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A modified star formation law as a solution to open problems in galaxy evolution

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In order to reproduce the low mass end of the stellar mass function, most current models of galaxy evolution invoke very efficient supernova feedback. This solution seems to suffer from several shortcomings however, like predicting too little star formation in low mass galaxies at z=0. In this work, we explore modifications to the star formation (SF) law as an alternative solution to achieve a match to the stellar mass function. This is done by applying semi-analytic models based on De Lucia & Blaizot, but with varying SF laws, to the Millennium and Millennium-II simulations, within the formalism developed by Neistein & Weinmann. Our best model includes lower SF efficiencies than predicted by the Kennicutt-Schmidt law at low stellar masses, no sharp threshold of cold gas mass for SF, and a SF law that is independent of cosmic time. These simple modifications result in a model that is more successful than current standard models in reproducing various properties of galaxies less massive than 10^{10}Msun. The improvements include a good match to the observed auto-correlation function of galaxies, an evolution of the stellar mass function from z=3 to z=0 similar to observations, and a better agreement with observed specific star formation rates. However, our modifications also lead to a dramatic over-prediction of the cold mass content of galaxies. This shows that finding a successful model may require fine-tuning of both star formation and supernovae feedback, as well as improvements on gas cooling, or perhaps the inclusion of a yet unknown process which efficiently heats or expels gas at high redshifts.

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