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When did the initial mass function become bottom-heavy?

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The characteristic mass that sets the peak of the stellar initial mass function (IMF) is closely linked to the thermodynamic behaviour of interstellar medium (ISM), which controls how gas fragments as it collapses under gravity. As the Universe has grown in metal abundance over cosmic time, this thermodynamic behaviour has evolved from a primordial regime dominated by molecular hydrogen cooling to a modern regime where the dominant process in dense gas is protostellar radiation feedback, transmitted to the gas via dust grains. We study gas thermodynamics in collapsing dusty molecular clouds at a wide range of metallicities, from primordial to super-Solar, in different ISM conditions. We show that the transition in the IMF from the primordial regime to the modern regime begins at metallicity $Z \sim 10^{-4}\,\mathrm{Z}_\odot$, passes through an intermediate stage where metal line cooling is dominant, and then transitions to the modern dust- and feedback-dominated regime at $Z \sim 0.05\,\mathrm{Z}_\odot$. This transition is accompanied by a dramatic change in the characteristic stellar mass, from $\sim 50\,\mathrm{M}_\odot$ at $Z \sim 10^{-6}\,\mathrm{Z}_\odot$ to $\sim 0.3\,\mathrm{M}_\odot$ once radiation feedback begins to dominate, which marks the appearance of the bottom-heavy Milky Way IMF. The exact transition from top- to bottom-heavy IMF occurs at intermediate metallicities. Specifically, this transition is sensitive to the abundances of C and O, which observations of metal-poor stars and dwarf galaxies show is non-Solar-scaled. Our work brings together the stellar and galaxy communities by revealing the impact of the IMF on our understanding of the metal-poor Universe.

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