scattered values (in blue) at low $M_{\rm dust}^{\rm ref}$. Concerning the fraction of small a-C(:H), the values of Nersesian et al. (2019) are in very good agreement with our reference run.

In summary, the comparisons of Sects. 3.3.1–3.3.3 have demonstrated that the discrepancies induced by different fitting methods or model assumptions can be well understood. We are therefore confident that our reference run is the most robust among the diversity of approaches we have tested.

3.4. Comparison with Lianou et al. (2019)

Lianou et al. (2019, hereafter L19) recently used our model, HerBIE, to analyze the DustPedia photometry. There are three main technical differences between our analysis and theirs. Firstly, they used the implementation of the 2013 version of the THEMIS model (Jones et al. 2013), while we use the revised 2017 version (Jones et al. 2017). Secondly, they did not profit from the possibility to include ancillary data in the prior (Sect. 3.1). Finally, they did not include the remaining sources from the DGS sample. The comparisons of $M_{\rm dust}$ and $q_{\rm AF}$ are shown in Fig. 7.

Panel a of Fig. 7 shows that their dust mass is about a factor of two lower than ours. This can be partly understood in the light of the difference in grain mixtures. Indeed, Jones et al. (2017) revised the THEMIS model by including the more realistic Köhler et al. (2014) optical properties. To fit the same observational constraints, they compensated this update by changing the mantle thickness, as well as the dust-to-gas mass ratio: $M_{\rm dust}/M_{\rm H} = 8.6{\times}10^{-3}$ according to Table 2 of Jones et al. (2013) and $M_{\rm dust}/M_{\rm H} = 7.4 \times 10^{-3}$ according to Table 1 of Jones et al. (2017). This sole modification explains why a mass derived with the 2013 THEMIS version would be a factor of ≃0.86 lower than with the 2017 version. However, this does not explain the whole extent of the discrepancy. The comparison of our dust masses with those derived with CIGALE (Sect. 3.3.3) certainly excludes such a large error, on our side. It can be noted that there is also some scatter around the median ratio of $M_{\rm dust}/M_{\rm dust}^{\rm ref}$. A part of this discrepancy can naturally be explained by the fact that several galaxies have a very poor spectral coverage. As demonstrated in Sect. 3.2, the prior becomes dominant in this case. In our case, the prior contains the information provided by the ancillary data, thus helping to reduce the dust parameter range.

Panel b of Fig. 7 shows the comparison of $q_{\rm AF}$. The two quantities are in good agreement. There is some scatter around the median, for the same reason as mentioned for $M_{\rm dust}$. However, the problem with this quantity is the way L19 discuss it. They improperly report the meaning of $q_{\rm AF}$ that they call "*QPAH*" (L19, Sect. 3, 5th item). They write it represents "the mass fraction of hydrogenated amorphous carbon dust grains with sizes between 0.7 nm and 1.5 nm", while it actually is the mass fraction of a-C(:H) with sizes between 0.4 nm and 1.5 nm. Furthermore, they claim the Galactic value of this parameter is 7.1%, while it is $q_{\rm AF}^{\rm Gal} = 18.6\%$ for the 2013 version and $q_{\rm AF}^{\rm Gal} = 17.0\%$ for the 2017 version. The value of 7.1% is the mass fraction of a-C(:H) between 4 Å and 7 Å. Consequently, they mistakenly show that most of the DustPedia sample has a higher fraction of small a-C(:H) than the Milky Way, while it is not the case (cf. Sect. 4.2). In summary, we are confident that our derived parameters are both more precise and more accurate than L19's.

4. The derived dust evolution trends

In this section, we present the main dust evolution trends derived from the reference run (Sect. 3.2). These results are displayed as correlations between two inferred parameters, for each source in the sample. Displaying the full posterior PDF of each galaxy as density contours is visually impractical. Instead, we display its extent as a skewed uncertainty ellipse (SUE; Appendix F). SUEs approximately represent the 1σ contour of the PDF, retaining the information about the correlation and the skewness of the posterior, with a dot at the maximum a posteriori. When discussing parameter values in the text, we often quote the 95% credible range ($\text{CR}_{95\%}$), which is the parameter range excluding the 2.5% lowest and 2.5% highest values of the PDF. We also adopt the following terminology. We call extremelly low-metallicity galaxy (ELMG), a system with $Z \lesssim Z_\odot/10$. To simplify the discussion, since the heavy-element-to-gas mass ratio, Z, is usually called metallicity, we introduce the term dustiness to exclusively denote the dust-to-gas mass ratio:

$$Z_{\rm dust} \equiv \frac{M_{\rm dust}}{M_{\rm gas}}, \tag{4}$$

by specific, we denote quantities per unit stellar mass (similar to sSFR): (i) the specific dust mass is $sM_{\rm dust} \equiv M_{\rm dust}/M_\star$; (ii) the specific gas mass is $sM_{\rm gas} \equiv M_{\rm gas}/M_\star$. We note that, in all the displayed relations, the number of objects depends on the availability of the ancillary data (Table 2).

4.1. Evolution of the total dust budget

We first focus on scaling relations involving the total dust mass, $M_{\rm dust}$, with respect to the gas and stellar contents, the metallicity and the star formation activity. Casasola et al. (2020) have explored additional scaling relations, focussing on DustPedia LTGs.

4.1.1. Qualitative discussion

Figure 8 presents four important scaling relations. Panel a shows the evolution of the dust-to-baryon mass ratio:

$$f_{\rm dust} \equiv \frac{M_{\rm dust}}{M_{\rm gas} + M_\star}, \tag{5}$$

as a function of the gas fraction:

$$f_{\rm gas} \equiv \frac{M_{\rm gas}}{M_{\rm gas} + M_\star}. \tag{6}$$

This well-known relation was previously presented by Clark et al. (2015), De Vis et al. (2017b), and Davies et al. (2019). It shows that: (i) at early stages ($f_{\rm gas} \gtrsim 0.7$; mainly irregulars), there is a net dust build-up; (ii) it then reaches a plateau ($0.2 \lesssim f_{\rm gas} \lesssim 0.7$; mainly LTGs) where the dust production is counterbalanced by astration; (iii) at later stages ($f_{\rm gas} \lesssim 0.2$; mainly ETGs), there is a net dust removal. Several sources have peculiar positions relative to the above mentioned trend. Firstly, the irregular (blue SUE) with $f_{\rm dust} \simeq 0.01$ is PGC 166077. It is however technically not an outlier, as $\text{CR}_{95\%}(f_{\rm dust}) = [1.7 \times 10^{-3}, 2.8 \times 10^{-2}]$, overlapping with the rest of the sample. Secondly, the two ETGs (red SUEs) with a low $f_{\rm dust}$, at $f_{\rm gas} \simeq 0.3$ and $f_{\rm gas} \simeq 0.6$, are NGC 5355 and NGC 4322, respectively. For NGC 4322, $\text{CR}_{95\%}(f_{\rm dust}) = [1.2 \times 10^{-6}, 1.4 \times 10^{-4}]$, marginally overlapping with the rest of the sample. For NGC 5355, however, $\text{CR}_{95\%}(f_{\rm dust}) = [2.7 \times 10^{-6}, 6.8 \times 10^{-5}]$, making it a true outlier. The ETG (red SUE) with $f_{\rm gas} \simeq 1$ is ESO 351–030. It is the