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

Weichen Wang (JHU)

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Susan Kassin (STScI) Camilla Pacifici (STScI), Guillermo Barro (U of Pacific), Alexander de la Vega (JHU), Raymond Simons (JHU), Brett Salmon (STScI), Sandy Faber (UCSC), Harry Ferguson (STScI), Pablo G. Perez-Gonzalez (UCM, Spain), Gregory Snyder (STScI), Karl Gordon (STScI), Zhu Chen (SHNU), Dritan Kodra (Pittsburgh)

Image Credit: NASA / ESA / HST

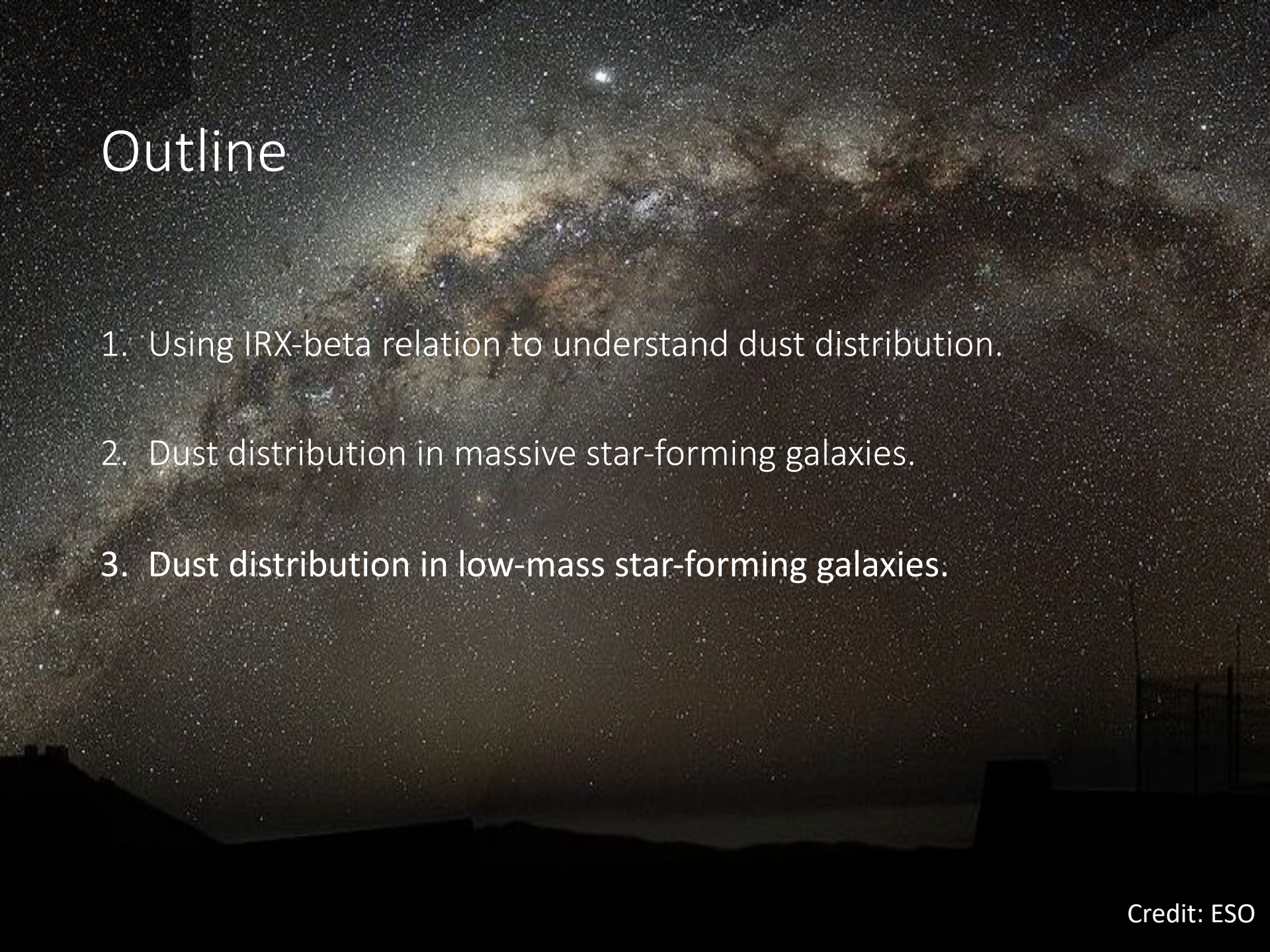
Why does dust distribution in galaxies matter?

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

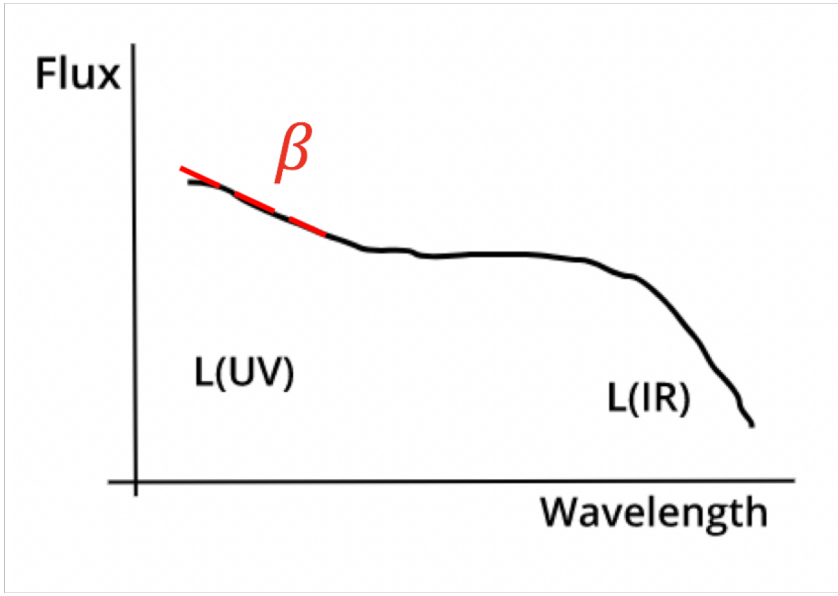
1. Using IRX-beta relation to understand dust distribution.
2. Dust distribution in massive star-forming galaxies.
3. Dust distribution in low-mass star-forming galaxies.



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:

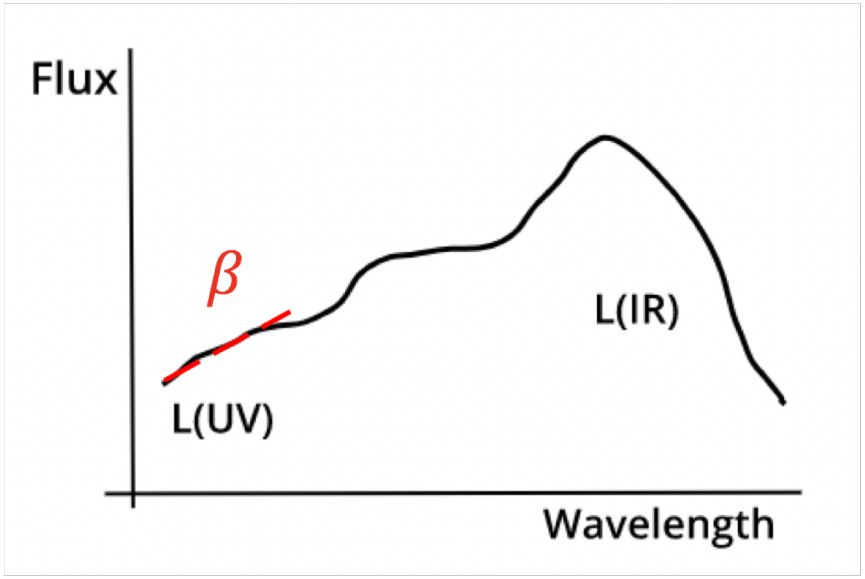
Low IRX value

Small (more negative) β value

2. Galaxies with much dust:

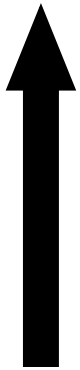
High IRX value

Large β value

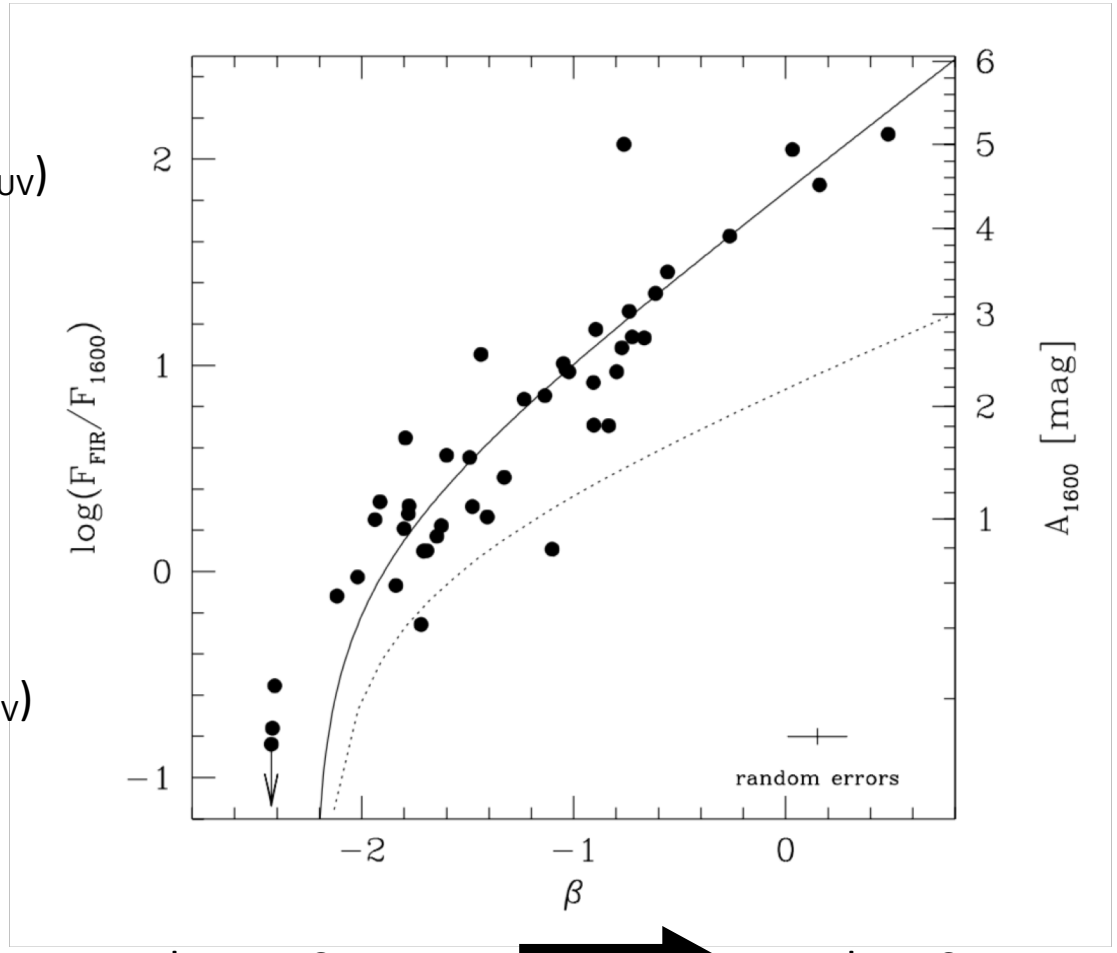


Using IRX and β to understand dust distribution

High IRX (high A_{UV})



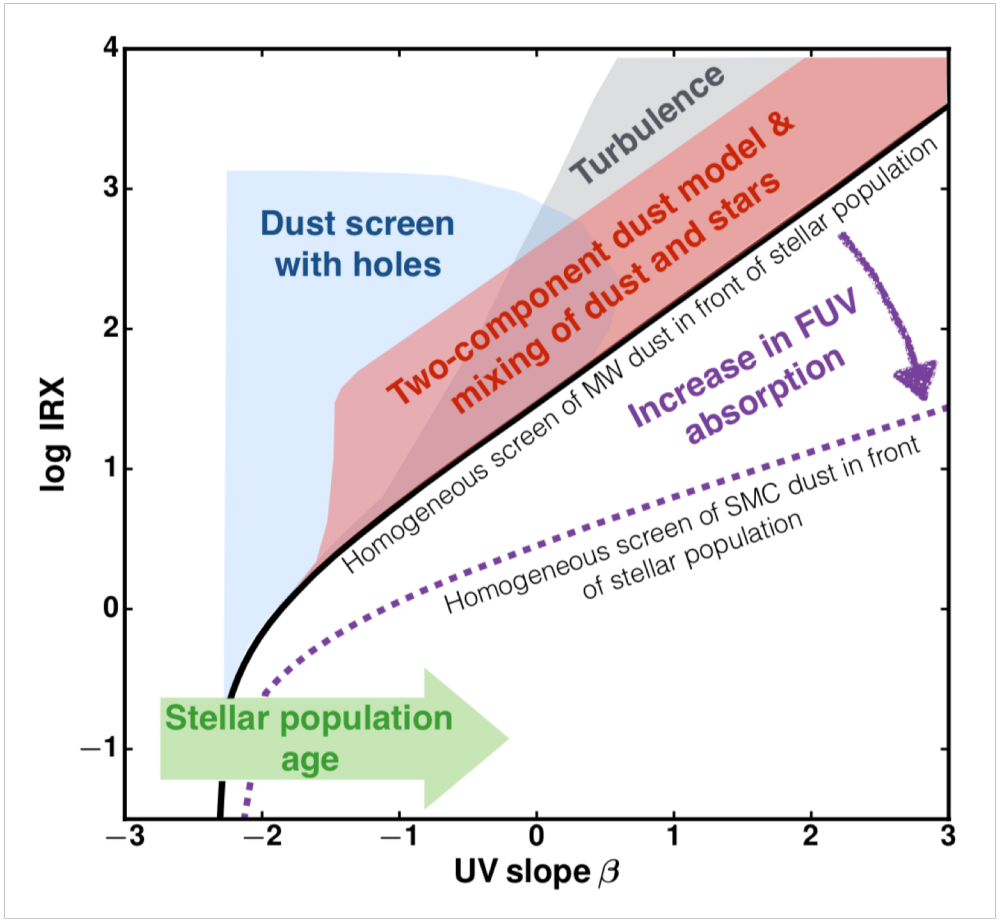
Low IRX (low A_{UV})



Blue UV Spectrum  Red UV Spectrum

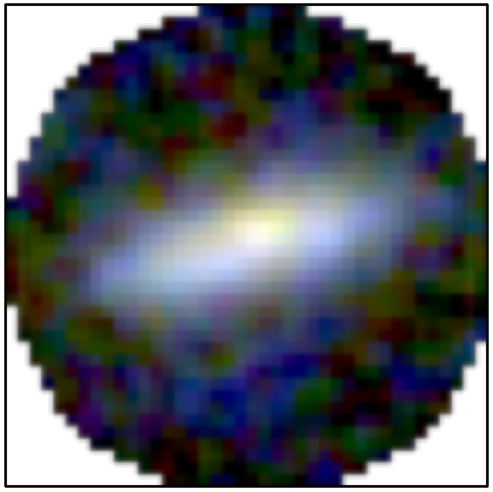
Local Starburst Galaxies, (Meurer, Heckman, and Calzetti 1999)

