Evolution of dusty quiescent galaxies over the last six billion years

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In pursuit of giants

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II. Evolution of dusty quiescent galaxies over the last six billion years from the hCOSMOS survey

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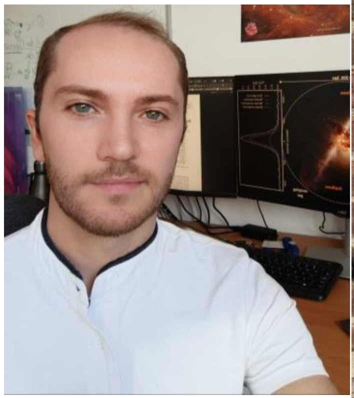

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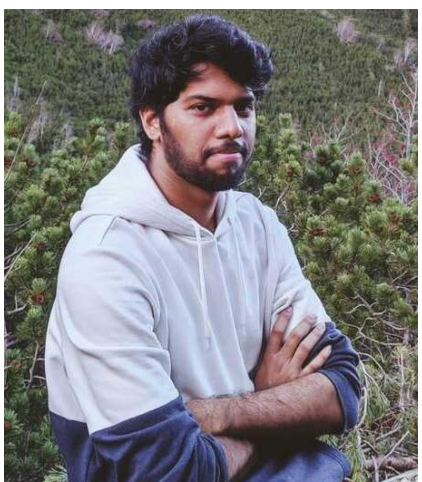

P. Sawant

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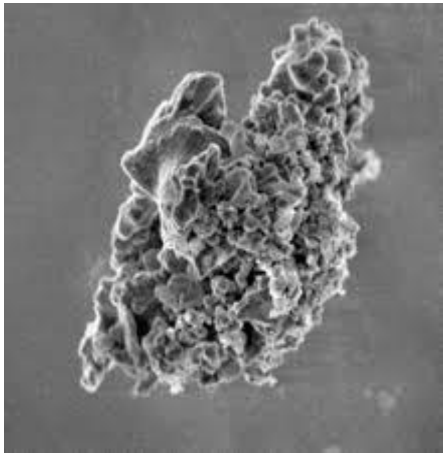
K. Lisiecki

What is dust and why we study it?



few hundredths of a µm up to few µm

Silicates (Mg_2SiO_4,$MgSiO_3$)

