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Impact of the First Stars to the First Galaxy Formation

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Abstract. We present the results from our cosmological simulations of the first stages of galaxy formation. We use `Gadget-2` (Springel 2005), modified to include detailed cooling, chemistry, and radiative transfer of primordial gas to study the impact of the first stars on galaxy formation. In contrast to previous work, we apply a realistic treatment of stellar feedback by using updated stellar models for the first stars. In this proceeding, we briefly summarize how stellar feedback from the first stars affects the primordial IGM inside the first galaxies.

Keywords. First stars, early Universe

Summary

In our simulations, the first-ever star with a mass of $60\,\mathrm{M}_\odot$ forms at a redshift of $z \sim 28$ inside a 5×10^5 $\mathrm{M}_\odot$ dark matter halo. Once this star evolves to the main sequence, when the stable hydrogen burning at the core occurs, its surface temperature quickly rises to $\mathrm{T} \sim 10^5$ K and begins to emit a large amount of photons that ionize hydrogen and helium. The gas inside the host halo is strongly photo-heated to temperatures, of $\mathrm{T} \sim 2 \times 10^4$ K, allowing the gas to escape the gravitational well of the host halo, forming an outflow. When the star dies, the I-front ultimately creates an extensive H II region of size ~ 4 kpc. It implies that radiative feedback of the first stars can significantly ionize the gas of the IGM and changes the collapse mass scale for the first galaxies (e.g., Bromm & Yoshida 2011). Besides radiative feedback, the first stars synthesize the first heavy chemical elements beyond hydrogen and helium during their evolution. These metals are eventually dispersed in the IGM when the stars die as supernovae. In our simulation, we assume the first-ever $60\,\mathrm{M}_\odot$ star dies as a core collapse supernova with explosion energy of 3×10^{51} erg. Such a supernova explosion can efficiently spread the metals over a region of size about 1 kpc in a few million years and enrich the metallicity of pristine gas inside IGM to $10^{-3} - 10^{-6}$ $\mathrm{Z}_\odot$. If the chemical enrichment is over a critical metallicity ($\sim 10^{-3}$ $\mathrm{Z}_\odot$), it results in the formation of Pop II stars. Overall, the stellar feedback of the first stars can significantly affect the later star formation history and the assembly of the first galaxies.

References

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