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The origin of low escape fractions of ionizing radiation from Lyman-break galaxies at high-redshift

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The physical origin of low escape fractions of ionizing radiation derived from Lyman-break galaxies (LBGs) at $z \sim 3$–4 is a puzzle in the theory of reionization. We perform idealized disk galaxy simulations to investigate how galactic properties, such as metallicity and gas mass, affect the escape of Lyman continuum (LyC) photons using radiation-hydrodynamic code, \texttt{RAMSES-RT}, with strong stellar feedback. We find that the luminosity-weighted escape fraction from a metal-poor ($Z = 0.1\,Z_{\odot}$) galaxy embedded in a halo of mass $M_h \simeq 10^{11}\,M_{\odot}$ is $\langle fesctd \rangle \simeq 8\%$. However, when the gas metallicity is increased to $Z = 1Z_{\odot}$, the escape fraction is significantly reduced to $\left\langle f_{esc}^{3D} \right\rangle \simeq 1\%$, as young stars are enshrouded by their birth clouds for a longer period of time. On the other hand, increasing the gas mass by a factor of 5 leads to $\left\langle f_{esc}^{3D} \right\rangle \simeq 4\%$, as LyC photons are only moderately absorbed by the thicker disk. Our experiments seem to suggest that high metallicity is primarily responsible for the low escape fractions observed from LBGs, supporting the scenario in which the escape fraction has a negative correlation with halo mass. Indeed, our simulated galaxy with the typical metallicity ($Z = 0.3\,Z_{\odot}$) shows the relative escape fraction of
$f_{esc,rel}^{3D} = 8\%$, consistent with recent observations of LBGs with $M_{1500} \sim -20$ at $z \sim 4$.

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