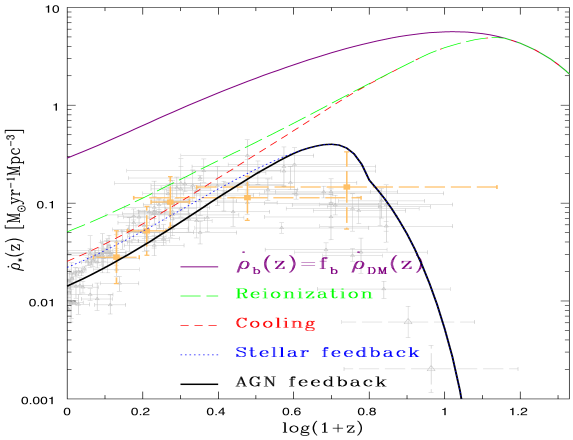

Fig. 1. Predicted SFRD histories by introducing different astrophysical ingredients as indicated in the panel. The final model is in good agreement with observations, showed by gray triangles (UV-based inferences) and orange squares (submm-based inferences) taken from the compilation of Hopkins & Beacom (2006).

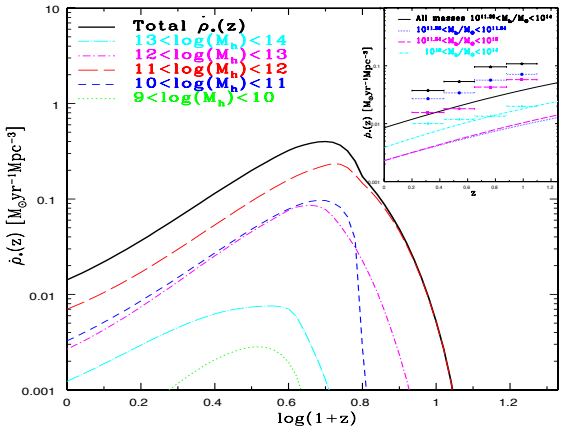

Fig. 2. Dissection by mass of predicted SFRD. Astrophysical ingredients alter the hierarchy of ΛCDM backbone. Massive halos ($M_h > 10^{12}\ M_\odot$) are in good agreement with observations (shown in the inset as dots with error bars taken from Mobasher et al. 2009). Low mass halos cannot reproduce recent observations of downsizing. The mass ranges in the main panel and the inset are different.

strong SF bursts (sub-millimeter galaxies?) are expected in such a way that $\epsilon_{\rm SF} \rightarrow 1$. At low z's, mergers are typically dry in such a way that no starbursts are expected. Halos formed from"normal" peaks ($\nu \approx 1$) host normal disk galaxies, where SF is self-regulated and quite ($\epsilon_{\rm SF} \ll 1$). By taking into account all these arguments, we approximate $\epsilon_{\rm SF}$ as $1/\left[5 - 12\log(1+z)\log(\nu)\right]$.

3. RESULTS AND CONCLUSIONS

Figure 1 shows the effects over the SFRD history of introducing consequently the 4 astrophysical processes mentioned above. We start from the BARD history (equation 3, purple solid line), which is basically an imprint of the hierarchical ΛCDM halo asssembly. Before re-ionization, $M_{\rm min(z)}$ corresponds to halos with $T_{\rm vir} = 300$ K, and after it, is determined by the UV background according to Hoeft et al. (2006). The SFRD is not affected significantly by these effects (green long-dashed line), being the difference with the preceding curve mainly due to $\epsilon_{\rm SF}$. The delay of gas infall due to radiative cooling diminishes SFR for massive haloes, which are formed at late times (red short-dashed line). SN driven outflows strongly decrease the SFRD in low mass halos, which are abundant at early epochs (blue dotted line). Finally, AGN feedback diminishes even more the SFR in massive halos at low z's (black solid line).

Figure 2 shows the dissection by mass in equally spaced intervals (1 dex) of the final model. At all z's, the main contribution to the SFRD comes from halos of $10^{11} - 10^{12}\ M_\odot$, which at $z \gtrsim 3$ are associated to very high peaks ($\nu > 2-3$), but at latter epochs, become typical $\nu \sim 1$ halos. Galaxies in very large and very small halos almost do not contribute to the SFRD. The astrophysical ingredients produce some inversion of the ΛCDM hierarchy but not enough at intermediate/low masses as to agree with observations which evidence strong 'downsizing': low-mass galaxies contribute more to the SFRD at late epochs than the larger ones (see inset in Figure 2).

We conclude that at a global level, our ΛCDM-based model is able to explain the observed cosmic SFRD history (Figure 1), showing that the SN-driven outflows in low-mass halos and radiative cooling/AGN feedback in massive halos are relevant ingredients for this agreement. When dissecting the SFRD history by M, our results for massive galaxies agree with observations but the SFRD contribution of low-mass galaxies at low z's is below the observed one (downsizing). Some extra astrophysical process should delay the active SF in low-mass halos (the less massive the halo, the more efficient should be this delay).

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