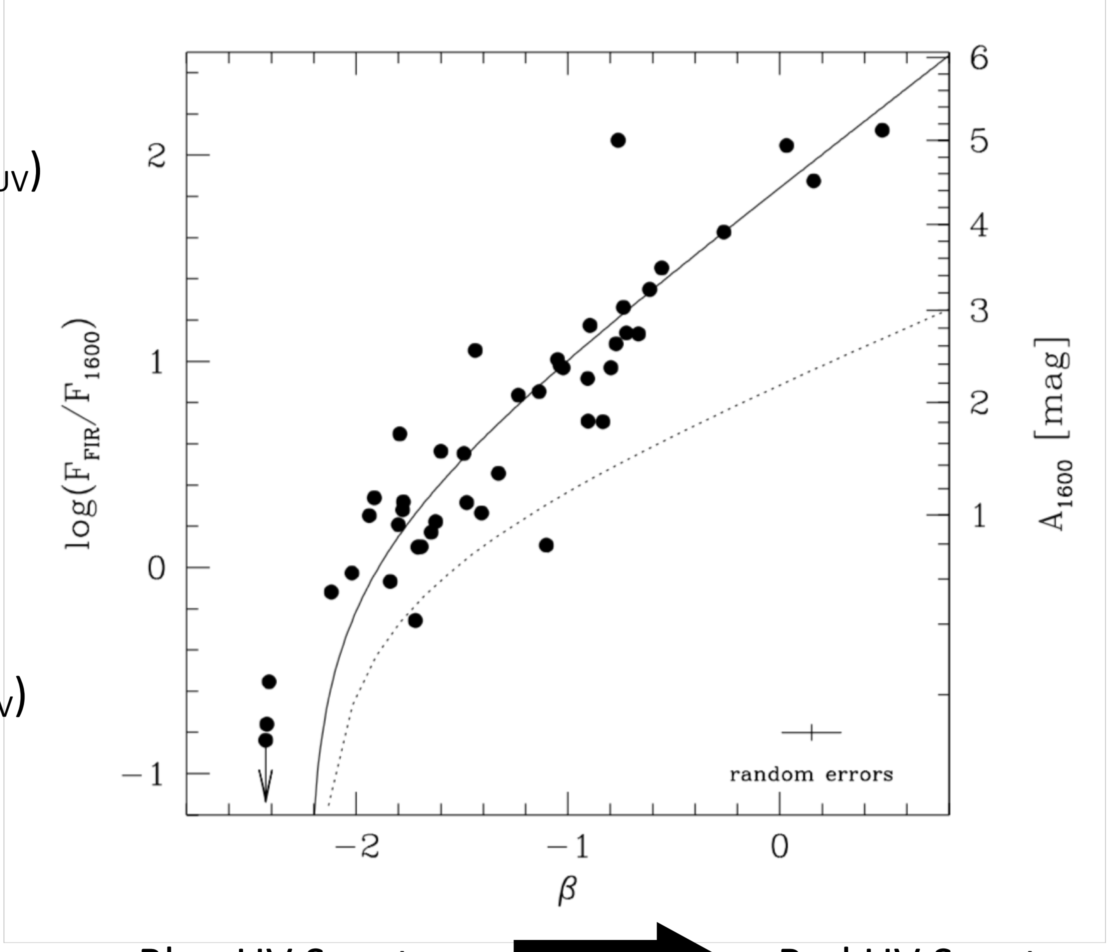
Large β value



Using IRX and β to understand dust distribution

High IRX (high A_{UV})

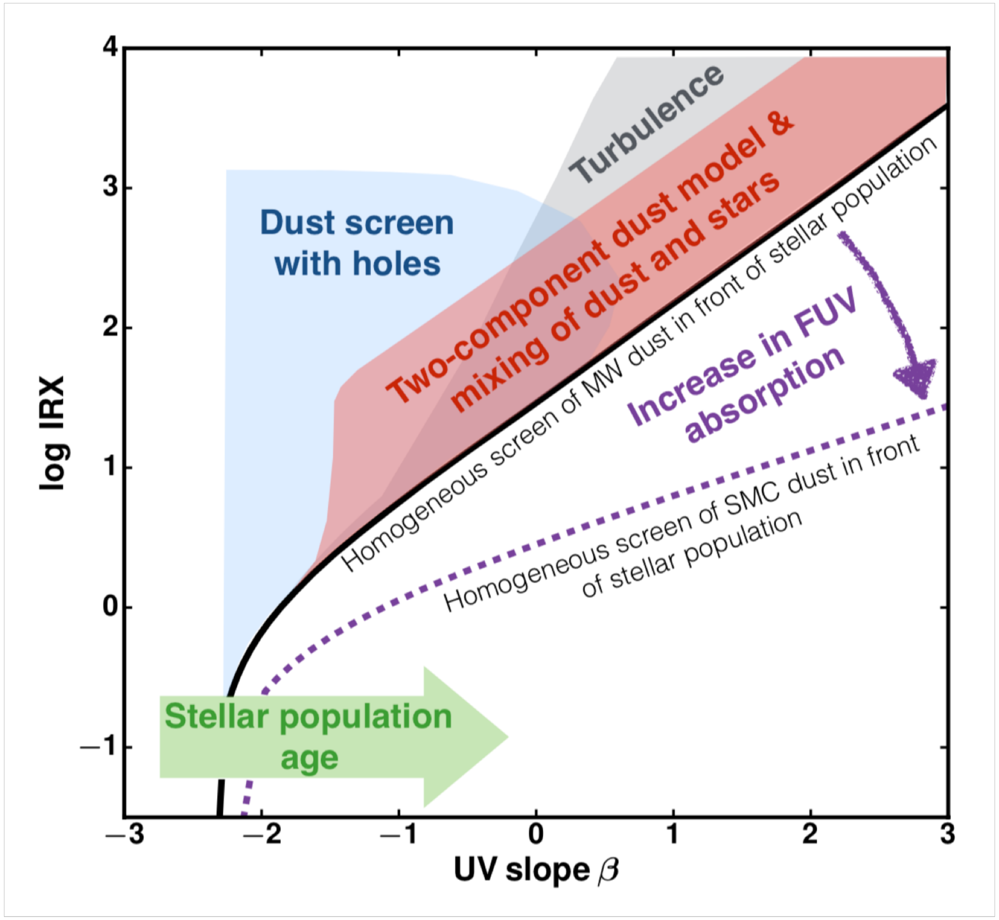
Low IRX (low A_{UV})



