Optimized dynamo action within a 'mean'-field approach

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From the Zeldovich toroidal anti-dynamo theorem, we know that arbitrary parallel shear flows cannot act as kinematic dynamos for any value of the magnetic Reynolds number. This theorem is mathematically strict, but not physically robust: small flow perturbations in the flow can easily trigger dynamo action. Using a nonlinear optimization strategy inspired by [1,2], we measured just how big a flow perturbation needs to be as a function of Rm, in order to trigger kinematic dynamos in the Kolmogorov shear flow. This work was presented at earlier meeting and is now available in [3].

In this talk, I will present some ongoing work on these optimal perturbation flows. Given that both the optimal flow and the magnetic eigenmode have fairly simple spatial structures, we can search for optimal flows within a reduced 1 dimensional "mean"-field model. This method is conceptually similar to recent work on the problem of subcritical transition to turbulence [4,5]. Optimizing within this reduced (mean field) approach is much less costly and should allow to reach into the asymptotic regime of high R_m, that is unaccessible to the full 3D optimization technique we have been using before.

[1] Willis, A.P. 2012 Optimization of the magnetic dynamo. *Phys. Rev. Lett.* **109** (25), 251101.

[2] Chen, L., Herreman, W. & Jackson A. 2015 Optimal dynamo action by steady flows confined into a cube. *J. Fluid Mech.* **783**, 23-45.

[3] Herreman, W. 2016 Minimal flow perturbations that trigger dynamo in shear flows. *J. Fluid Mech.* **795**, R1.

[4] Biau, D. & Bottaro, A. 2009 An optimal path to transition in a duct. *Phil. Trans. R. Soc. Lond. A: Mathematical, Physical and Engineering Sciences* **367** (1888), 529–544.

[5] Pralits, J.O., Bottaro, A. & Cherubini, S. 2015 Weakly nonlinear optimal perturbations. *J. Fluid Mech.* **785**, 135–151.