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Dark Matter Heating in Evolving Proto-Neutron Stars: A Two-Fluid Approach

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Neutron stars provide a unique laboratory to probe dark matter (DM) through its gravitational imprint on stellar evolution. We study proto-neutron stars in a two-fluid, quasi-static framework with non-annihilating asymmetric DM (fermionic or bosonic) that interacts with ordinary matter only via gravity, and follow the Kelvin–Helmholtz cooling phase. We find a clear thermal signature: compact DM cores deepen the potential well and heat/compress the baryons, while extended DM halos add external support and cool the stellar matter. Unlike DM cores, hyperons also soften the equation of state but typically lower the temperature, providing a way to distinguish these effects. DM further increases compactness and shifts the hyperon onset, with the strongest impact during deleptonization and the neutrino-transparent stage. These changes in early thermal evolution could be tested with supernova neutrino signals and young neutron-star cooling curves.

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