Blue UV Spectrum → Red UV Spectrum

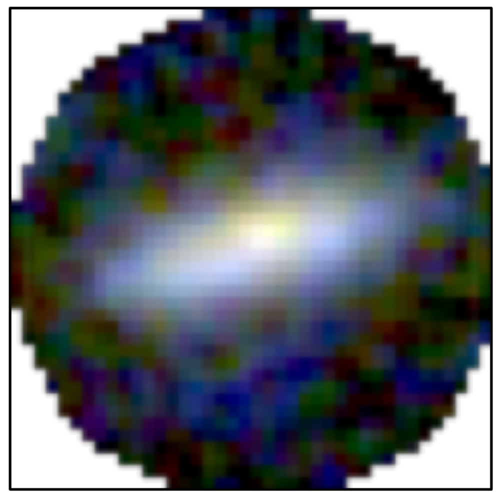
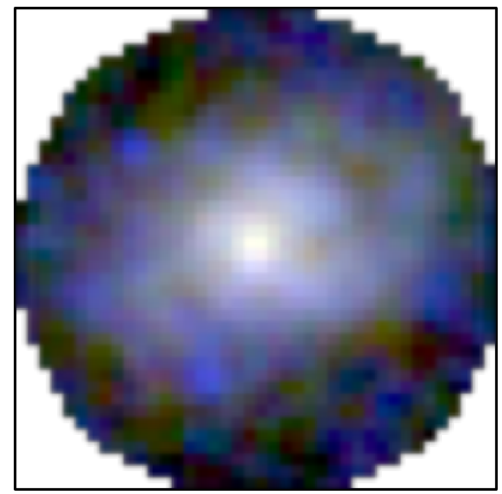
Local Starburst Galaxies, (Meurer, Heckman, and Calzetti 1999)

Using IRX and β to understand dust distribution



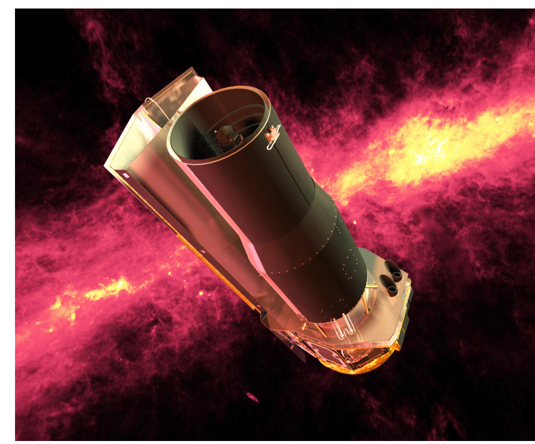
Theoretical modelling by Popping, Puglisi, & Norman 2017

2. High-mass star-forming galaxies (>10^{10} $\mathrm{M_{sun}}$)

Data from the CANDELS survey (GOODS-S and GOODS-N)

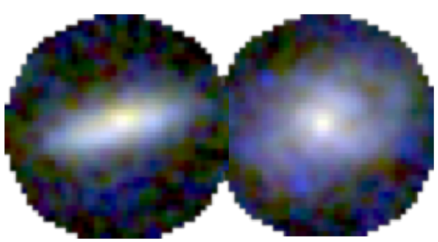
1. Star-forming galaxies ($10^{10} - 10^{11}$ $\mathrm{M_{sun}}$) at z=1.3-1.7
2. L(IR) is converted from Spitzer 24 µm flux
3. Measure β from ground-based U-band and HST ACS bands.



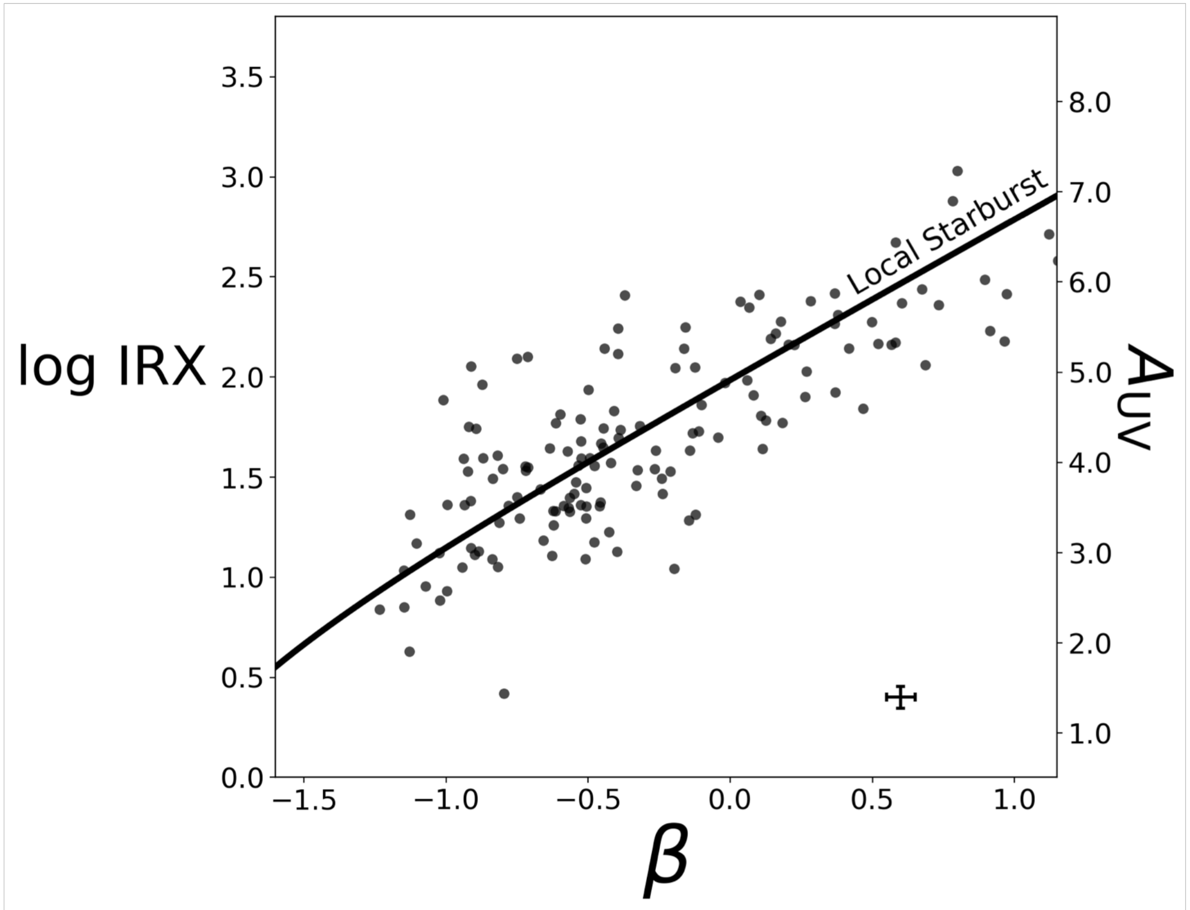
Observation Results:
average trend is consistent with local starbursts

