EULAG-MHD: Simulation of the Global Solar Dynamo

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This paper documents a magnetohydrodynamic (MHD) adaptation of the general-purpose hydrodynamical simulation code EULAG [Prusa et al., Comput. Fluids **37**, 1193 (2008)].

This MHD code has been recently shown to produce unprecedented solar-like magnetic cycles and dynamo action in global large-eddy simulations of solar magneto-convection [Ghizaru et al., ApJL **715**, L133 (2010); Racine et al., ApJ **735**, 46 (2011)]. Because of its meteorological heritage, EULAG incorporates some features non-standard in anelastic solar codes, which prove beneficial for our simulation of the global dynamo.

In this paper we present our anelastic MHD equations and identify the modifications adopted from the atmospheric experience. For this purpose, we use a physically intuitive, Cartesian vector form of the governing equations in disregard of the model geometry and curvilinear coordinate framework adopted. Then, we recast the governing equations in the form consistent with the problem geometry and the solution procedures, and document the numerical algorithm for integrating these governing equations. Some sample results highlighting practical advantages of our Implicit Large Eddy Simulation approach are presented, together with evidence that numerical treatment of small scales may be critical for the production of cyclic behavior and regular polarity reversals in this type of global simulations.