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Methodology for estimating the magnetic Prandtl number and application to solar surface small-scale dynamo simulations

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It is still an open question if the quiet Sun small-scale magnetic field mainly originates of a turbulent cascade acting on fields produced by a global-scale dynamo, or if it is mainly generated locally by a small-scale turbulent dynamo. Consequently, a number of numerical studies focusing on turbulent dynamos was carried out in the recent past. Despite of these works providing extremely useful information on many aspects of small-scale dynamo action, it is still unclear how to extrapolate these results to the Sun, in particular because of the disparate regimes of magnetic Prandtl numbers, Pr_m, between numerical simulations and the real Sun. The present work addresses these issues in a twofold way. First, a general methodology for estimating the effective diffusivities stemming from radiative MHD simulations is proposed. It is based on the method of Projection on Proper elements, initially introduced in the plasma physics community to verify plasma turbulence simulation codes. It relies on a post processing step using different, higher order accurate numerical operators. Second, a study of how the magnetic field resulting from small-scale solar dynamo simulations depends on the Reynolds number, Re, and magnetic Reynolds number, Re_m, is presented. For this, several radiative MHD simulations with different effective viscosity and plasma resistivity are carried out with the CO5BOLD code and the resulting magnetic energy growth rate and saturated magnetic field are characterized in terms of Re and Re_m. It is shown that it is possible to simulate small-scale dynamo action also in the regime $Pr_m < 1$.

Author: Dr RIVA, Fabio (Istituto Ricerche Solari Locarno (IRSOL), Università della Svizzera italiana (USI), CH-6605 Locarno-Monti, Switzerland.)

Co-author: STEINER, Oskar (Leibniz-Institut für Sonnenphysik)

Presenter: Dr RIVA, Fabio (Istituto Ricerche Solari Locarno (IRSOL), Università della Svizzera italiana (USI), CH-6605 Locarno-Monti, Switzerland.)

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