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The POPSICLE project: star cluster formation at cosmic dawn

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The era of cosmic dawn began with the first stars that formed in the Universe a mere 200 - 300 million years after the Big Bang. These stars produced the first supernovae and black holes, enriched the interstellar medium (ISM) with metals, were the building blocks of the first galaxies, and significantly contributed to cosmic reionization. However, compared to star formation and feedback in metal-rich environments today, the lack of direct observations at low metallicities as well as high redshifts has posed a significant challenge for understanding the physics behind their formation and evolution. In this talk, I will introduce POPSICLE, a new framework for high resolution simulations that caters to star formation and feedback in low metallicity environments reminiscent of redshift > 10 galaxies. I will describe how incorporating the full spectrum of ISM physics coupled to stellar evolution is crucial to constrain the stellar initial mass function (IMF) and feedback in such environments. I will particularly focus on the impacts of non-equilibrium chemistry, cosmic rays, and cooling in these environments, and discuss the interplay between different physicochemical mechanisms that govern the IMF, feedback and black hole growth in the early Universe. I will conclude by showcasing the capability of GPU-accelerated simulations to revolutionize our understanding of the astrophysics of cosmic dawn, and bring theory at par with state of the art observations from JWST.

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