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Probing the baryon cycle of primordial galaxies in the ALMA and JWST era

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Observational facilities such as Atacama Large Millimeter/submillimeter Array (ALMA) and James Webb Space Telescope (JWST) have propelled astronomy into a new era. With an increasing influx of observations, we are encountering cosmic objects that challenge our theoretical frameworks. Especially, recent studies reporting abnormally high gas and dust reservoirs in the galaxies challenge our current prescriptions about dust formation in the early Universe.

In this work, we make use of chemical evolution models to probe the evolution of gas and dust within star-forming galaxies at a redshift of ~ 5, observed by the ALMA Large Program ALPINE. These galaxies were formed just one billion years after the Big Bang, which denotes a crucial phase when the Universe underwent transformation from the primordial galactic formation to the onset of the peak of cosmic star formation rate density. We attempt to match the observed dust content and star formation rate of these galaxies by considering different dust production mechanisms, including Type II supernovae, asymptotic giant branch stars, and dust growth within the ISM.

Our models successfully reproduce the gas and dust content in most of these primordial galaxies, indicating dust production primarily through SNII and gas/dust removal via galactic outflows and moderate inflow of primordial gas. However, a fraction of galaxies show a rapid dust build-up in a short time-frame (~ 20 - 100 Myr). This fast dust production might be partially explained by adopting a top-heavy initial mass function, thus favouring the formation of more massive stars and a more rapid stellar evolution. I will also discuss the role and synergies between ALMA and JWST in advancing our knowledge of chemical enrichment in the early Universe.

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