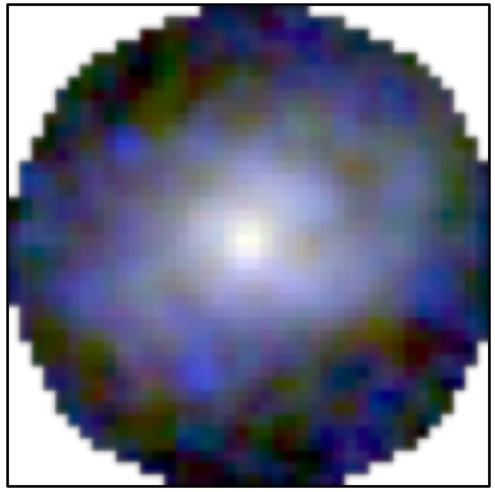
Using IRX and β to understand dust distribution



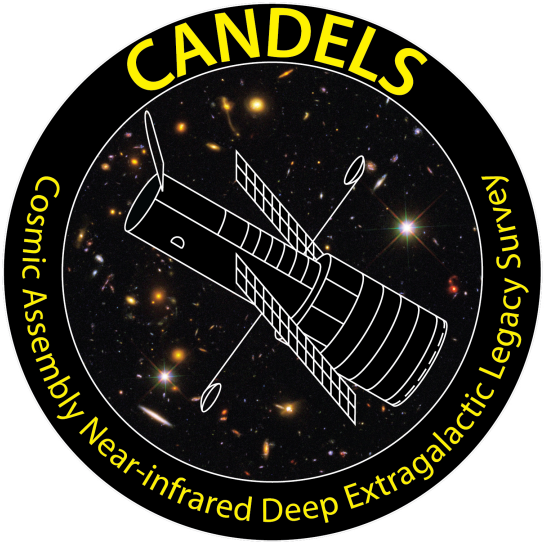
Theoretical modelling by Popping, Puglisi, & Norman 2017

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

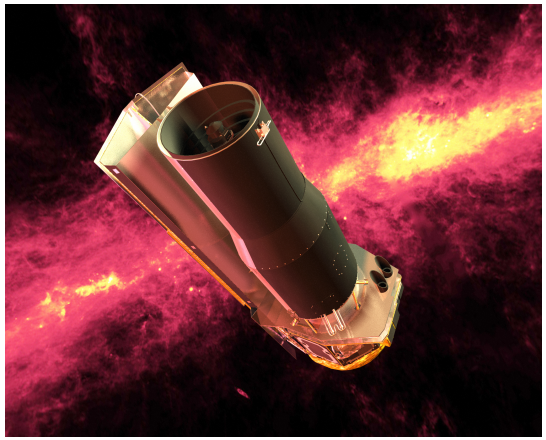




Data from the CANDELS survey (GOODS-S and GOODS-N)



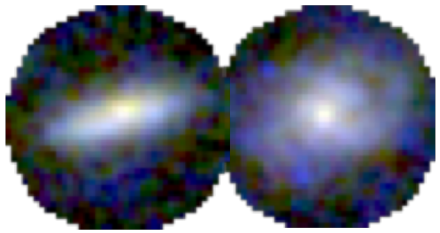
1. Star-forming galaxies ($10^{10} - 10^{11}$ $\mathbf{M_{sun}}$) at z=1.3-1.7
2. L(IR) is converted from Spitzer 24 μm flux
3. Measure β from ground-based U-band and HST ACS bands.



Observation Results:
average trend is consistent with local starbursts

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

$1.35 < z < 1.75$



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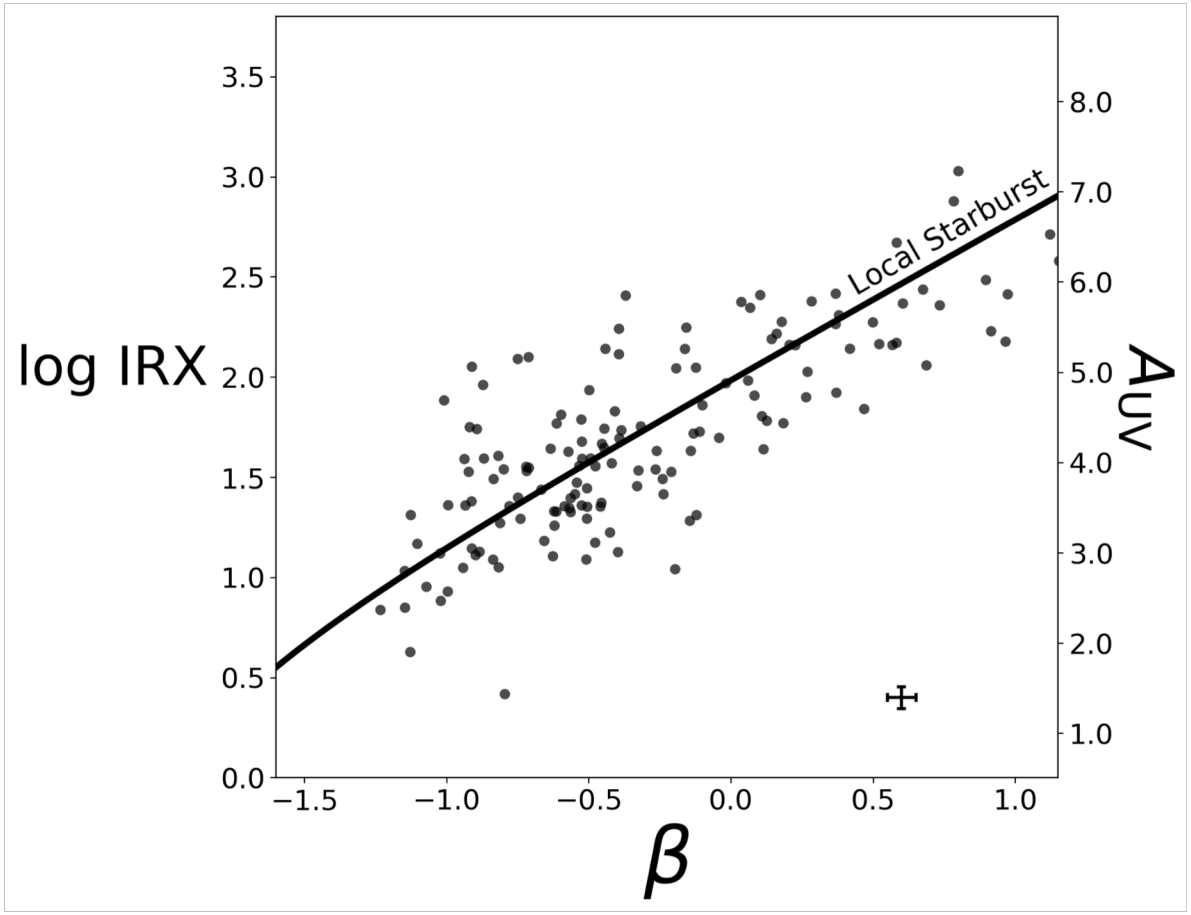


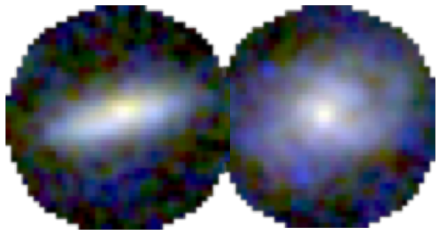
Observation Results:
edge-on galaxies stay above face-on galaxies.

