Gas fraction of galaxies and impact of mergers across cosmic times

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Abstract

The recent acceleration in millimetre astronomy with ALMA has shown that the gas mass fraction of galaxies is an increasing fonction of redshift, until at least z=3 (Combes et al., 2013). In particular, the bulk of star-forming galaxies typically have a molecular gas mass fraction above 50% of their total baryonic mass. We use parsec-scale hydrodynamical simulations of isolated and interacting galaxies with different gas fractions to study the impact of this sole parameter on the conditions of star formation on galactic scales.
We first show that the high-gas fraction is responsible for the instability of the disk structure in gas-dominated disks, and lead to the formation of massive 10ˆ8-9 Msun and long-lived (> 100 Myr) gaseous clumps. By testing different models of stellar feedback, including supernovae and radiative pressure from HII regions, we see that their evolution is more sensitive to the galactic shear and gas fraction than to stellar feedback.

We further show that these clumps are the birth nests of young massive star clusters. This clumpy distribution of star formation is consistent with the observed UV rest-frame light clumpy morphology of galaxies at z _˜ 2, along with the obtained masses and survival times (see e.g. Guo et al., 2014, 2015).

Although galaxy interactions are able to expel these star clusters to the halo of the galaxy merger remnant, and protect them from the galactic tidal field, we note that mergers of gas-dominated galaxies do not produce more clumps. This suggests that major mergers are not a major channel of formation of star clusters at z > 2. This is mainly due to a saturation of the turbulence, whose initially high level can barely be increased by the interaction. This saturation also suggests that galaxy mergers are much less efficient at producing starbursts than they are at lower gas-fraction. This provides an explanation for the observed decreasing efficiency of merger-driven starburst with redshift (see e.g. Rodighiero et al., 2011)
Last but not least, detailed simulations of disk instabilities during interactions of intermediate-redshift type gas fraction disks (gas mass fraction of 30%, typical of z=0.7) show the formation of massive young stellar clumps, similar to the ones observed in isolated z=2 type galaxies. This work in progress could provide an explanation to the increased clumpiness observed for starbursting galaxies at this redshift in the COSMOS field (Calabro et al., in prep.).

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