Galaxy Evolution and Feedback across Different Environments
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The relation between dust amount and galaxy mass across the cosmic time

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Abstract. Dust Obscured Galaxies (DOGs) are observed as far as the reionization epoch. Their cosmic density peaks together with the star formation rate. DOGs also rule the star formation in high stellar mass galaxies. In this work we used a chemodynamical model to evolve the amount of dust in galaxies. We ran forty models varying initial mass and both dust formation efficiency and dust production. We find that for high star formation rate systems the accretion dominates the dust evolution and it explains high-z DOGs. Low star formation rate systems are better suited to investigate dust production. Also, we find that a $M_{\rm Dust}/M_{\rm Gas}$ versus $M_{\rm Dust}/M_*$ diagram is a good tracer of galaxy evolution.

Keywords. galaxies: evolution, galaxies: ISM, galaxies: high-redshift, (ISM:) dust, extinction

1. Introduction

Dust obscured galaxies (DOGs) are objects with almost all their light obscured by dust. They are the most luminous galaxies and the most intense stellar nurseries in the Universe. The observation of dusty evolved galaxies at $z \gtrsim 6$, in the reionization era, constrains the maximum time taken by dust production Knudsen *et al.* 2017.

High mass galaxies (even normal star forming ones) have most of their star formation (SF) obscured by dust, reaching ~90% in galaxies with $\log(M/{\rm M}_\odot) = 10.5$, while low mass ones tend to have most of the SF unobscured (Whitaker *et al.* 2017). This pattern seems to be present in galaxies with $z \lesssim 2.5$–3.0 (Whitaker *et al.* 2017; Magdis *et al.* 2017). In this work, we investigate the dependence of dust and star formation rates (SFR) on the build-up of dust in galaxies. We also investigated the dominant processes to produce dust during the reionization epoch.

2. Simulation

We used the Friaça & Terlevich (1998) chemodynamical model to investigate dust amount evolution. We assumed a Salpeter initial mass function and a specific SF law, $\nu_{\rm SF} \propto \rho^{1/2}$, as in Friaça & Barbuy (2017). We simulated five initial galaxy masses, $M_{G,0}$, in the range 5×10^7 and 2×10^{12} ${\rm M}_\odot$ (see Fig. 1). The galaxy is initially composed by pristine gas and dark matter with the ratio of $M_{DM}/M_{G,0} = 5.6$. The SF is characterized by a star formation efficiency, ν_0, varying between 0.1 and 10.0 ${\rm Gyr}^{-1}$ (see Fig. 1).

The dust production formulation "Case A" is the same as in Dwek (1998), while "Case B" has lower grain condensation efficiency, $\delta^X(A)$, set as 0.1 for stellar winds and type II supernova (SN), and 0.0 for SN Ia. The accretion in the cold interstellar medium

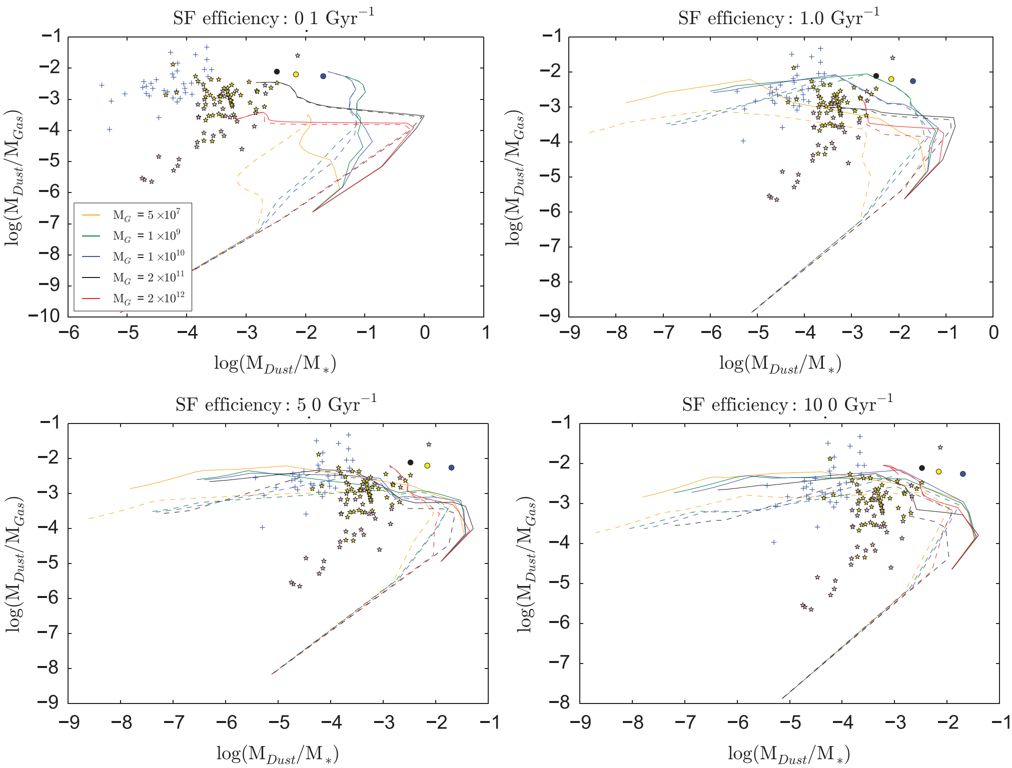

Figure 1. Dust-to-gas vs. dust-to-star mass ratio predicted by the models. Each panel corresponds to a star formation efficiency of the model and the model tracks are color-coded according to the initial galaxy mass. Solid and dashed lines stand for Case A and Case B dust production formulation, respectively. Rémy-Ruyer *et al.* (2014, 2015) are tagged as yellow and pink stars, Lianou *et al.* (2016) [elliptical galaxies] as blue cross, Magdis *et al.* 2017 D49 as yellow, and M28 as black, and Knudsen *et al.* (2017), A1689-zD1 as a blue big dot.

follows Gioannini *et al.* (2017). We considered grains formed by C and Si. We combine all $M_{G,0}$ values, with all ν_0 and with both $\delta^X(A)$ formulations, resulting in forty different models.

3. Results and Conclusion

High SFR models build the bulk of their dust mass in ∼0.6 Gyr, nearly the age of the Universe at the reionization. Their dust mass is almost insensitive to $\delta^X(A)$ during star formation peak, due to grain accretion. Low SFR models take a few Gyr to build the bulk of their dust mass. The $M_{G,0} = 1 \times 10^{10}$ $M_\odot$ and $\nu_0 = 10.0$ Gyr^{-1} models need ∼0.4 Gyr to reach the equivalent of A1689-zD1 (at $z \sim 7.5$) dust-to-gas ratio. Our result also points to a constant obscuration rate in galaxies with $z \gtrsim 3$.

To balance evolutionary effects, we propose a $M_{\rm Dust}/M_{\rm Gas}$ versus $M_{\rm Dust}/M_*$ diagram (Fig. 1). In this figure, the star forming galaxies follow a clear path, while the elliptical galaxies lie at higher $M_{\rm Dust}/M_{\rm Gas}$ and $M_{\rm Dust}/M_*$ locus. The high-z sample does not exhibit a distinguished pattern. The $M_{\rm Dust}/M_{\rm Gas}$ versus $M_{\rm Dust}/M_*$ diagram is thus a powerful tool to study the interplay between obscuration and galaxy evolution. Further discussion can be found in Barbosa-Santos *et al.* (2020).

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