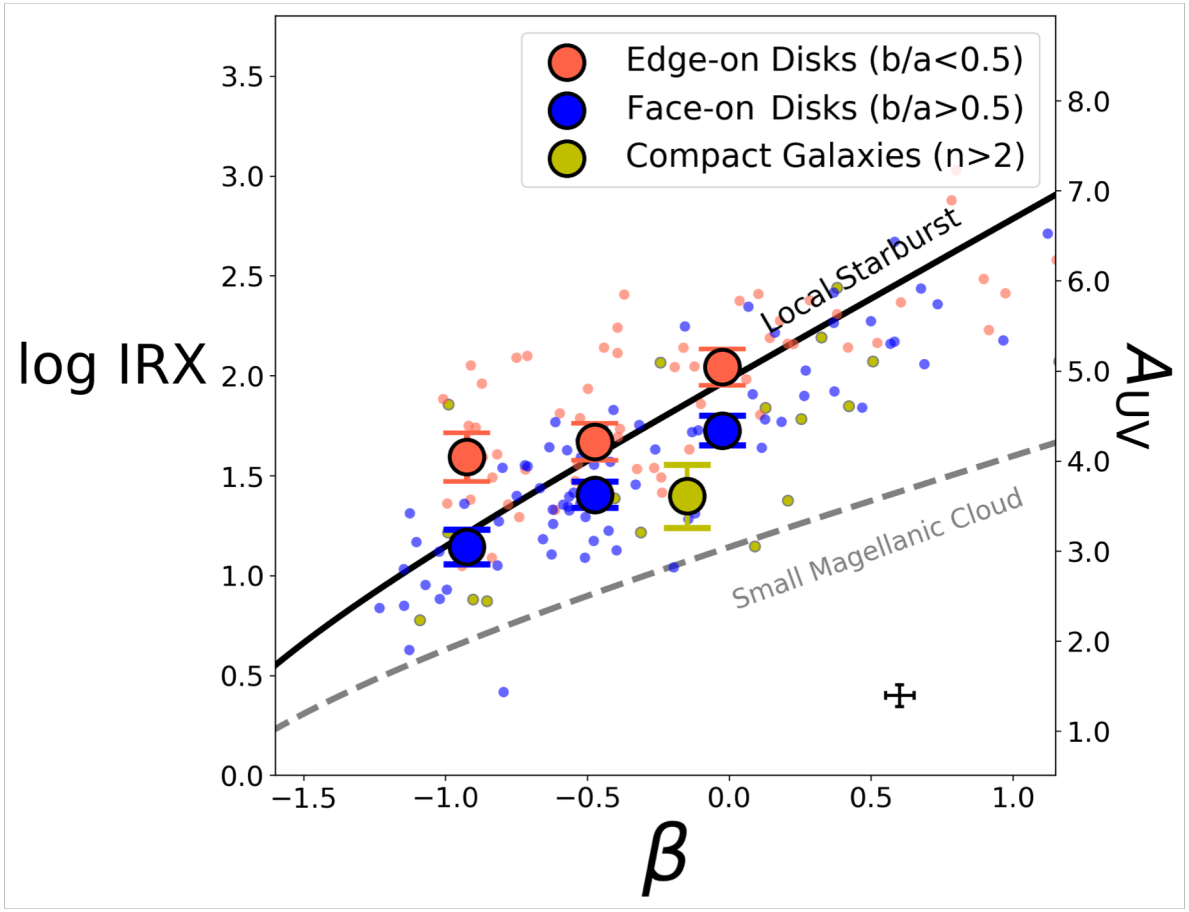
Red: Edge-on galaxies

Blue: Face-on galaxies

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

$1.35 < z < 1.75$





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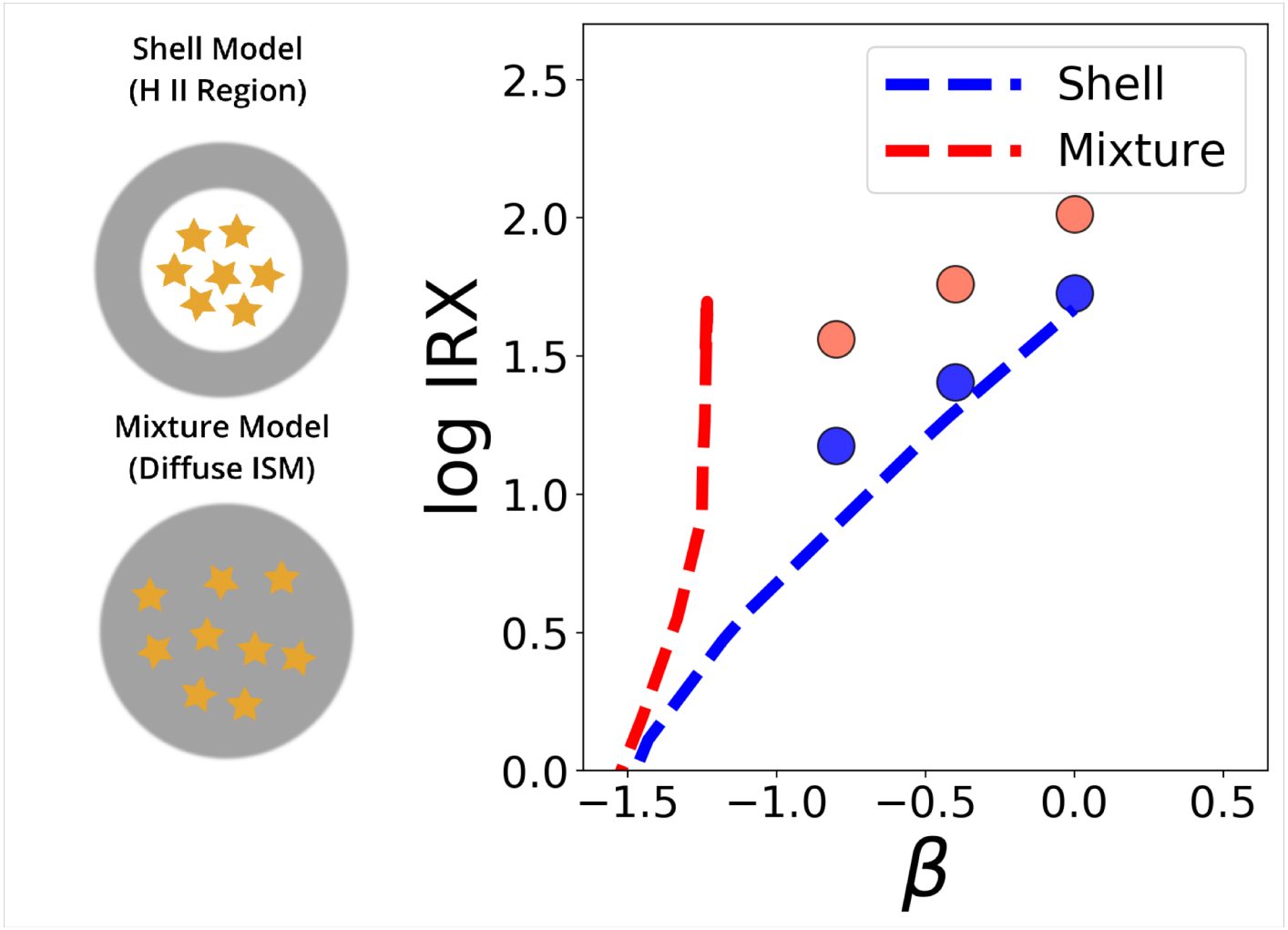
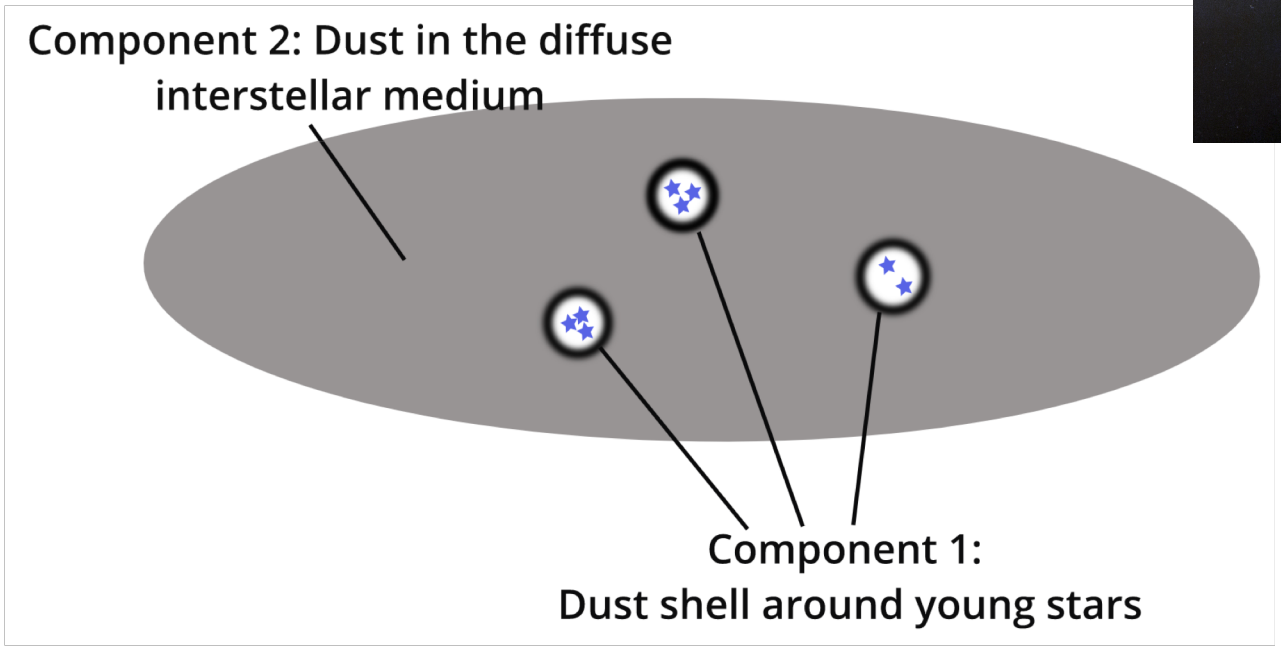
Using simple dust distribution models to understand the observed IRX-β relation



