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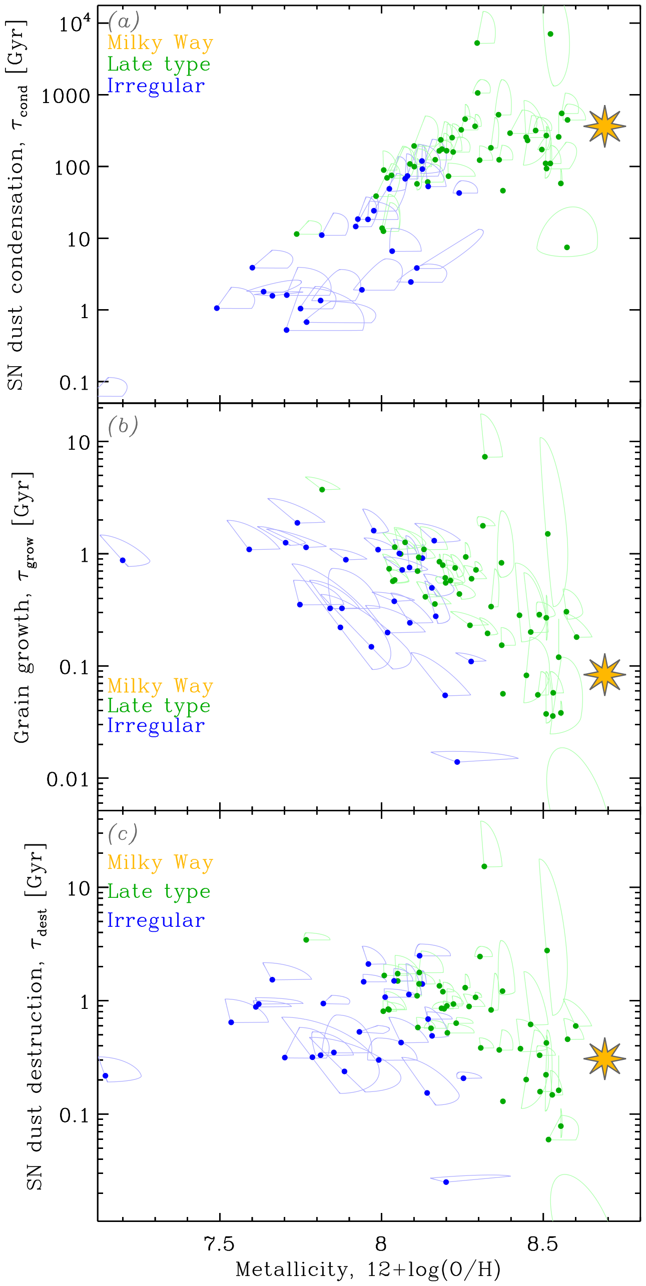

Fig. 18. Dust evolution timescales, assuming a Salpeter (1955) IMF. The three panels display the posterior PDF of the three dust evolution timescales. The SUEs represent the value of these timescales as a function of metallicity, for each galaxy. The yellow star represents the Milky Way, at the maximum a posteriori of the three tuning parameters.

5.4. Discussion

5.4.1. On the low inferred SN II dust yield

Our SN II dust yield is lower than the most recent estimates in situ. Measuring the dust mass produced by a single SN II is quite difficult, as it implies disentangling the freshly-formed dust from the surrounding ISM. It also carries the usual uncertainty about dust optical properties. A decade ago, the largest dust yield ever measured was $Y_{\rm SN} \simeq 0.02\,M_\odot$ (in SN 2003gd; Sugerman et al. 2006). The *Herschel* space telescope has been instrumental in estimating the cold mass of supernova remnants (SNR). The yields of the three most well-studied SNRs are now an order of magnitude higher:

Cassiopeia A: $Y_{\rm SN} \simeq 0.04{-}1.1\,M_\odot$ (Barlow et al. 2010; Arendt et al. 2014; De Looze et al. 2017; Bevan et al. 2017; Priestley et al. 2019);

The Crab nebula: $Y_{\rm SN} \simeq 0.03{-}0.23\,M_\odot$ (Gomez et al. 2012; Temim & Dwek 2013; De Looze et al. 2019);

SN 1987A: $Y_{\rm SN} \simeq 0.45{-}0.8\,M_\odot$ (Dwek & Arendt 2015; Matsuura et al. 2015).

In all these cases, the newly-formed grains have not yet experienced the reverse shock (Bocchio et al. 2016). The net yield is thus expected to be significantly lower.

Even if ≃10−20% of the dust condensed in an SN II ejecta survives its reverse shock (e.g., Nozawa et al. 2006; Micelotta et al. 2016; Bocchio et al. 2016), we have to also consider the fact that massive stars are born in clusters. The freshly-formed dust injected by a particular SN II, having survived the reverse shock, will thus be exposed to the forward shock waves of nearby SNe II (e.g., Martínez-González et al. 2018). This effect is not accounted for by Eq. (14), as it does not account for clustering, nor does it account for the excess dustiness around these stars due to the recent grain production. Our estimate of $\langle Y_{\rm SN}\rangle$ is therefore an effective empirical yield, that probably accounts for this effect.

5.4.2. The relevance of local low-metallicity galaxies

Our analysis confirms the long-lasting consensus that Milky Way dust is essentially grown in the ISM (Sect. 1). The apparently paradoxical fact here is that we have drawn this conclusion from the low-metallicity domain. It is because dust production is dominated by SN II condensation below the critical metallicity that we could constrain its efficiency and show it is unimportant at solar metallicity. The relevance of dwarf galaxies here is not necessarily that they can be considered as analogs of primordial distant galaxies, but that they sample a particular, key, dust production regime.

5.4.3. Implications for high-redshift systems

High-redshift ($z \gtrsim 6$) objects exhibiting copious amounts of dust (≃$10^7{-}10^8\,M_\odot$), close to the reionization era, have been challenging grain formation scenarios (e.g., Dwek et al. 2007, 2014; Valiante et al. 2009; Laporte et al. 2017). These objects are indeed only a few 100 Myr old, but have a roughly Galactic dustiness. SN II dust condensation would need to have a high efficiency (≃1 $M_\odot$/SN) to account for the observed dust mass (Dwek et al. 2007, 2014). AGB star yield can explain this dust content for $z \simeq 6$ objects (Valiante et al. 2009), but not at $z \simeq 8$ (Laporte et al. 2017).

Our results imply that grain growth should be the dominant dust formation mechanism in these galaxies. The dustiness of these massive objects being roughly Galactic, their metallicity should thus be Galactic too. The grain growth timescale should therefore be shorter than ≃100 Myr (panel b of Fig. 18), well below the age of these systems. Consequently, these very distant galaxies may not be the best laboratories to constrain the SN II dust yield.

5.4.4. Comparison with recent studies

As stated in Sects. 1 and 5.2.3, past studies have not been rigorously fitting cosmic dust evolution models to observations of galaxies. Recently, N20 and De Looze et al. (2020, hereafter DL20) have addressed this issue. N20 have adopted a