$10^{10} - 10^{11}\ \mathrm{M_{sun}}$

$1.35 < z < 1.75$



Wang et al. 2018, ApJ



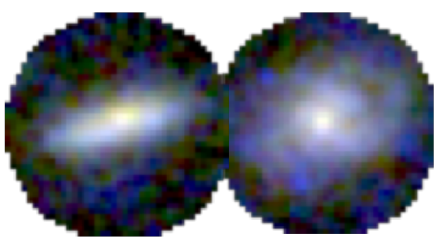
Observation Results:
edge-on galaxies stay above face-on galaxies.

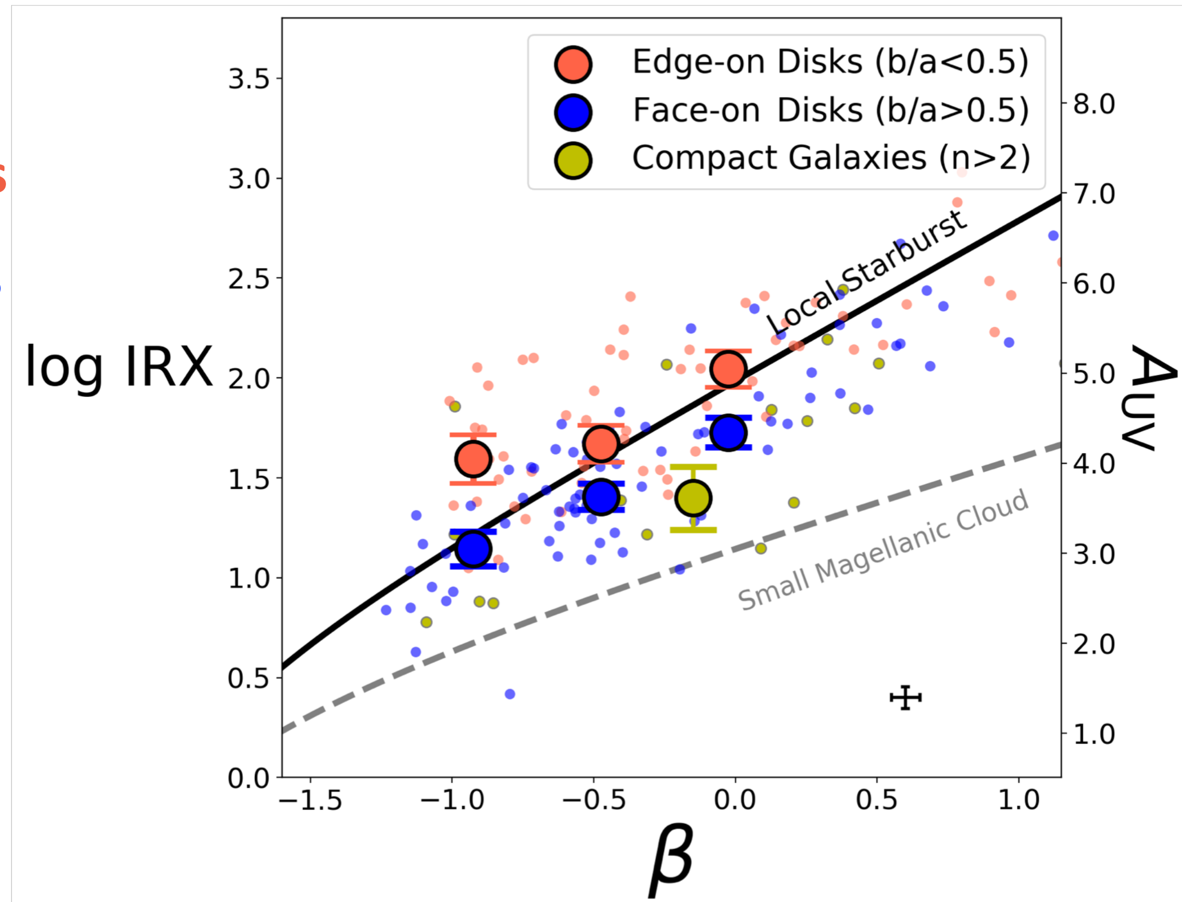
Red: Edge-on galaxies

Blue: Face-on galaxies