A two-component dust model



Component 1:

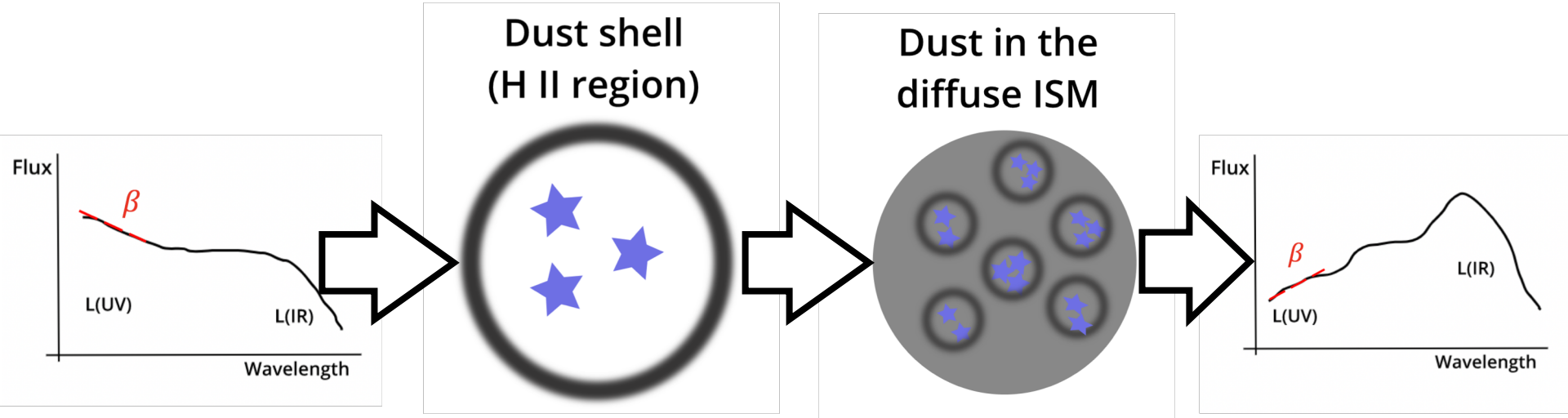
Dust shells around young O stars: **Same attenuation for stars at all locations**

Component 2:

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

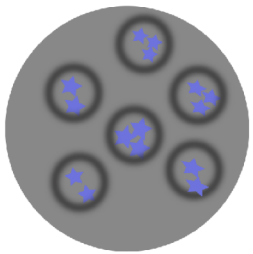
(Charlot & Fall 2000; Calzetti 2001; Chevallard et al. 2013)

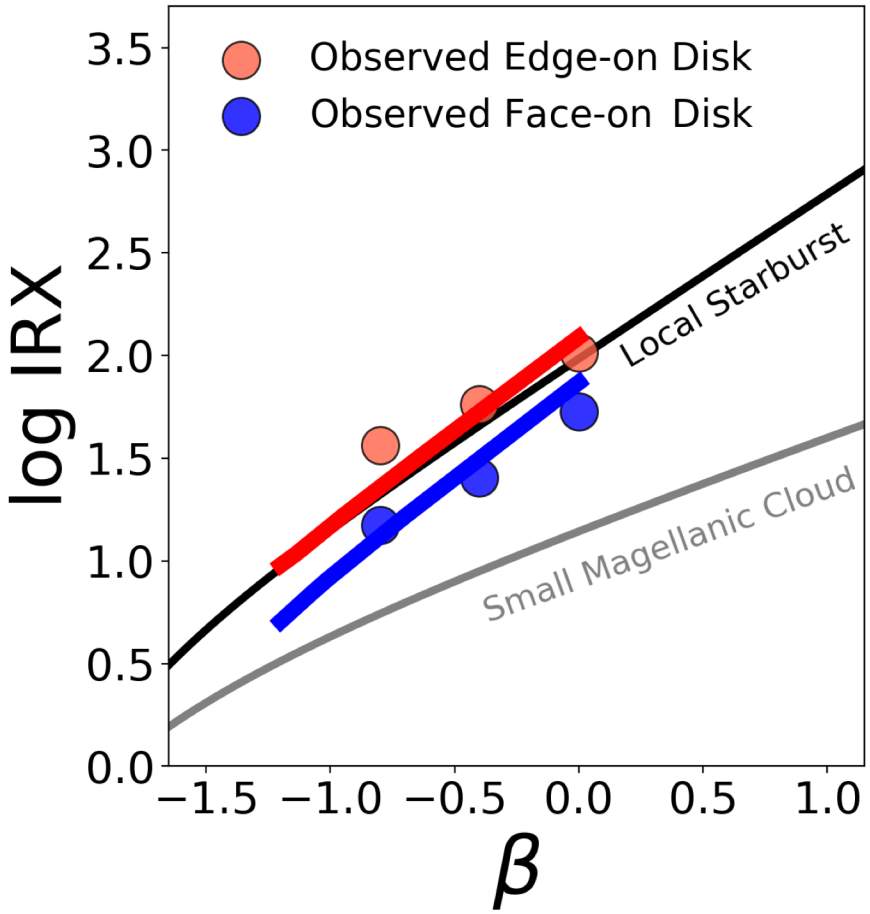
Using IRX-β relation to understand dust distribution: radiative transfer modelling



Radiative transfer results from Seon & Draine (2016).

