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Comparison of Hyperonic Equations of State for Core Collapse Supernovae Simulations

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Abstract. In this work, we study the dynamical collapse of a non rotating massive star to a black hole using relativistic supernova equations of state (EoS) incorporating Λ hyperons which would be populated, due to Pauli exclusion principle, in the dense matter region after the core collapse. We use 1D GR hydrodynamic code *GR1D* for our numerical simulations and compare the properties of the currently available hyperonic equations of state.

Keywords : equation of state – stars: neutron, supernovae: general

1. Introduction

Dynamical core collapse of a massive star is being studied for the last six decades. Properties of matter at very high density have a crucial role to play in the metastabilty of the protoneutron star (PNS) which is the remnant of a core collapse supernova explosion. Recent observations suggest that the equation of state of dense matter should be compatible with $2M_\odot$ neutron star. We have taken the recently developed BHB$\Lambda\phi$ EoS (Banik et al. 2014) and the widely used HShen Λ EoS (Shen et al. 2011) for our study. Between them only BHB$\Lambda\phi$ EoS satisfies the observational criteria. We performed the simulations using the *GR1D* code by O'Connor and Ott (2010). It is based on Eulerian formulation of GR hydrodynamics with high resolution shock capturing scheme working with non-equidistant grid. It uses microphysical EoSs for supernova matter and a simplified and computationally efficient treatment of neutrino heating and cooling.

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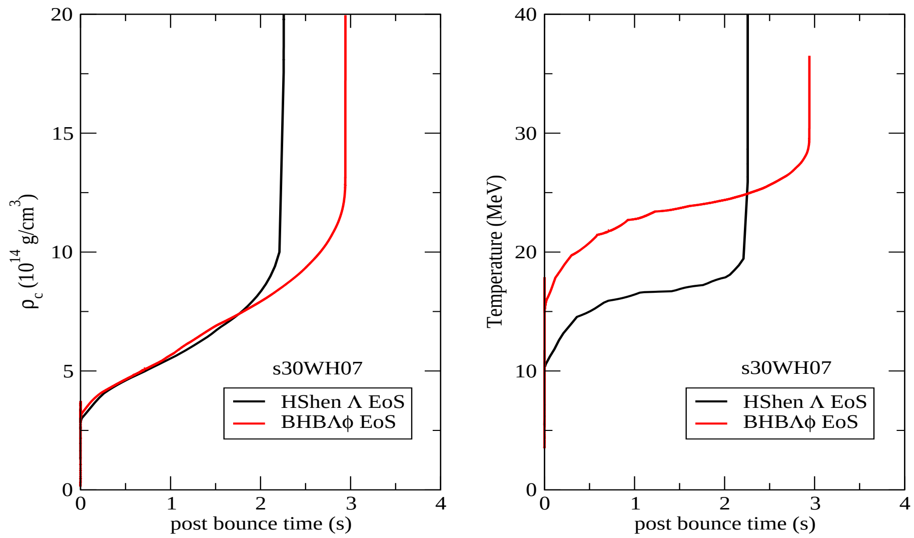

Figure 1. Temporal evolution of central density and temperature of PNS

2. Results and Summary

We choose a $30M_\odot$ progenitor (s30WH07) of Woosley and Heger (2007) and observe the formation of a PNS and its subsequent collapse into a black hole (BH). The evolution of central baryonic density and central temperature with post bounce time are shown in the above figure. At bounce, the central density is almost same for both EoS models, but the temperature is higher for BHB$\Lambda\phi$ EoS due to its smaller incompressibility at nuclear saturation density. Then both density and temperature increase gradually followed by a steep increase denoting the BH formation. At higher density the BHB$\Lambda\phi$ EoS is stiffer than the HShen Λ EoS. This leads to larger post bounce time to BH formation for BHB$\Lambda\phi$ EoS. In summary, we have studied the effect of hadron-hyperon phase transition in core collapse supernova. We found the appearance of hyperons fails to generate a second shock, but leads to a faster BH formation than only nucleonic EoS counterparts.

References

Banik S., Hempel M., Bandyopadhyay D., 2014, ApJS, 214, 22
O'Connor E., Ott C., 2010, Class. Quantum Grav., 27, 114103
Shen H., Toki H., Oyamatsu K., Sumiyoshi K., 2011, ApJS, 197, 20
Woosley S. E., Heger A., 2007, Phys. Rep., 442, 269