$10^{10} - 10^{11}\ \mathrm{M_{sun}}$

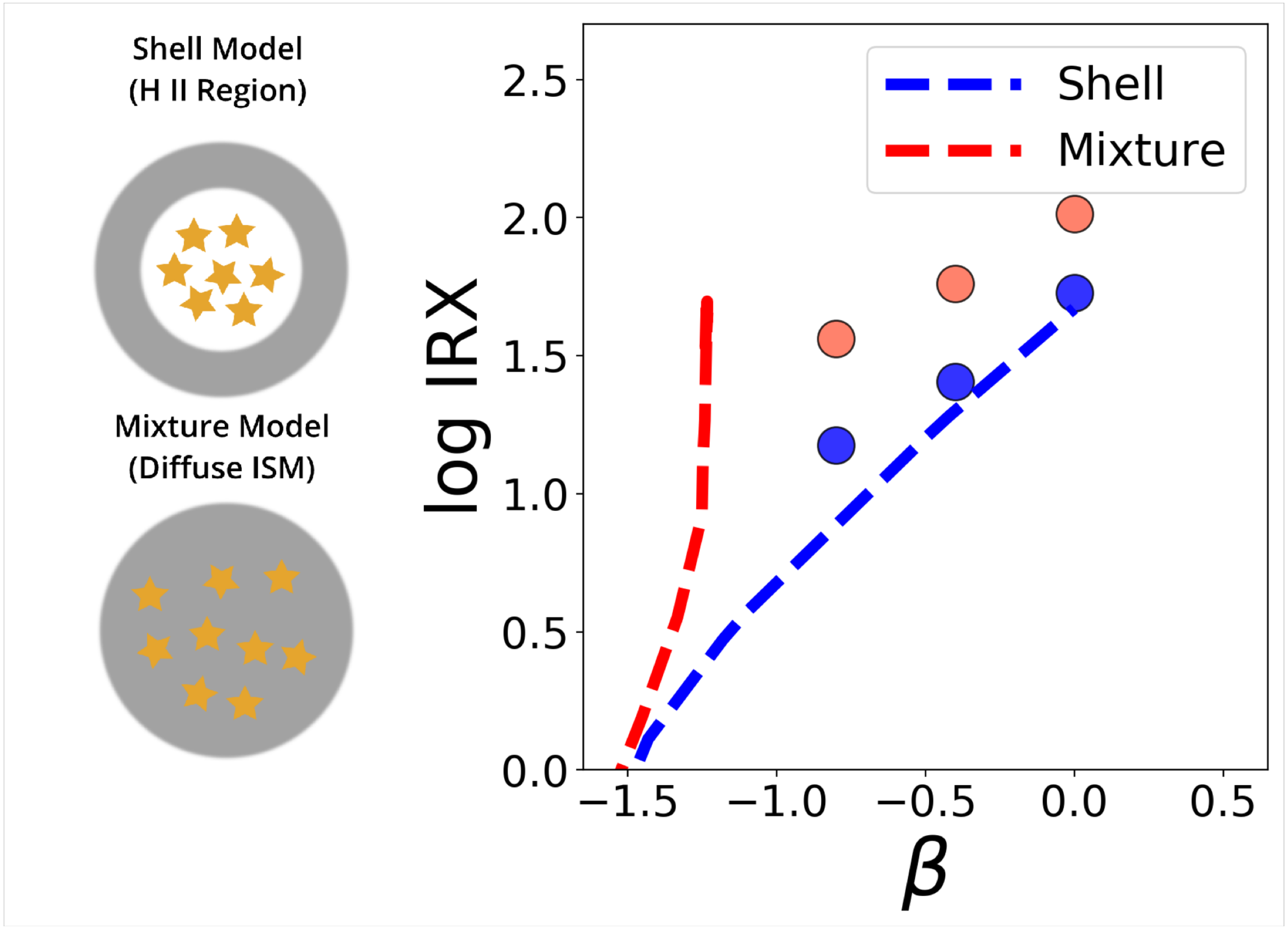
$1.35 < z < 1.75$



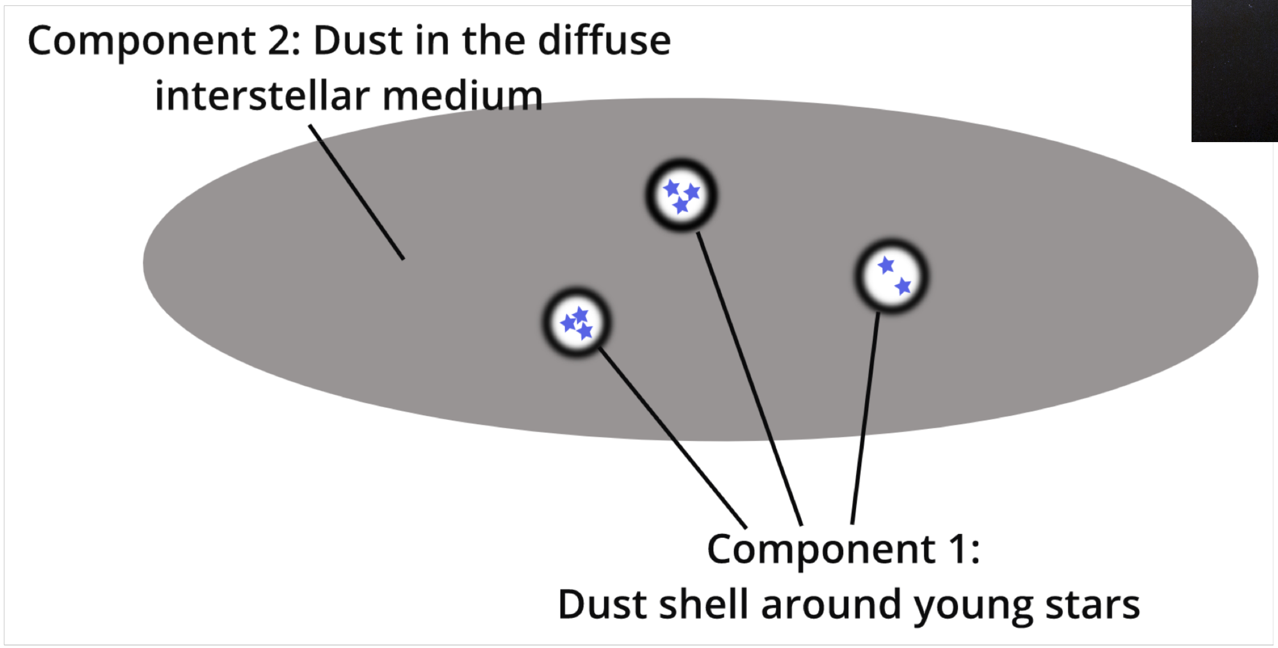


Wang et al. 2018, ApJ

Using simple dust distribution models to understand the observed IRX-β relation



A two-component dust model



Component 1:

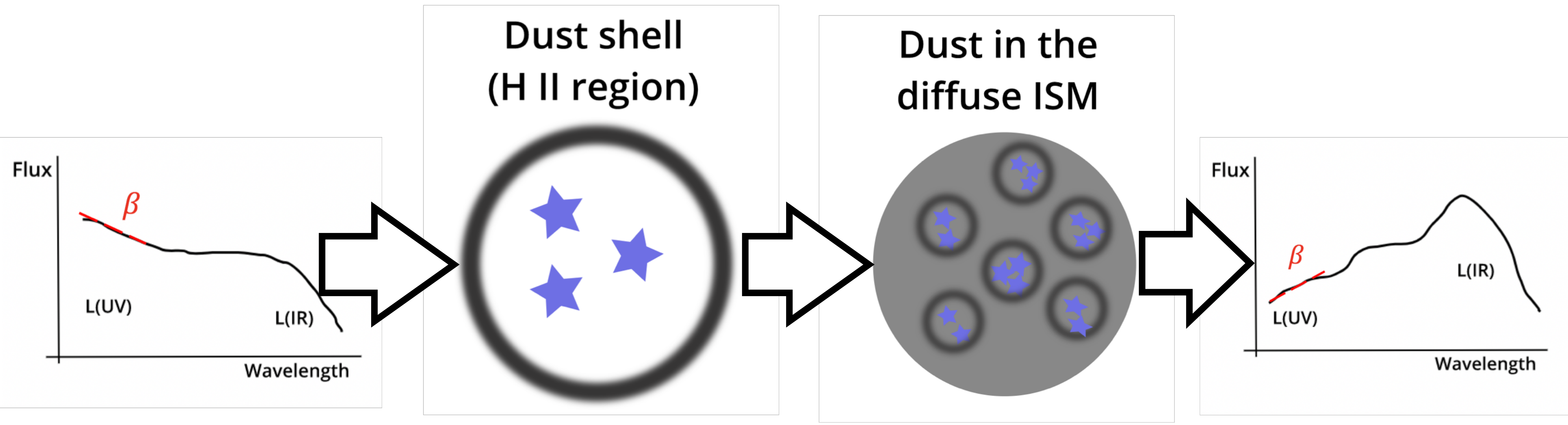
Dust shells around young O stars: **Same attenuation for stars at all locations**

Component 2:

Dust in the diffuse interstellar medium: **Lower attenuation near disk surface**

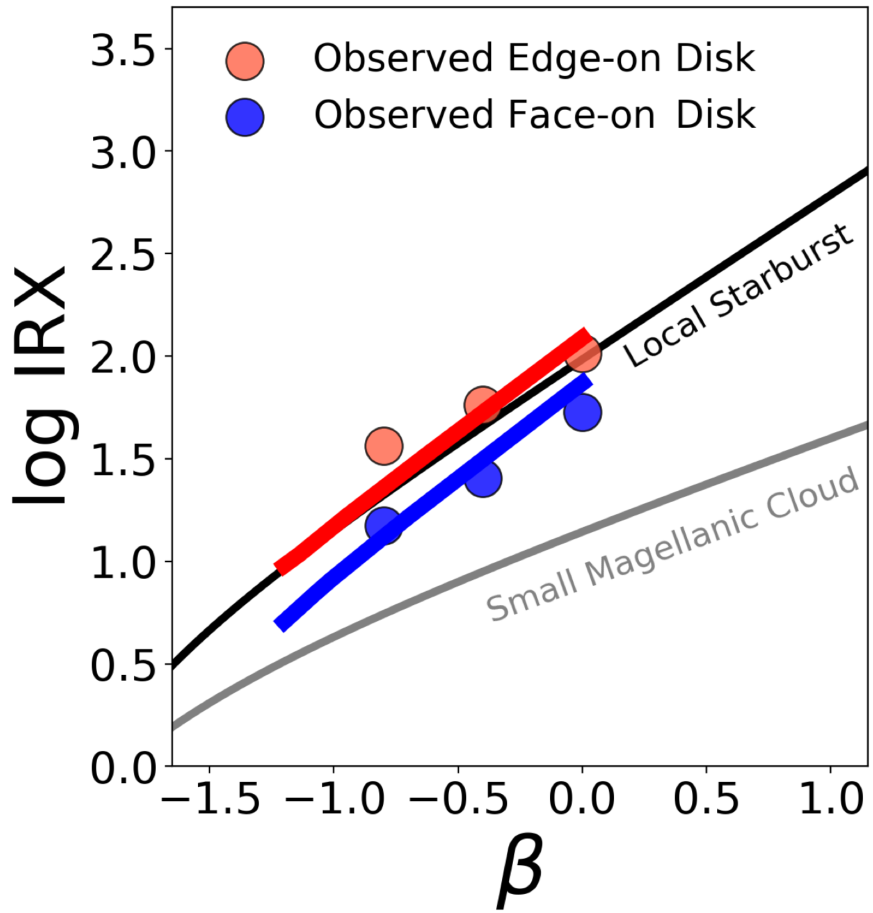
(Charlot & Fall 2000; Calzetti 2001; Chevallard et al. 2013)

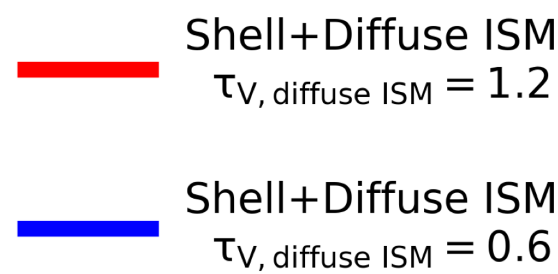
Using IRX-β relation to understand dust distribution: radiative transfer modelling



Radiative transfer
results from
Seon & Draine (2016).

