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Cold atomic and molecular gas in simulations of early galaxy formation – coldSIM

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New results from advanced numerical modelling of galaxy formation in the early Universe (Maio et al., 2021 to be submitted) will be presented and discussed by means of hydro/chemistry simulations of cold gas (coldSIM), from the epoch of reionization to later times. Besides star formation, feedback effects, stellar evolution and metal spreading, the new modelling includes gas fine-structure mm/sub-mm transitions, accurate time-dependent "non-equilibrium" chemistry calculations extended to consider the relevant small-scale cold-gas physics (H2 formation channels, self-shielding, dust grain catalysis, photoelectric and cosmic-ray heating, etc.) and the interplay with different UV backgrounds.
We will show that primordial haloes can host molecular-driven star and galaxy formation already at high redshift, when popIII stars are the dominat generation, quickly followed by popII-I. HI gas density parameters are found to decrease in time from z~6 to z~2, consistently with available data and under a broad range of conditions. On the contrary, H2 molecules are more sensitive to physical modelling and resulting H2 density parameters are in line with recent IR/mm observational determinations when time-dependent chemical abundances are consistently coupled to gas shielding and UV radiation. Large molecular fractions as high as ~60% (as reported lately) can be justifed by either three-body interactions in pristine media or dust grain catalysis in exceptionally enriched sites at those times. Differently from previous simulation-based studies, that did not include non-equilibrium chemistry and struggled to reproduce HI and H2 behaviours, our findings highligth the possibility to understand cosmic chemical evolution in different epochs by following detailed non-equilibrium calculations coupled to state-of-the-arte numerical simulations.

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