Stellar magneto-convection with RAMSES

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Abstract

Turbulent magneto-convection is one of the fundamental processes in stellar interiors being it at the core of energy and mass transport, dynamo action, and mixing of elements. We conduct a proof-of-concept for the realization of numerical simulations of compressible, stellar magneto-convection on a three-dimensional Cartesian grid with the code RAMSES. We adapted the code to deal with highly subsonic turbulence, typical of stellar convective flows, by implementing a well-balanced scheme in the numerical solver.
As a result, we are able to simulate stellar convection zones while preserving the equilibrium profiles of the stellar interior.
We test our implementation by performing a resolution study on a portion of convection zone of a low-mass AGB star undergoing a He-shell flash thermal pulse.
For each resolution we run a hydrodynamical (HD) and a magneto-hydrodynamical (MHD) simulation and obtain, from small perturbations around the equilibrium profiles, a fully developed convection zone within 1'000 s.
For the MHD runs, a turbulent small-scale dynamo generates magnetic fields with strength around 18% - 37% of the equipartition value.
We present the properties of the convective flows and magnetic fields, as well as a preliminary study on the generation and propagation of waves above the convective shell.
We conclude by discussing future developments related to this project.

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