Numerical models of magnetized core-collapse supernovae: state-of-the-art and challenges

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Résumé

The gravitational collapse of massive stars is characterized by complex multi-scale (both in space and time) physical processes, whose dynamics can be describe only by combining (magneto)hydrodynamic models with relativistiic effects, nuclear equations of state and a strong coupling between neutrinos and matter. Fast rotation and strong magnetic fields are fundamental ingredients for numerical models aimed at reproducing the central engines of outstanding stella explosions (such as hypernovae, GRBs and superluminous supernovae) through the so-called magneto-rotational explosion mechanism. In this talk I will first review our current understanding of the dynamics of magnetized supernova from a numerical perspective, highlighting current computational challenges related to the vast range of spatial and temporal scales which are relevant for the dynamics of the magnetic field. I will then present recent state-of-the-art 3d simulations of magneto-rotational explosions connected to the formation of magnetars, and show the main properties of the shock dynamics and the evolution of the central proto-neutron star (PNS). In particular, I will highlight the impact of different magnetic field configurations on the onset of dynamical instabilities and the associated signatures in the gravitational wave and neutrino emission.

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