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





Shell+Diffuse ISM, $\tau_{V,\,\text{diffuse ISM}} = 1.2$

Shell+Diffuse ISM, $\tau_{V,\,\text{diffuse ISM}} = 0.6$

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

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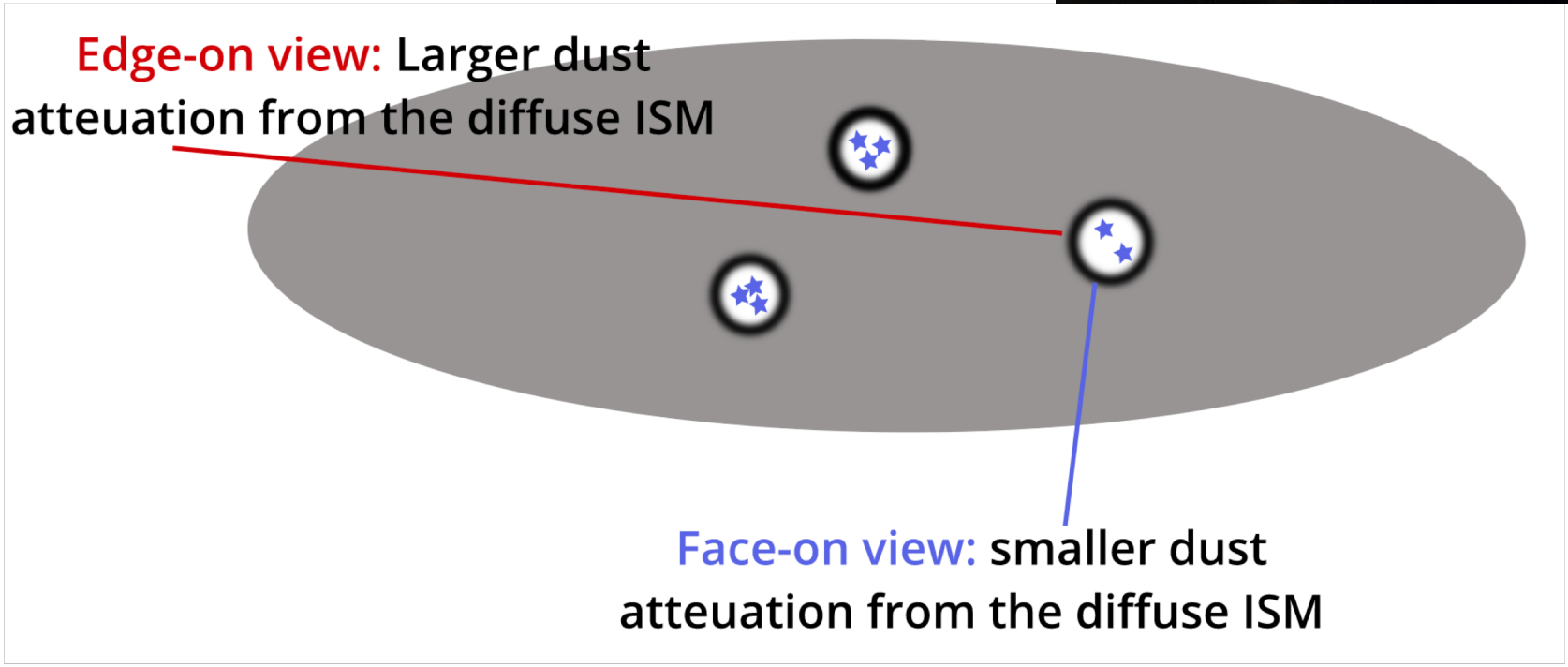
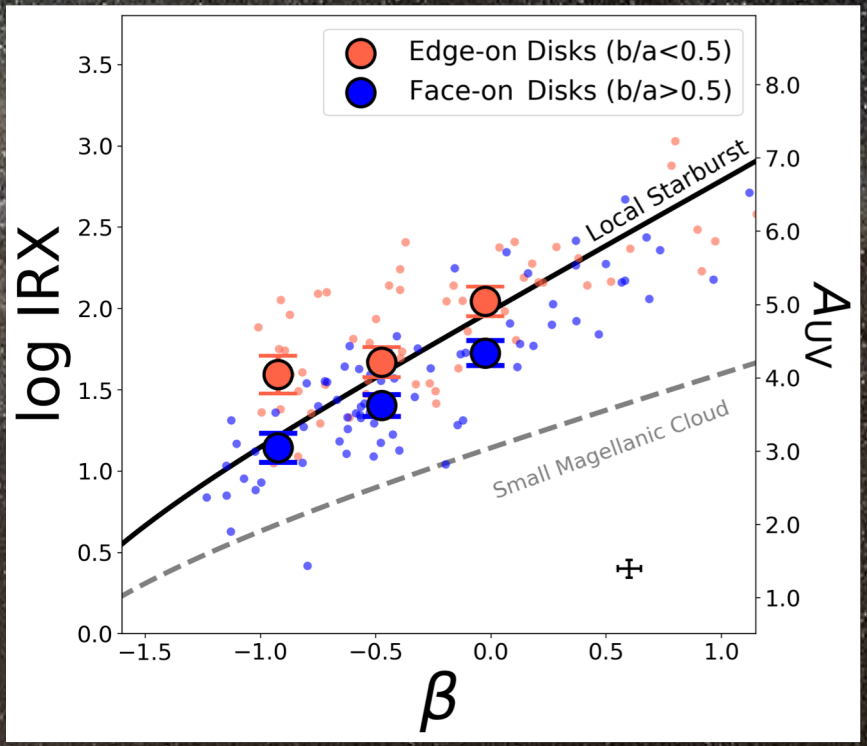
The IRX-β relation can be explained by the two-component dust model



Dust attenuation from shells does not change with viewing angle.

Conclusions

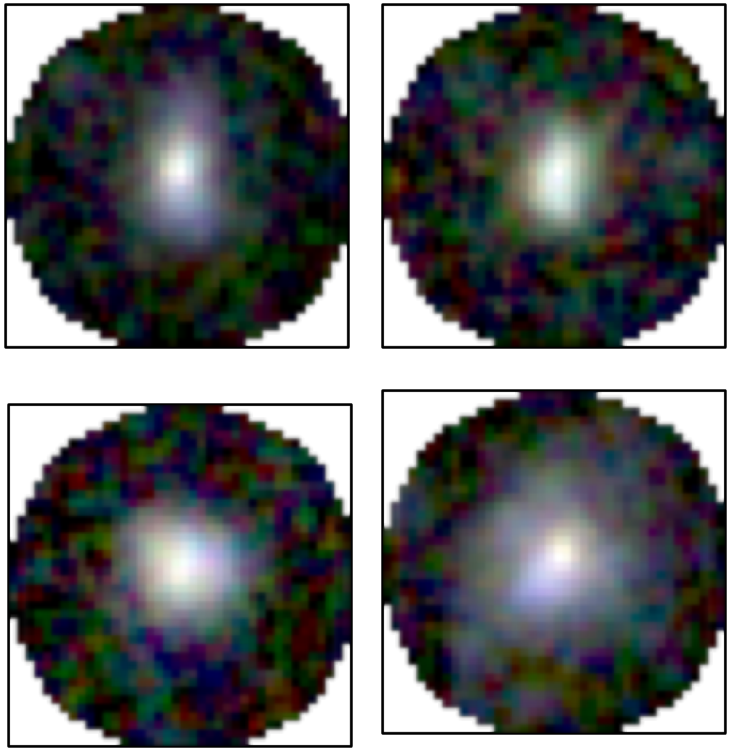
1. The IRX-β relation for massive star-forming galaxies varies with inclination at z~1.5.
2. Dust distribution inside massive galaxies can be explained by a two-component model.



