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Determining proto-neutron stars' minimal mass with a chirally constrained nuclear equation of state

We study the minimal masses and radii of proto-neutron stars during different stages of their evolution. The main focus lies on the stages directly after the supernova outward shock wave where neutrinos are captured in the core and the lepton per baryon ratio is approximately $Y_L = 0.4$ and a few seconds afterwards, when all neutrinos have left the star. All equations of state used for this purpose fulfill the binding energy constraints from chiral effective field theory for neutron matter at zero temperature. We find for the neutrino-trapped cases higher minimal masses than for the cases when neutrinos have left the proto-neutron stars. Thermal effects, in this work a given constant entropy per baryon, also increase the minimal mass. Calculations of core-collapse supernovae impose a lower limit of approximately $1.2M_\odot$ for neutron stars. Our determined values for the first evolution stage with $Y_L = 0.4$ and $s = 1$ is $M_{min} \sim 0.62M_\odot$ and for the stage after that with $Y_\nu = 0$ and $s = 2$ we find $M_{min} \sim 0.22M_\odot$. We also study the case of an accretion induced collapse of a white dwarf with a lepton fraction of $Y_L = 0.5$ and find large discrepancies in the results of different nuclear models studied. We furthermore examine the minimal mass dependence on the lepton fraction, which follows a similar relation for all equations of state studied.
Our focus lies on incorporating color superconducting phases at higher densities.

Category

Theory

Collaboration (if applicable)

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