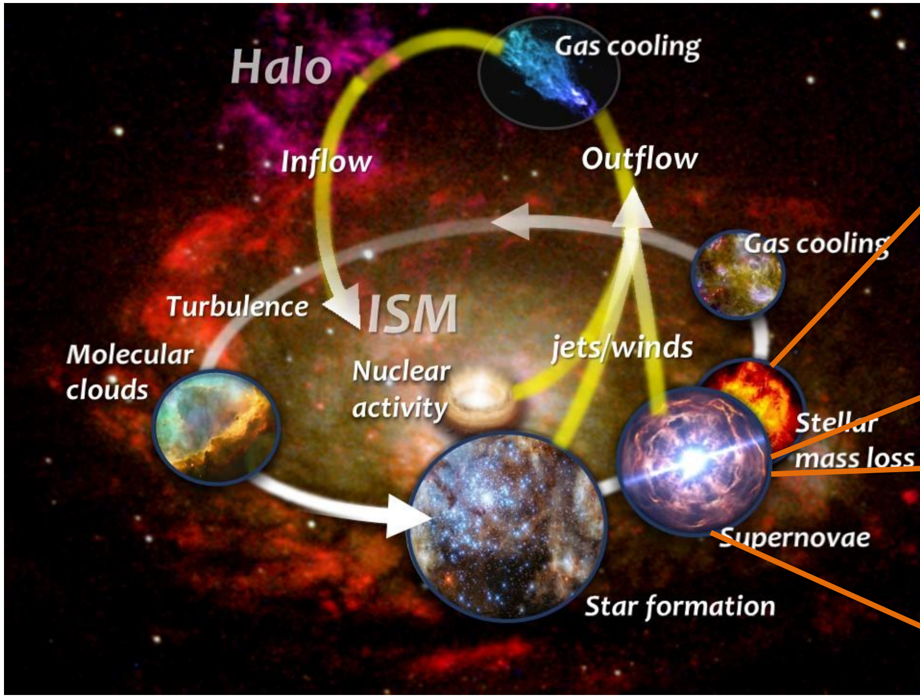
Carbon

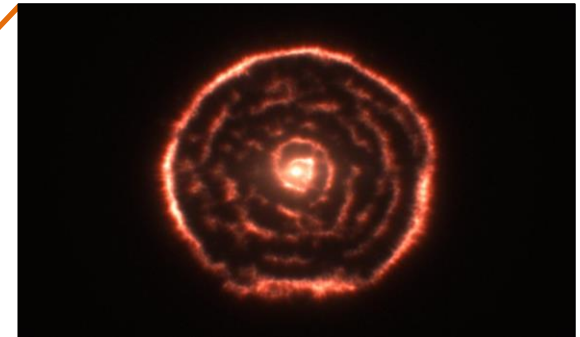
Dust is formed from metals, it is ≈1% of the total mass of the baryons!

…but it is important in several astrophysical contexts:

- star formation (gas cooling)
- molecule formation ("mechanical" catalyst)
- planets formation
- for studying the Solar System (pre-solar grains)
- stellar evolution (mass-loss in low-mass stars)
- dust evolution in galaxies

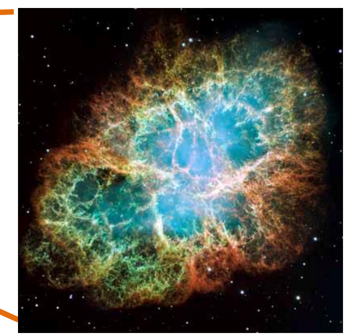
Dust evolution in the interstellar medium (ISM) of galaxies





Maercker et al.

Dust around evolved stars & SN remnants



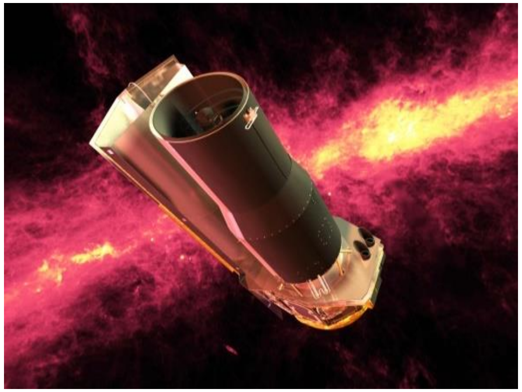
Different evolutionary time-scale according to the initial mass:

- >8-10 $M_{\odot}$ → evolve in less than 30 Myrs; explode as Type II supernovae (SNe II)
- ~<6-8 $M_{\odot}$ → evolve in more than 100 Myrs; lose their envelope (mass-loss) during the thermally pulsing asymptotic giant branch (TP-AGB) phase

Gas, metal and dust in galaxies change because of different physical processes:

- Grain evolution in the ISM of galaxies.
- Galactic inflows and outflows.

How do we see dust?