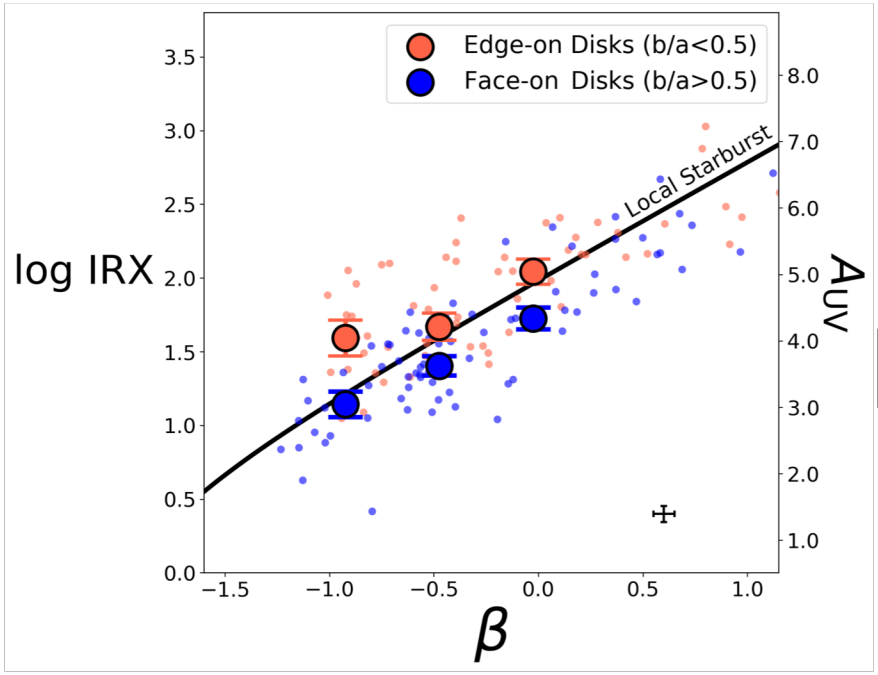
Credit: ESO

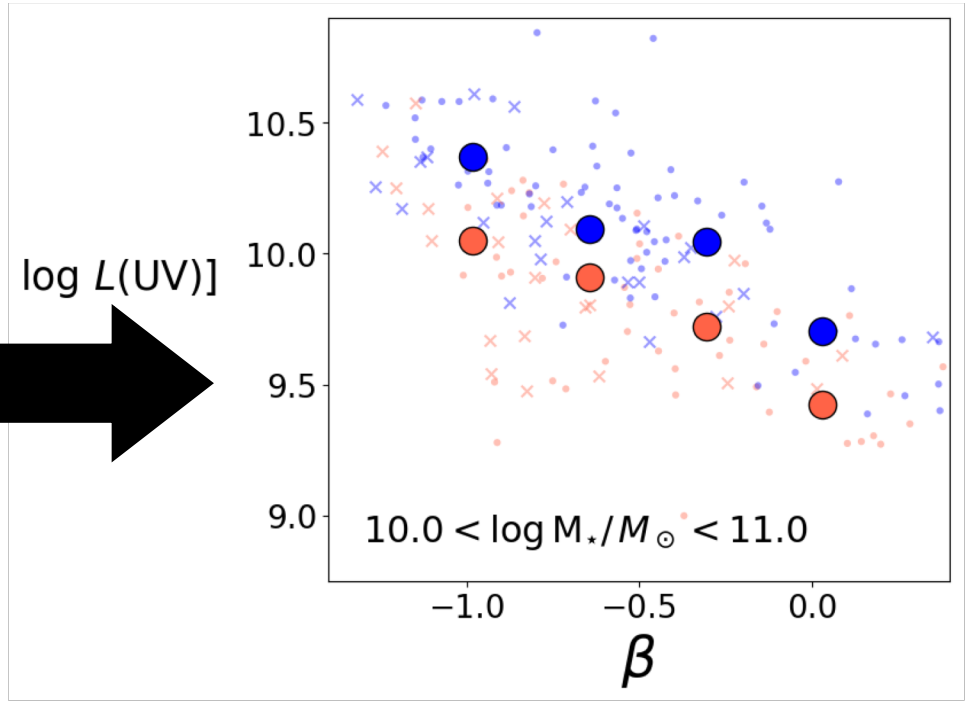
3. Low-mass star-forming galaxies ($<10^{10}$ M_{sun})

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

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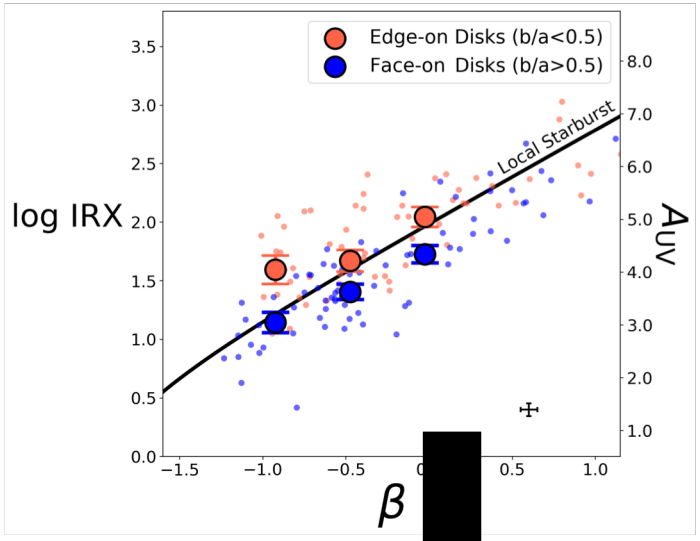
Low-mass star-forming galaxies (<10^{10} M_{sun})



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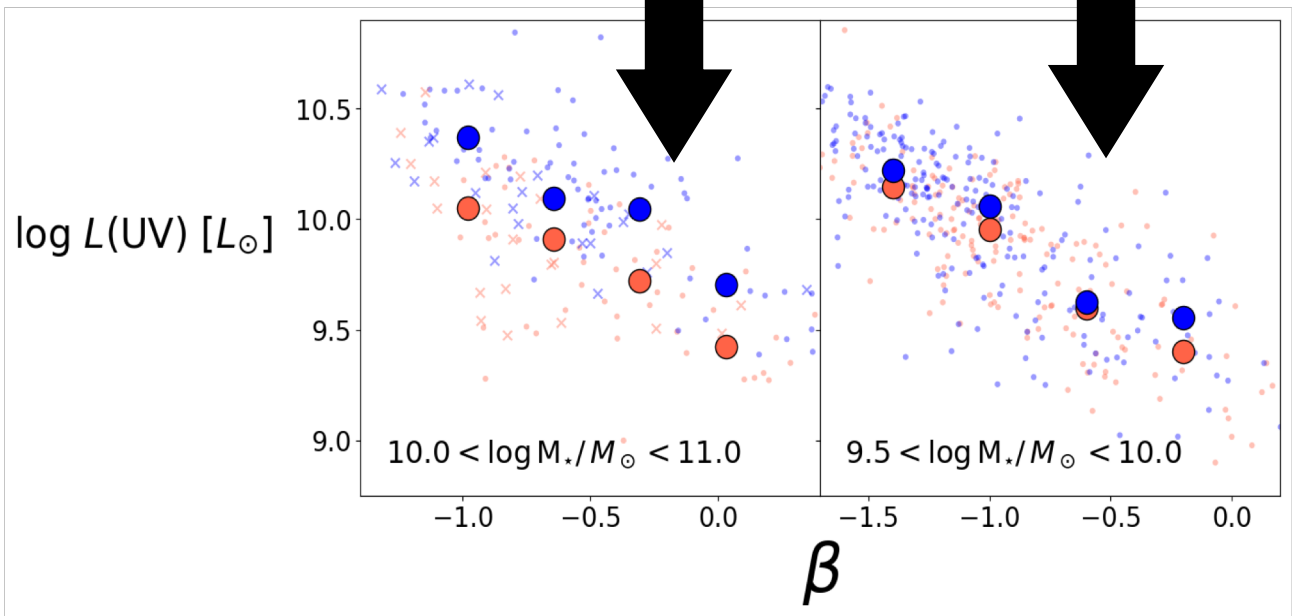
IRX-β relation



