Probing the baryon cycle of primordial galaxies: Insights from ALPINE survey with HST, ALMA and JWST

Prasad Sawant[1]

[1] *National Centre for Nuclear Research, Warsaw, Poland*

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. In particular, recent studies reporting unexpectedly large reservoirs of gas and dust in high-redshift galaxies challenge our current understanding of dust formation processes in the early Universe.

In this work, we employ chemical evolution models to investigate the build-up of gas and dust within star-forming galaxies at redshift of ~ 5, observed by the ALMA Large Program ALPINE. These galaxies, formed within the first billion years after the Big Bang, represent a critical epoch during which the Universe transitioned from primordial structure formation to the onset of the cosmic star formation peak. The ALPINE survey benefits from the panchromatic observations providing fundamental information about their gas/dust content, their morphological and kinematical properties and mechanisms influencing their baryonic cycle highlighted in the studies in recent years.

We model the evolution of gas and dust in these galaxies by incorporating various dust production pathways, including Type Ia and II supernovae, asymptotic giant branch (AGB) stars, and grain growth within the interstellar medium (ISM). Our models reproduce the observed gas and dust masses for the majority of the sample, highlighting the dominant role of Type II supernovae and ISM grain growth in dust production, removal of gas and dust via galactic outflows and moderate accretion of pristine gas. However, a subset of galaxies exhibit rapid dust enrichment on remarkably short timescales (~ 20 - 100 Myr), which cannot be fully accounted for using standard prescriptions. This fast dust production is partially explained by adopting a top-heavy initial mass function (IMF), thus favoring the formation of more massive stars and a more rapid dust production.

I will also discuss the role and synergies between ALMA and JWST in advancing our understanding of chemical enrichment in the early Universe. With new ALPINE observations from JWST, I will discuss their role in constraining the IMF and the nature of dust production in these primordial galaxies.