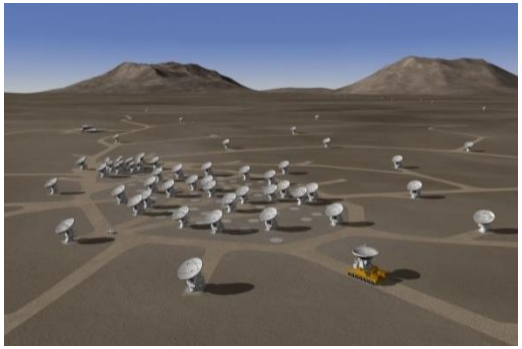


Spitzer

Mid-IR 3.6-38 μm

Herschel

Far-IR 55-672 μm



ALMA

Sub-mm/mm
0.3-3.6 mm

NOEMA

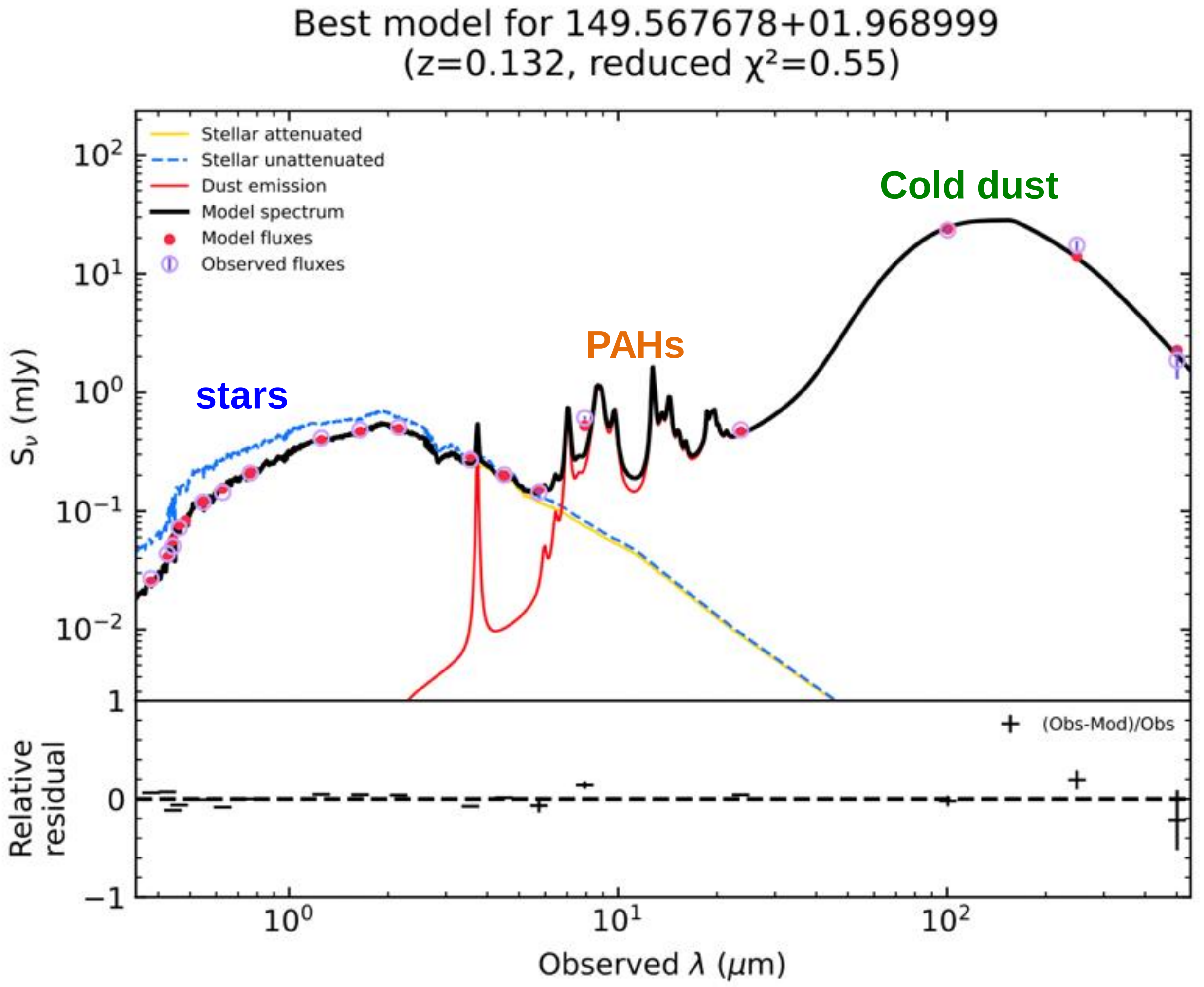
Sub-mm/mm
0.8-4.2 mm

James Webb Space Telescope (JWST), launched: December 2021

Near- to Mid-IR: 0.6-28 μm

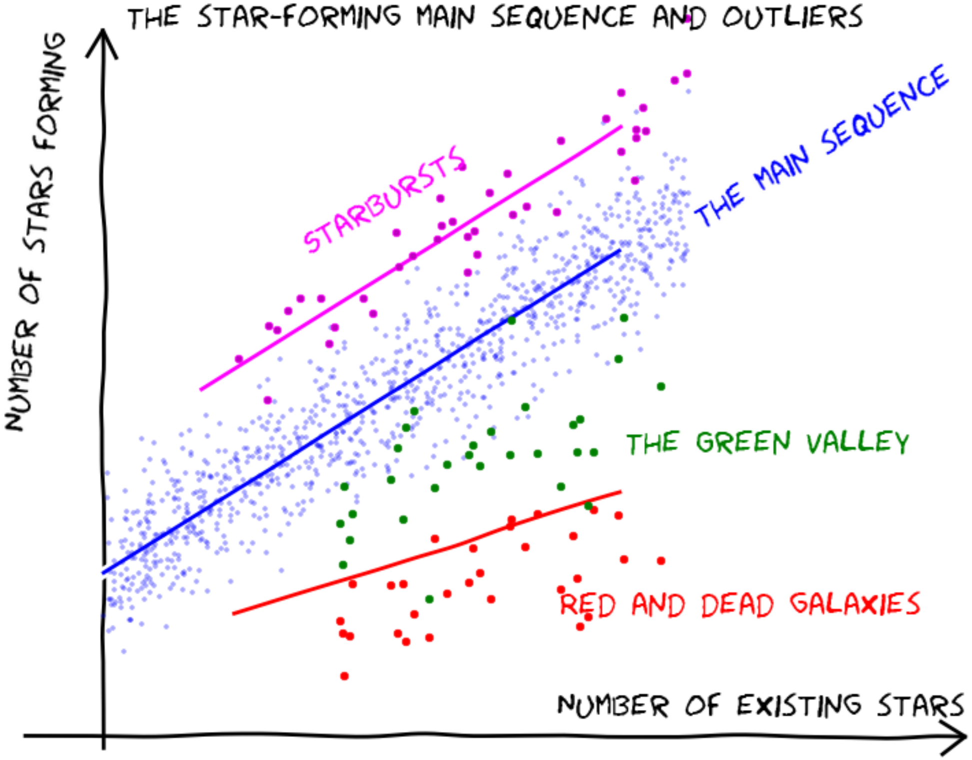
- Dust up to 2 Gyrs after the Big Bang
- Stars in galaxies 500 Myrs after the Big Bang