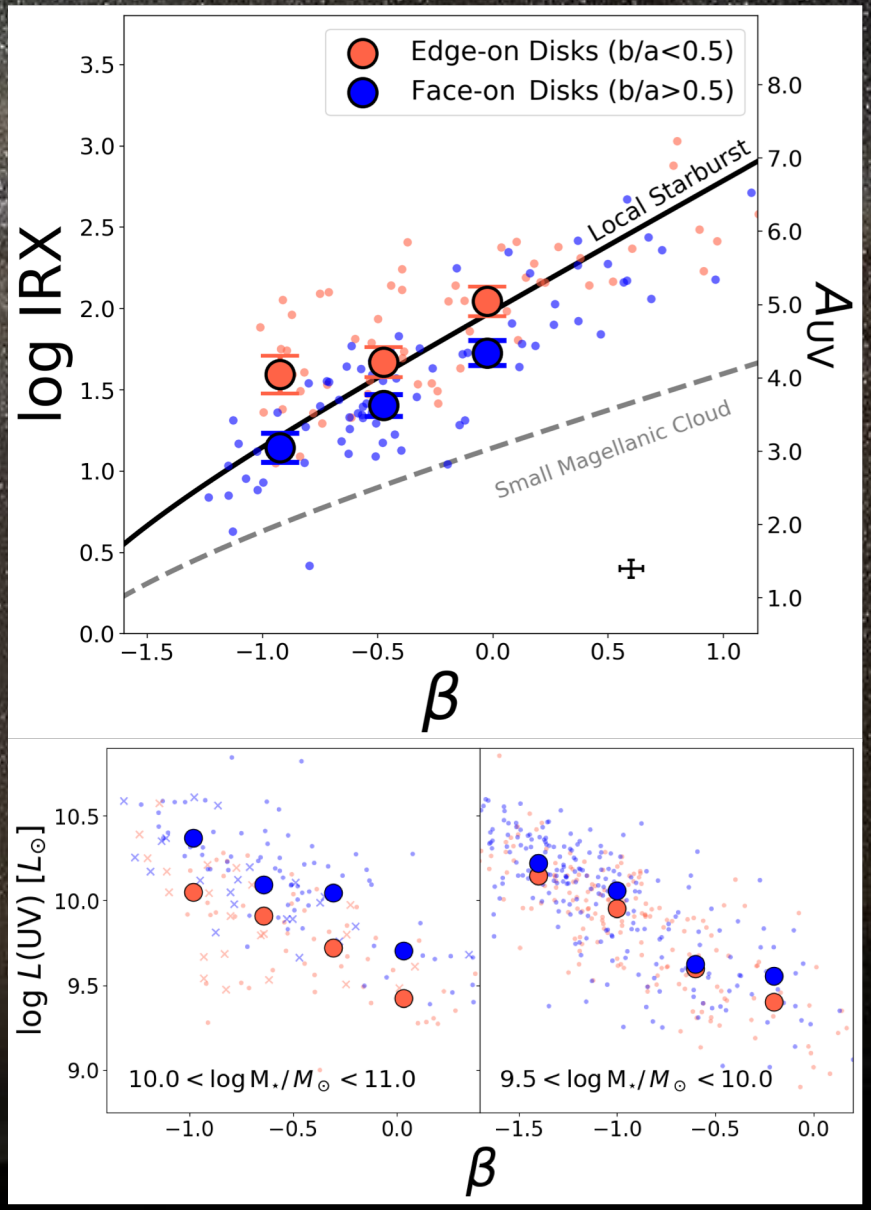
L_{UV}-β relation

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∼1.5 may even have prolate shapes (van der Wel et al. 2014).

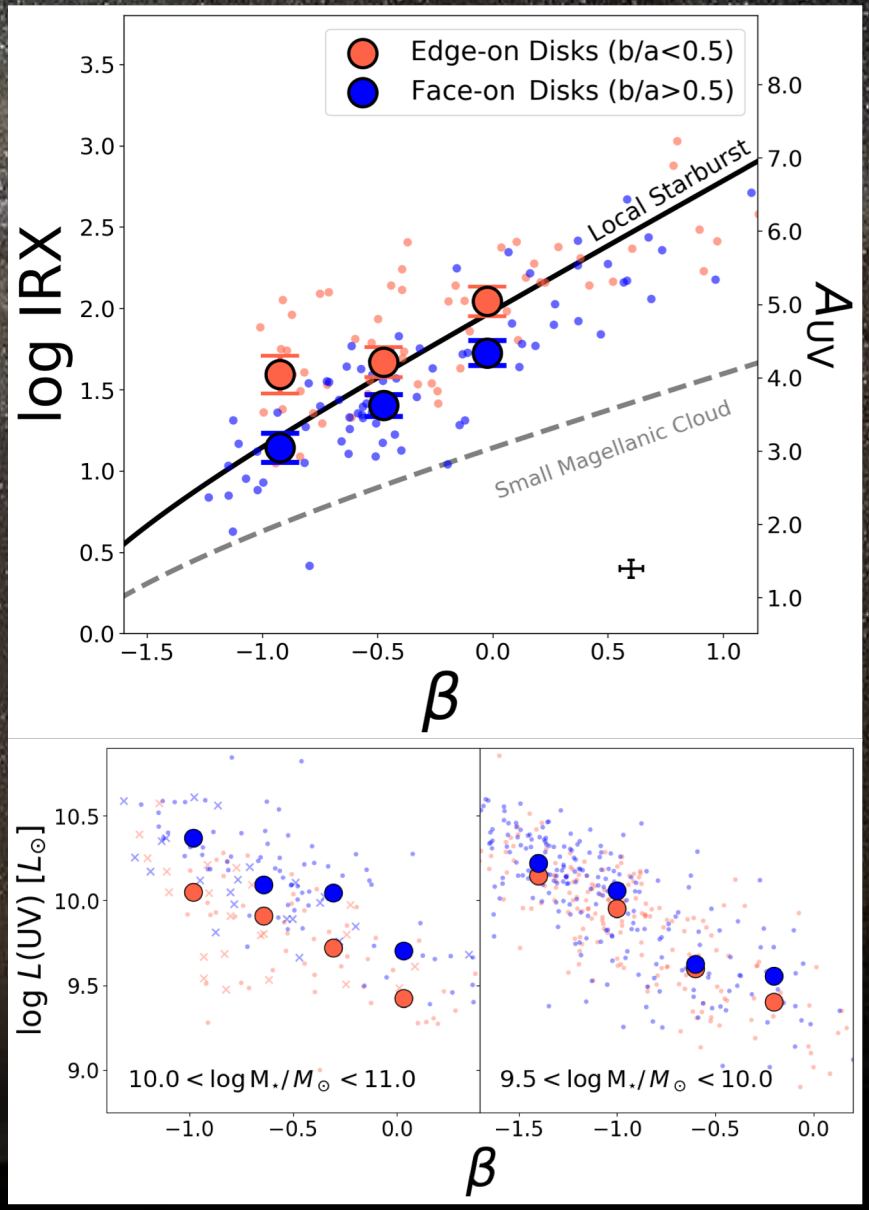
Conclusions



Credit: ESO

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