

# Magneto-rotational supernova explosions: a comparison between state-of-the-art numerical models

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## Abstract

The gravitational collapse of a massive star with a fast-rotating core sets the stage for the onset of magneto-rotational core-collapse supernovae (CCSN). The accreting central compact object is believed to be the central engine that can power up outstanding stellar explosions such as hypernovae and long gamma-ray bursts (GRB). Over the last decades magnetohydrodynamic numerical models of magnetized core-collapse have reached a high degree of complexity, as they include the effects of three-dimensional dynamics, nuclear equations of state, effects of general relativity, multi-dimensional neutrino transport schemes. This allows one in return to make quantitative predictions on the properties of the compact remnant, the multi-messenger signatures of the explosion, the launching conditions of the relativistic jet, and the explosive nucleosynthesis of new heavy elements contributing to the chemical evolution of galaxies. Such predictions depend crucially on the accuracy with which simulations can reproduce quantities such as the spin-down of the central proto-neutron star, the magnetic transport of angular momentum, the shock propagation through the stellar progenitor, and the neutron-richness of the ejecta. However, it remains still unclear to what extent the findings of numerical models of magneto-rotational explosions depend on the technical details of the specific tool used to produce them.

I will present results from a code-comparison project which considers, for the first time, the modeling of a prototypical 3D magneto-rotational explosion realized with state-of-the-art CCSN numerical codes that use different grid geometries, gravity treatment, and neutrino-matter interactions. I will show the impact that specific modeling choices have on the explosion dynamics, the shock propagation, the formation of the central compact object, the stability of the polar outflow, and the multi-messenger emission (neutrinos and gravitational waves) associated to a long GRB progenitor. The overall good agreement between completely independent codes showcases the maturity of the CCSN modeling community and the potential for more quantitative predictions related to outstanding stellar explosion models.