The pancromatic view of galaxies



Estimating the physical parameters through the SED fitting technique

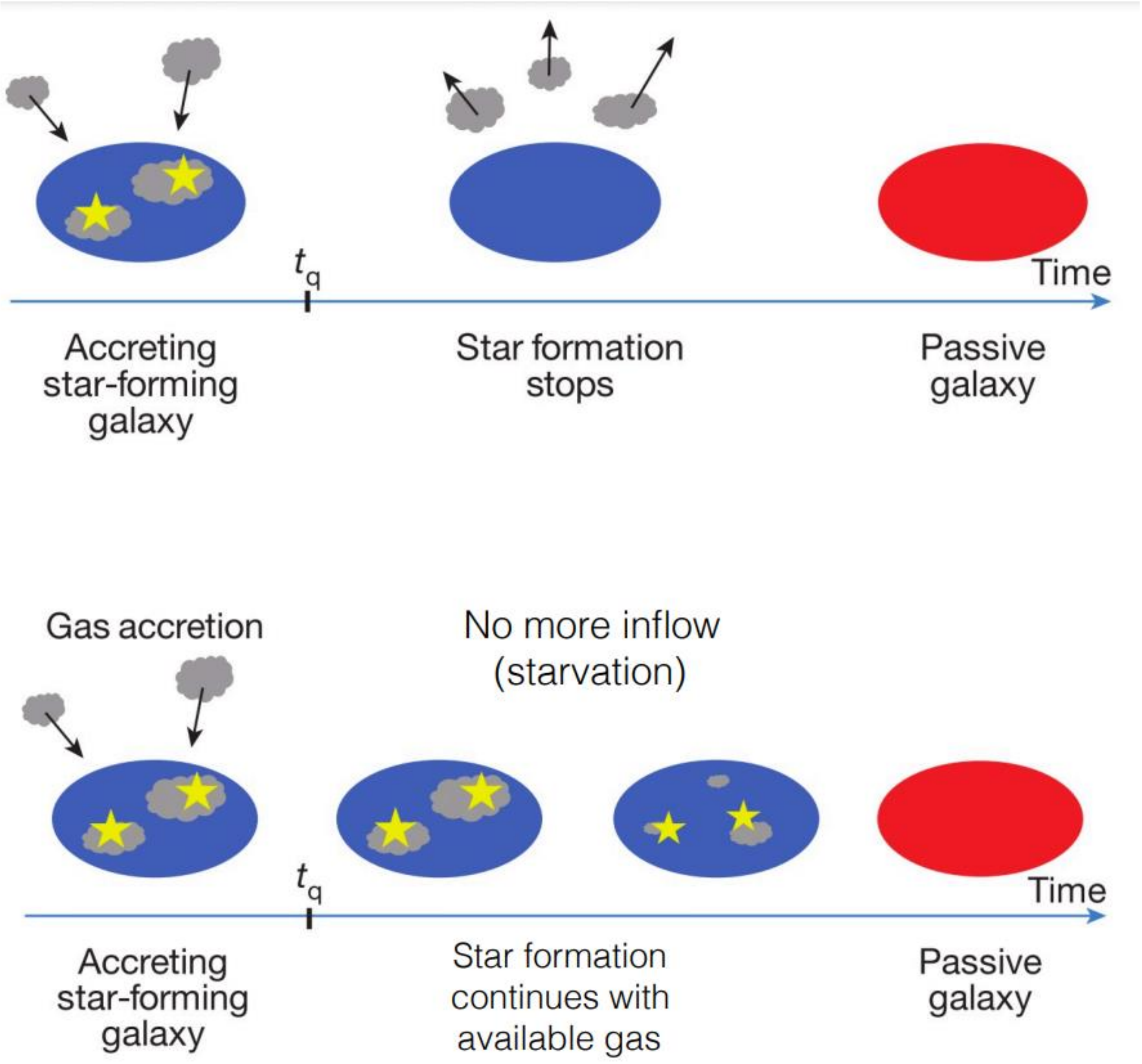
Quiescent galaxies



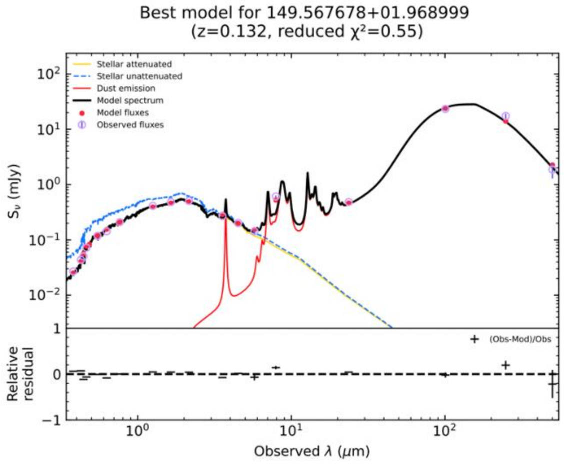
