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TIME-IMPLICIT HYDRODYNAMICAL SIMULATIONS OF STELLAR INTERIORS: APPLICATION TO TURBULENT CONVECTION

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Abstract. The talk described the first results on turbulent convection in the envelope of a red giant star obtained with the MUSIC code, a new multi-dimensional time-implicit code devoted to stellar interiors (Viallet, Baraffe & Walder, A&A, 2011). Currently, most of our physical understanding of stellar interiors and evolution largely relies on one-dimensional calculations. The description of complex physical processes like time-dependent turbulent convection, rotation or MHD processes mostly relies on simplified, phenomenological approaches, with a predictive power hampered by the use of several free parameters. These approaches have now reached their limits in the understanding of stellar structure and evolution. The development of multi-dimensional hydrodynamical simulations becomes crucial to progress in the field of stellar physics and to meet the enormous observational efforts aimed at producing data of unprecedented quality (COROT, Kepler GAIA). The MUSIC code solves the hydrodynamical equations in spherical geometry and is based on the finite volume method. The talk presented implicit large eddy simulations of the turbulent convection in a cold giant envelope both in 2D and 3D and covering 80% in radius of the stellar structure. The computational domain includes both the convective envelope and a significant fraction of the radiative zone, allowing for convective penetration. These simulations provide valuable insight to improve the description of turbulent convection in 1D models.

Keywords: Convection, Stars:interiors, Turbulence

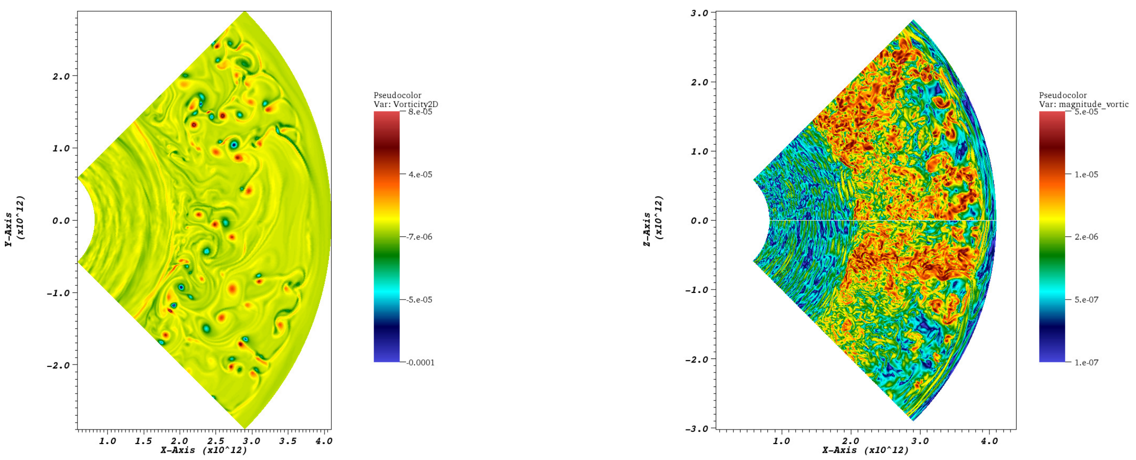

Fig. 1. Snapshots of the computational domain for the 2D and 3D red giant models. The left panel shows the vorticity field ω in a 432×512 simulation, the right panel shows the magnitude of the vorticity $||\vec{\omega}||$ in a 432×256^2 simulation (the figure shows two perpendicular cuts in the vertical direction side by side).

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