Using IRX-β relation to understand dust distribution: radiative transfer modelling

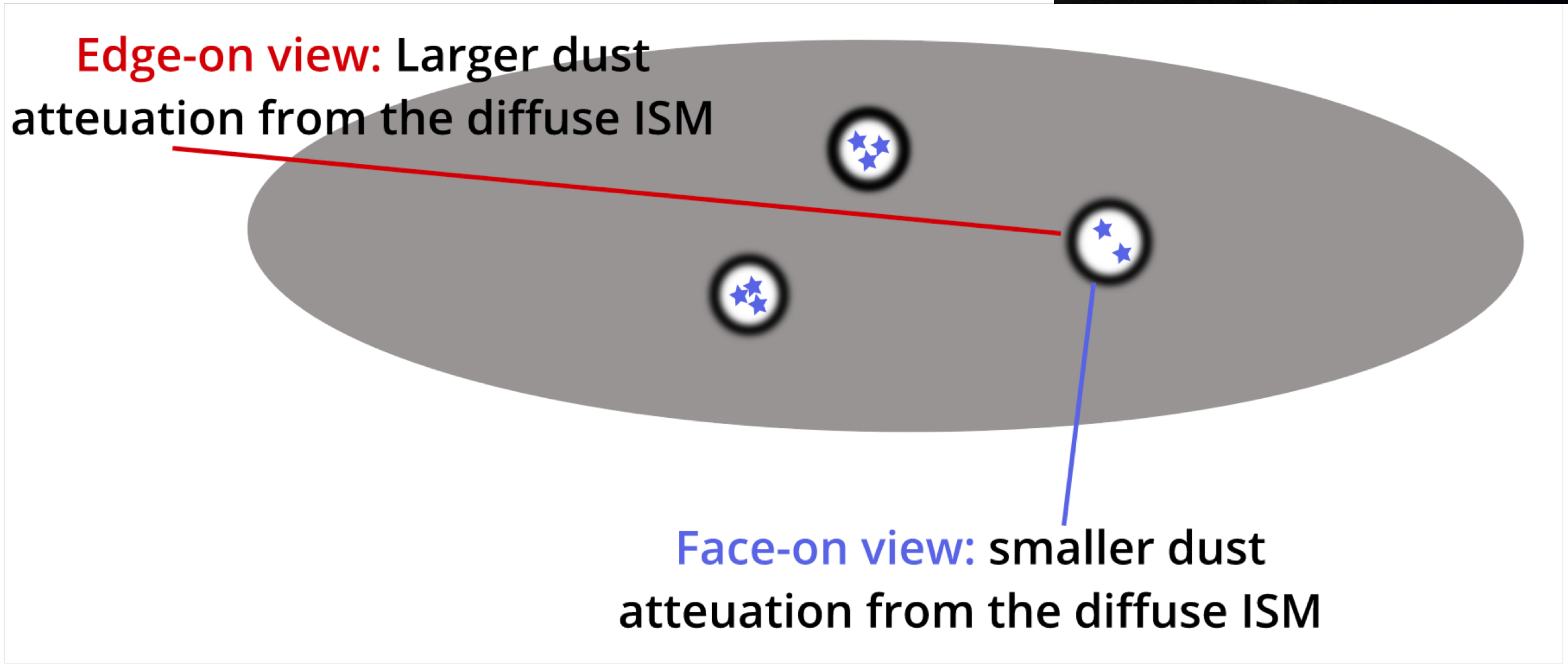




Edge-on galaxies have a higher dust optical depth from the diffuse interstellar medium.

Wang et al. 2018, ApJ

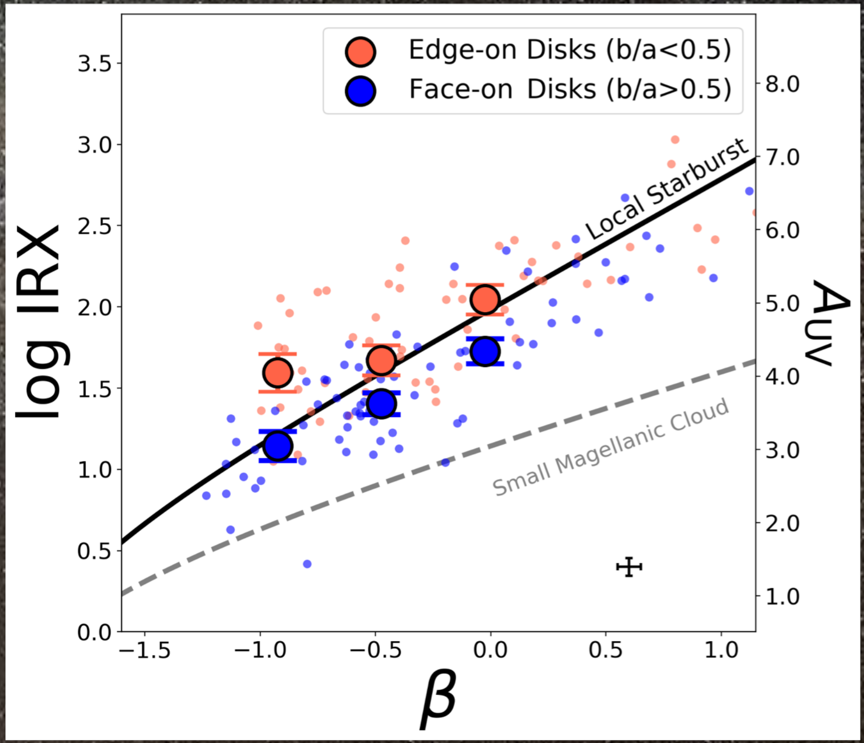
The IRX-β relation can be explained by the two-component dust model



Dust attenuation from shells does not change with viewing angle.