Our sample

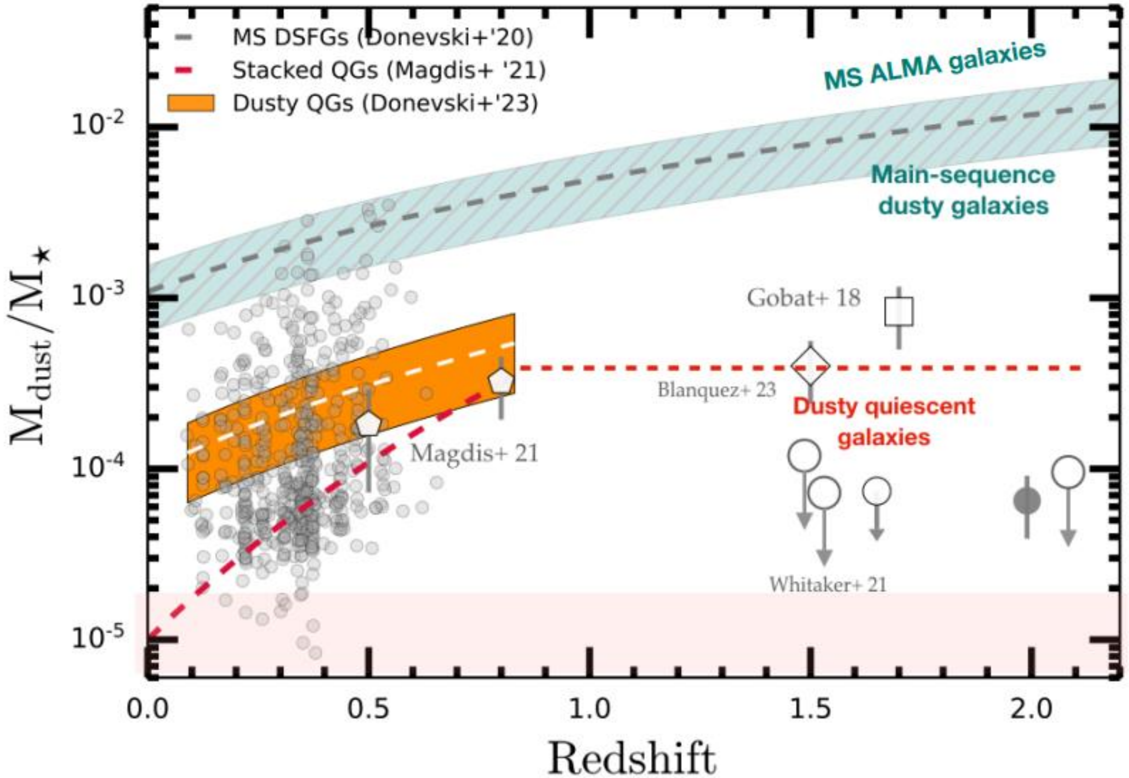
- **hCOSMOS survey (2000 quiescent galaxies)**
- **Redshift 0.1 < z < 0.6**
- **Multiwavelength SEDs (CIGALE)**
- **Prior information: Measured gas metallicity**

