CEMP Stars as Probes of First-Star Nucleosynthesis, the IMF, and Galactic Assembly

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Fragmentation Condition in a Primordial Accretion Disk

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The accretion disks around Population III (PopIII) stars are known to fragment under fast H_2 cooling.
Based on the vertical disk structure, we study the optical depth for H_2 line cooling under an accretion disk geometry. With the physically motivated optical depth, we find that cooling in the inner disk with $r < 10$ AU is attenuated significantly due to the large surface density. PdV heating becomes more efficient than cooling, which prevents fragmentation in the inner disk. Yet, in the outer disk, cooling becomes dynamical. The fast cooling favors fragmentation. We thus argue that most of the fragments are initially at the outer disk.
In addition, any surviving fragment has to migrate slower than the photo-evaporation process. We found that fragments with $0.01 - 0.05\,M_\odot$ would survive under Type I migration if disk mass is less than 10% of the star's mass. For a fragment more massive than $0.1M_\odot$, a gap would be opened up and migration would slow down. It increases the possibility for fragments encountering and merging with each other. The gravitational interaction between fragments would be crucial for mass growth of fragments, as well as the subsequent disk evolution.

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