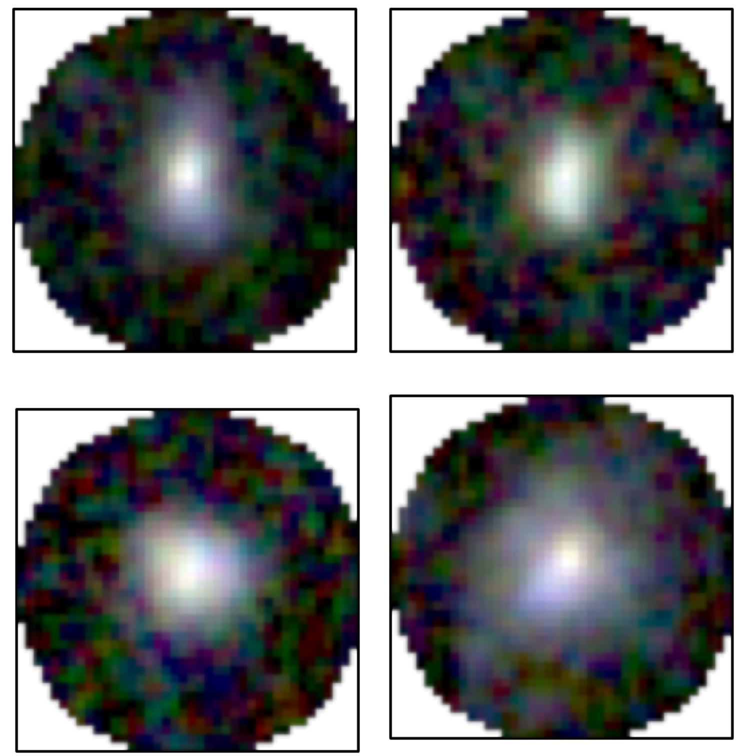
Conclusions

1. The IRX-β relation for massive star-forming galaxies varies with inclination at z~1.5.
2. Dust distribution inside massive galaxies can be explained by a two-component model.



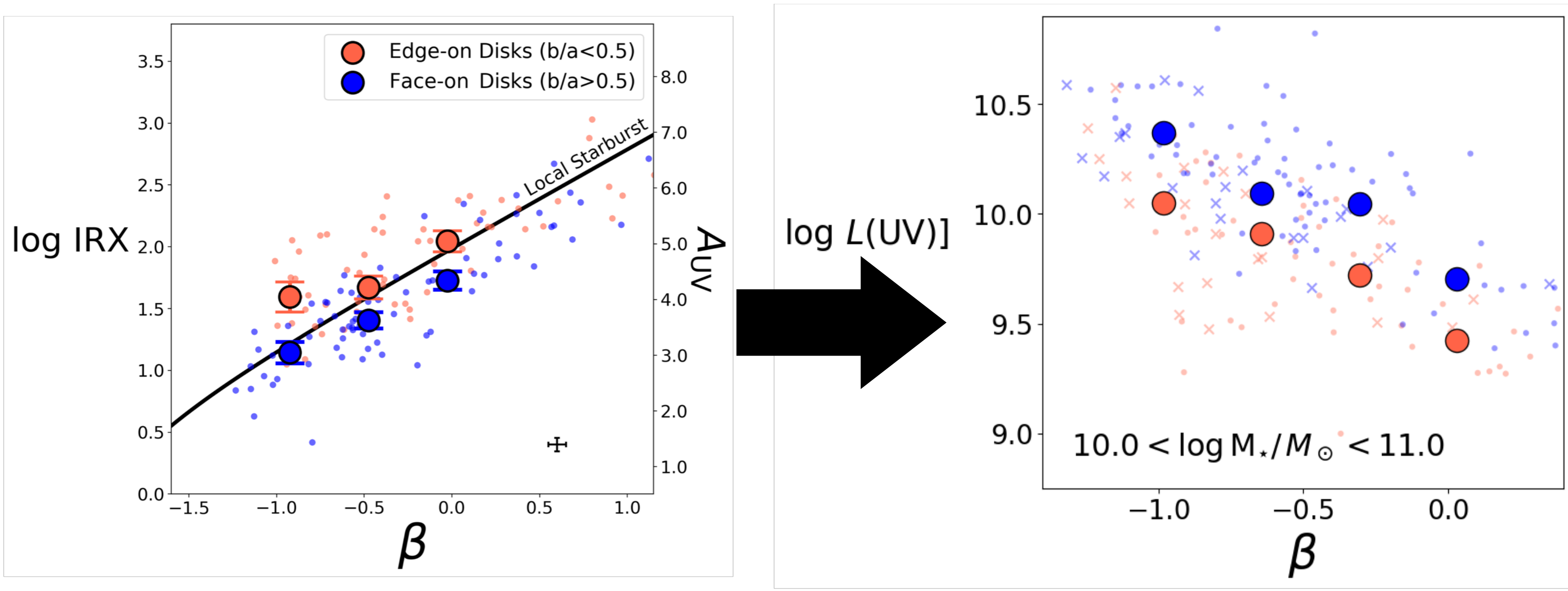
Credit: ESO

3. Low-mass star-forming galaxies ($<10^{10}\ \mathrm{M_{sun}}$)



The IRX-β relation cannot be directly measured due to the limited sensitivity of available 24 micron data.

Lessons from the massive sample: galaxies are fainter in UV if they have higher IRX values



At a given beta, edge-on galaxies have

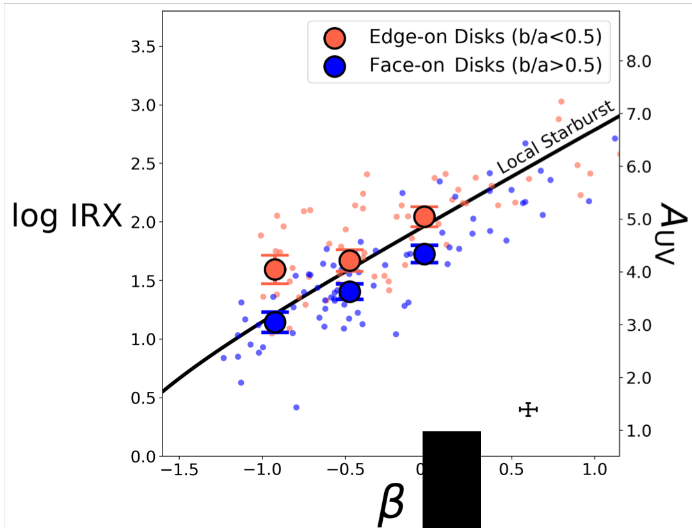
1. higher dust attenuation (IRX or A_{UV}).
2. Lower observed UV luminosity.