Galaxy quenching



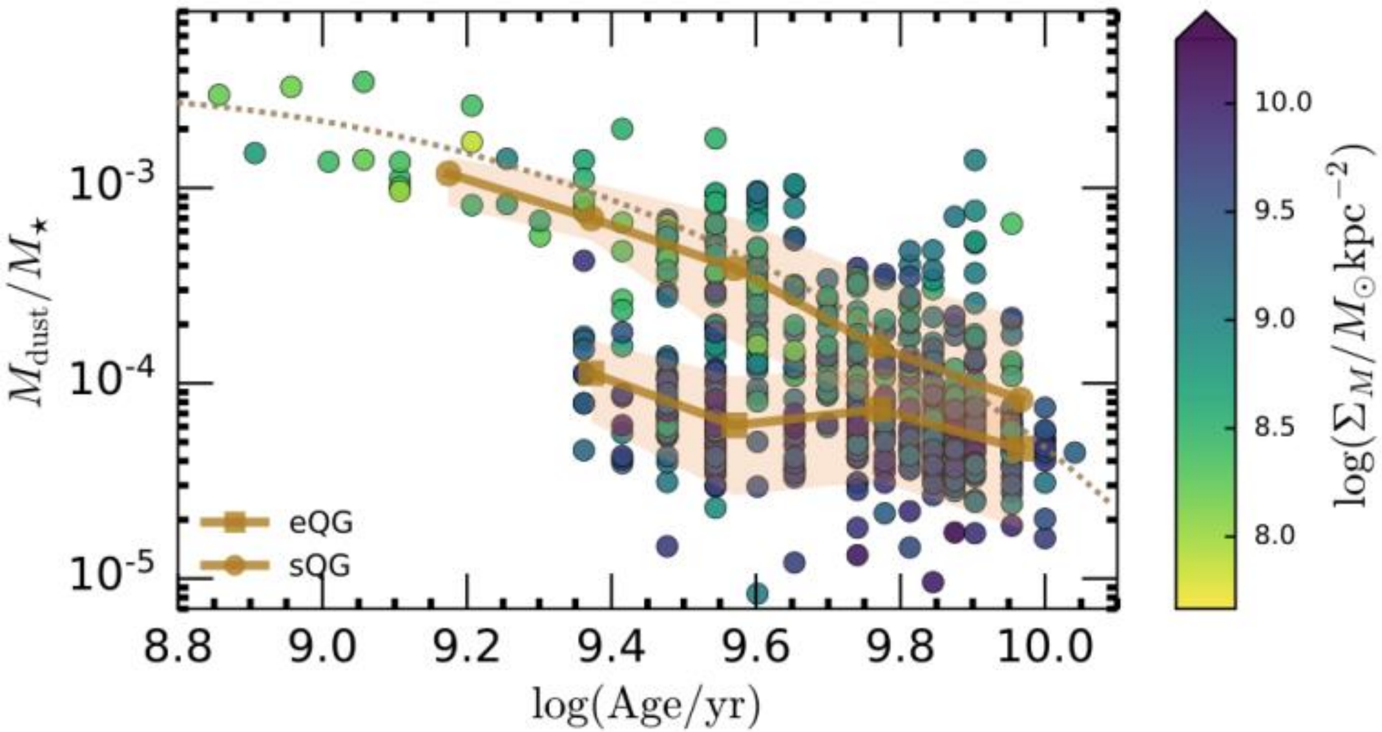
Dusty quiescent galaxies





≈25% of all quiescent galaxies (550 objects) in COSMOS (2 sq. deg) are dust-rich at z~0.5.

