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A New Formation Channel for Globular Clusters

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The puzzling origins of globular clusters have been greatly debated over the years. I will present a new formation channel for globular clusters, linking them to objects that formed without dark matter in the early Universe in the presence of the stream velocity. This stream velocity (Tseliakhovich & Hirata 2010) arises due to the drop in radiation pressure of baryons from matter-radiation decoupling and induces a phase shift/physical separation between dark matter and baryonic overdensity peaks (Naoz & Narayan 2014). This effect gives rise to gas dominant objects with little to no dark matter. These gas-rich structures, called Supersonically Induced Gas Objects (SIGOs), form naturally outside of dark matter halos as a consequence of the stream velocity. Running hydrodynamic AREPO simulations we find that SIGOs density is high enough to allow stars to form. Then, we model the star formation process and estimate the luminosity of the first star clusters within a SIGO. We find that SIGOs occupy a different part of the luminosity-mass parameter than classical, dark matter halos with gas. SIGOs are dimmer and have globular cluster-like masses. We further adopt a simple model to evolve the SIGOs to current day objects and show that their radius and luminosity is consistent with present-day (local) globular clusters. Since the relative velocity between the baryons and dark matter is coherent over a few Mpc scales, we predict that if this is the dominant mechanism for globular clusters, their abundance should vary significantly over these scales.

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