Red: Low b/a galaxies

Blue: High b/a galaxies

Wang et al. 2018, ApJ

Low-mass star-forming galaxies ($<10^{10}$ M_{sun})



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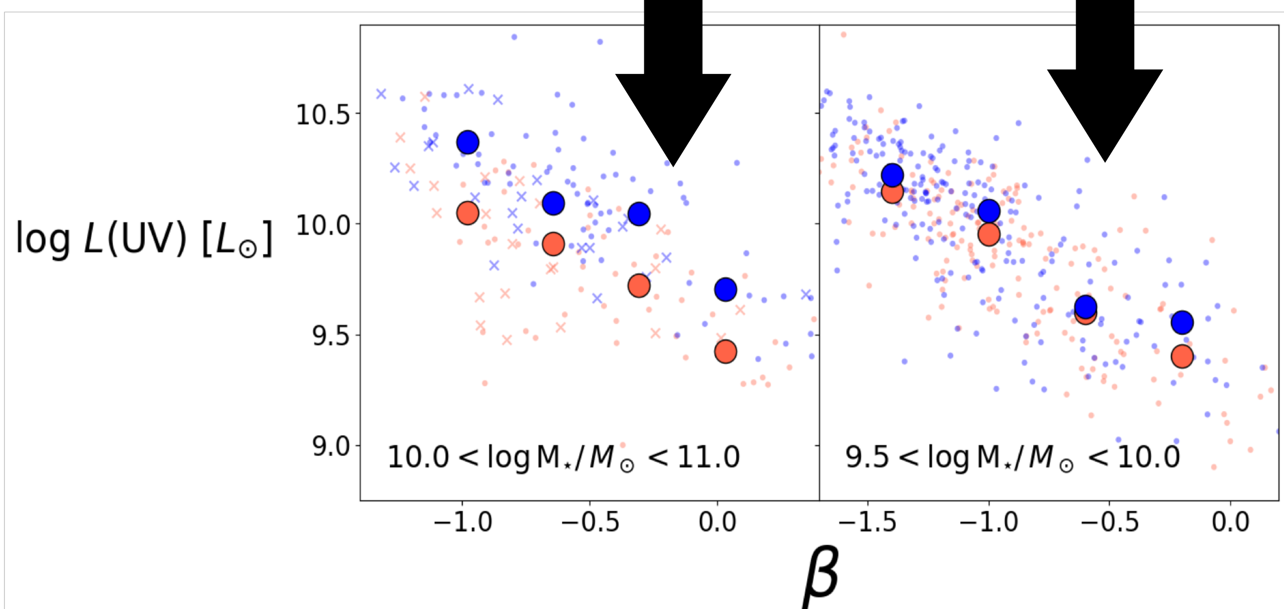
IRX-β relation



L_{UV} -β relation

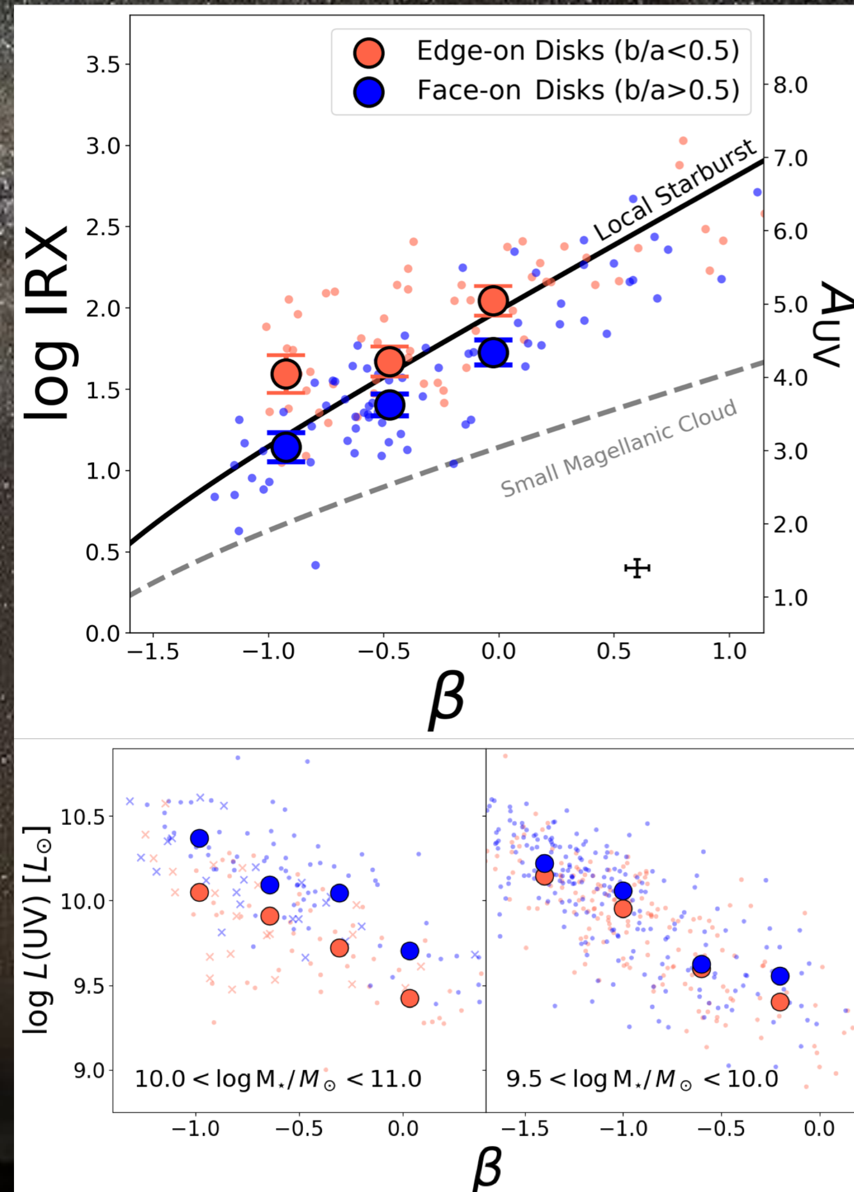
Low-mass star-forming galaxies do not behave like massive ones:

two possible physical reasons:

1. Gas and dust may not distribute in a well-shaped disk and dominated by the disordered motion (Simons et al. 2017).
2. A significant fraction of low-mass galaxies at $z \sim 1.5$ may even have prolate shapes (van der Wel et al. 2014).

Conclusions

1. The IRX-β relation for massive star-forming galaxies varies with inclination at z~1.5.
2. Dust distribution inside massive galaxies can be explained by a two-component model.
3. Low-mass galaxies do not seem to have such inclination dependence. Their dust distribution is different from that of massive galaxies.



Credit: ESO