Dust evolution in quiescent galaxies

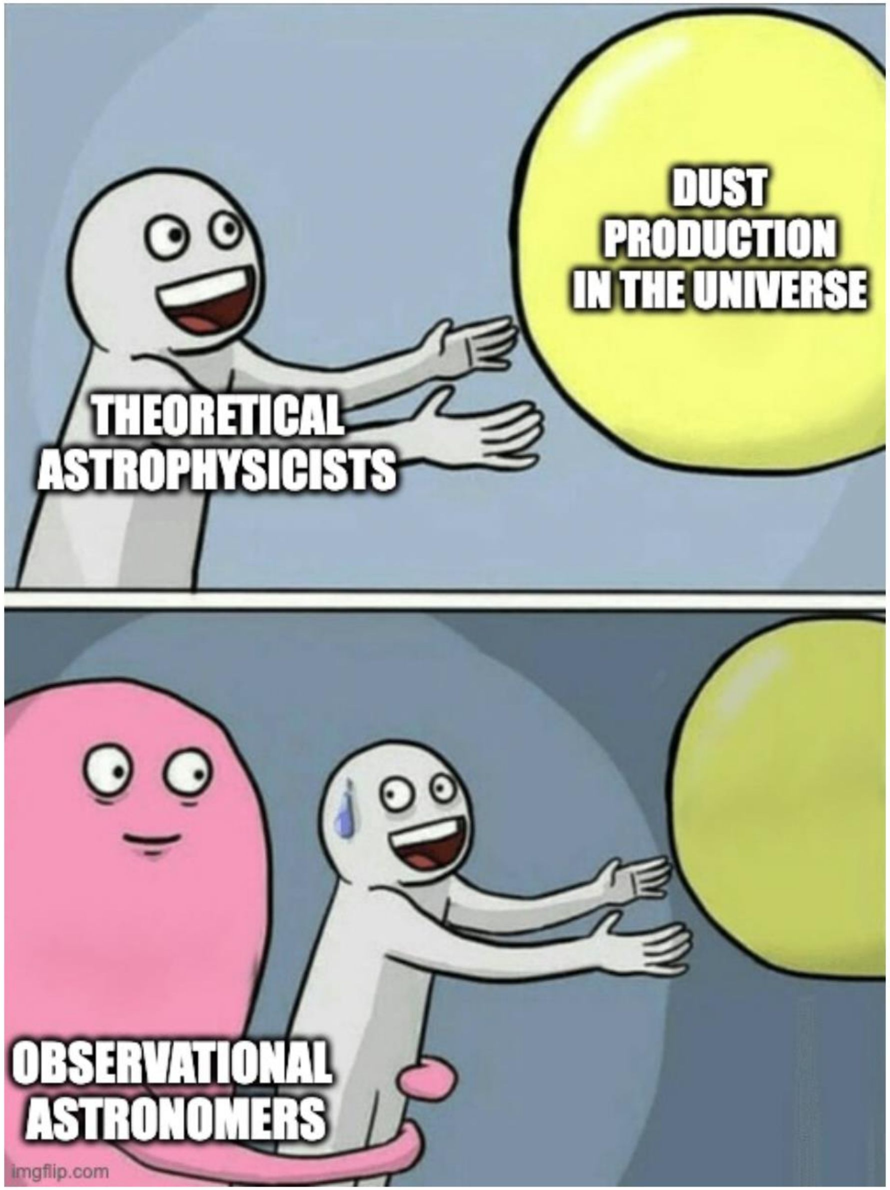


- **Impact of structural parameters**: M_{dust}/M_* higher in extended sources than in compact ones
  ➔feedback stronger in compact sources?

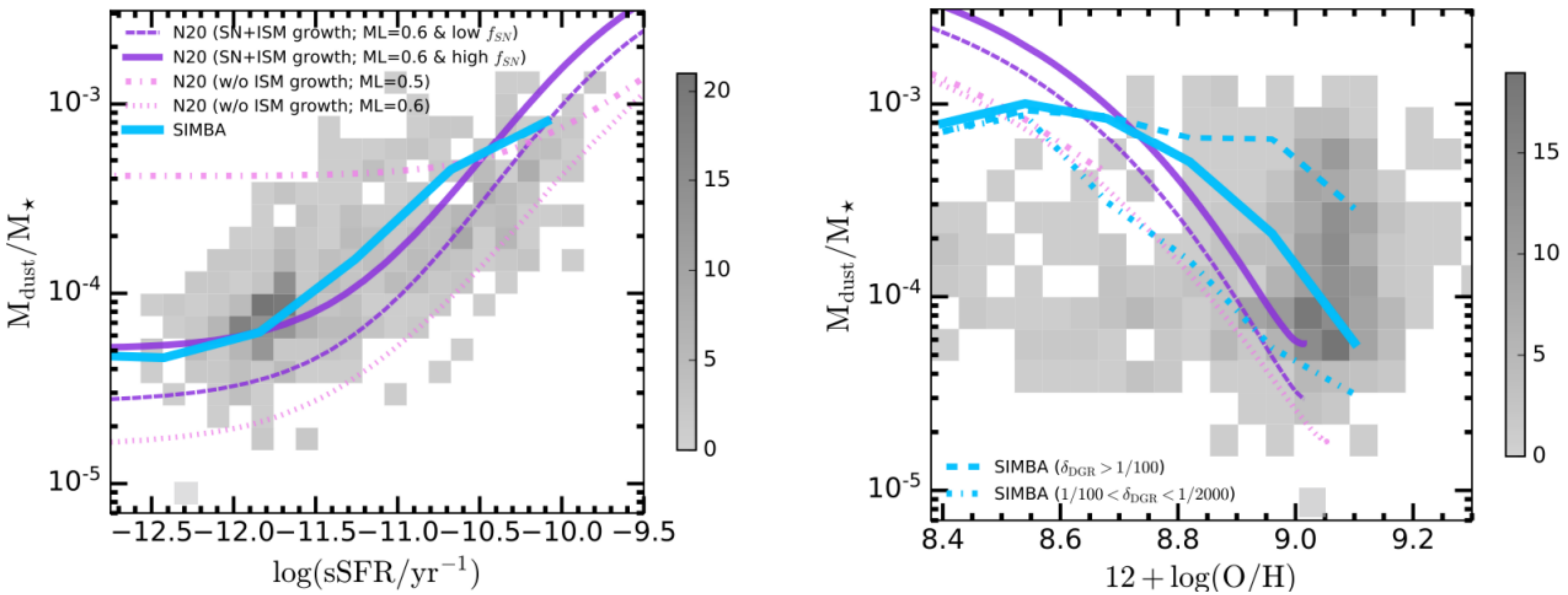
- **Large scatter in M_{dust}/M_*** :
  ➔ Non-uniform ISM conditions
  ➔ Different timescales for prolonged dust growth/removal

What drives dust evolution in quiescent galaxies?

What drives dust evolution in quiescent galaxies?



Modelling dust evolution in quiescent galaxies



Constraining dust cycle with models

- **Large condensation fraction of dust in SN (≈25-50%)**
- **Dust growth in the ISM**
- **Efficient feedback (outflow)**

Related and follow-up works on dust in galaxies

- Environmental dependence of galaxy quenching and study of their ISM evolution from cosmological simulations (**Lorenzon et al., to be submitted**)
- Influence of large-scale environment on the dust content of galaxies with cosmological simulations (**Donevski et al., submitted to Apj Letters**)
- Galactic winds in dwarf galaxies (**Romano et al. 2023, Romano et al., to be submitted**)
- Dust build-up at the epoch of reionization by studying ALPINE galaxies (**Sawant et al., to be submitted**)
- Explaining carbon dust at redshift of 6 (**Nanni et al., to be submitted**)
- Dust destruction processes: photo-evaporation induced by young stars and planetary nebulae (**Nanni et al., submitted to A&A letters**)

Conclusions

- **Dusty quiescent galaxies are not extremely rare (≈25%) at z~0.5.**
- **Dust in quiescent galaxies are related to the compactness of the galaxy and on its morphological type.**
- **The large scatter in M_{dust}/M_* indicates a variety of conditions in the ISM of galaxies.**
- **Dust evolution in the ISM can be explained by:**
  - Large dust production from Type II SNe;
  - Dust growth in the ISM;
  - Large scale galactic winds