Activity report based on time used on PDC and C3SE since October 2016

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During the reporting period, ten papers were published that all acknowledge SNAC. The science covered in these papers extends from the early Universe to solar magnetic fields and even the initiation of rain in turbulent clouds. The underlying simulations required extensive amounts of computing time and Beskow was the only machine capable of these. However, we have been consistently at the limit of our past allocation.

For all calculations, we use the Pencil Code, which is hosted by Google Code[1] The code has now been moved to `https://github.com/pencil-code`. Below, I describe the research outcome by quoting published papers since October 2016 in refereed journals. The numbering of the papers coincides with that of my full list of publications on `http://www.nordita.org/~brandenb/pub`. All the papers quoted below acknowledge SNAC and none of those papers were mentioned in the activity report of the previous period.

1 Early Universe magnetic fields

Using numerical simulations, we have for the first time demonstrated the occurrence of a turbulent chiral magnetic cascade in the early universe [352]; see also Figure 1. We have also discovered distinct classes of hydrodynamic and magnetohydrodynamic turbulent decay [344].

352. Brandenburg, A., Schober, J., Rogachevskii, I., Kahniashvili, T., Boyarsky, A., Fröhlich, J., Ruchayskiy, O., & Kleeorin, N.: 2017, "The turbulent chiral magnetic cascade in the early universe," *Astrophys. J. Lett.* **845**, L21

344. Brandenburg, A., & Kahniashvili, T.: 2017, "Classes of hydrodynamic and magnetohydrodynamic turbulent decay," *Phys. Rev. Lett.* **118**, 055102

2 Sunspot formation and NEMPI

We have now performed simulations showing the spontaneous flux concentrations from the negative effective magnetic pressure instability beneath a radiative stellar surface [360]. Our work on the identification of sharp magnetic structures from dynamos with density stratification has now been published [348].

360. Perri, B., & Brandenburg, A.: 2017, "Spontaneous flux concentrations from the negative effective magnetic pressure instability beneath a radiative stellar surface," *Astron. Astrophys.*, in press (arXiv:1701.03018)

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[1] The Pencil Code was written by Brandenburg & Dobler (2002) as a public domain code.

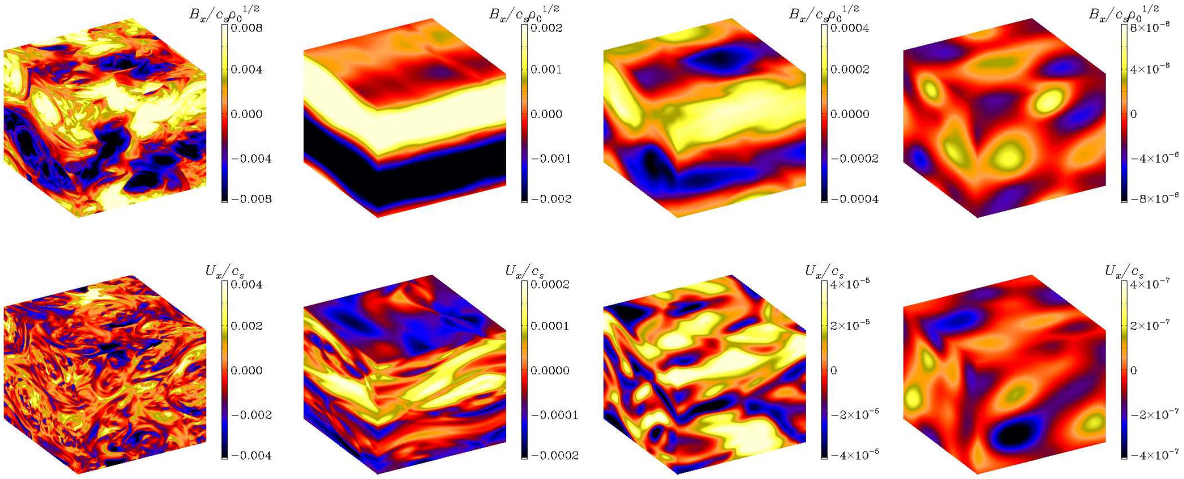

Figure 1: B_x (upper row) and U_x (lower row) on the periphery of the computational domain for (from left to right) decreasing chirality parameter.

348. Jabbari, S., Brandenburg, A., Kleeorin, N., & Rogachevskii, I.: 2017, “Sharp magnetic structures from dynamos with density stratification,” *Mon. Not. Roy. Astron. Soc.* **467**, 2753–2765

3 Dynamo action in the Sun

New simulations have now demonstrated the enhancement of small-scale turbulent dynamo by large-scale shear [359]. Using simulations with the test-field method, we have discovered a new contribution of kinetic helicity to turbulent magnetic diffusivity [356]. In preparation for a new observational technique to measure magnetic helicity in the solar corona, we have now demonstrated quantitatively the compensation of Faraday depolarization by magnetic helicity in the solar corona [351]; see also Figure 2. Simulations have also been used to verify an analytic solution of an oscillatory migratory α^2 stellar dynamo [346].

359. Singh, N. K., Rogachevskii, I., & Brandenburg, A.: 2017, “Enhancement of small-scale turbulent dynamo by large-scale shear,” *Phys. Rev. Lett.*, submitted (arXiv:1610.07215)

356. Brandenburg, A., Schober, J., & Rogachevskii, I.: 2017, “The contribution of kinetic helicity to turbulent magnetic diffusivity,” *Astron. Nachr.* **338**, 790–793

351. Brandenburg, A., Ashurova, M. B., & Jabbari, S.: 2017, “Compensating Faraday depolarization by magnetic helicity in the solar corona,” *Astrophys. J. Lett.* **845**, L15

346. Brandenburg, A.: 2017, “Analytic solution of an oscillatory migratory α^2 stellar dynamo,” *Astron. Astrophys.* **598**, A117

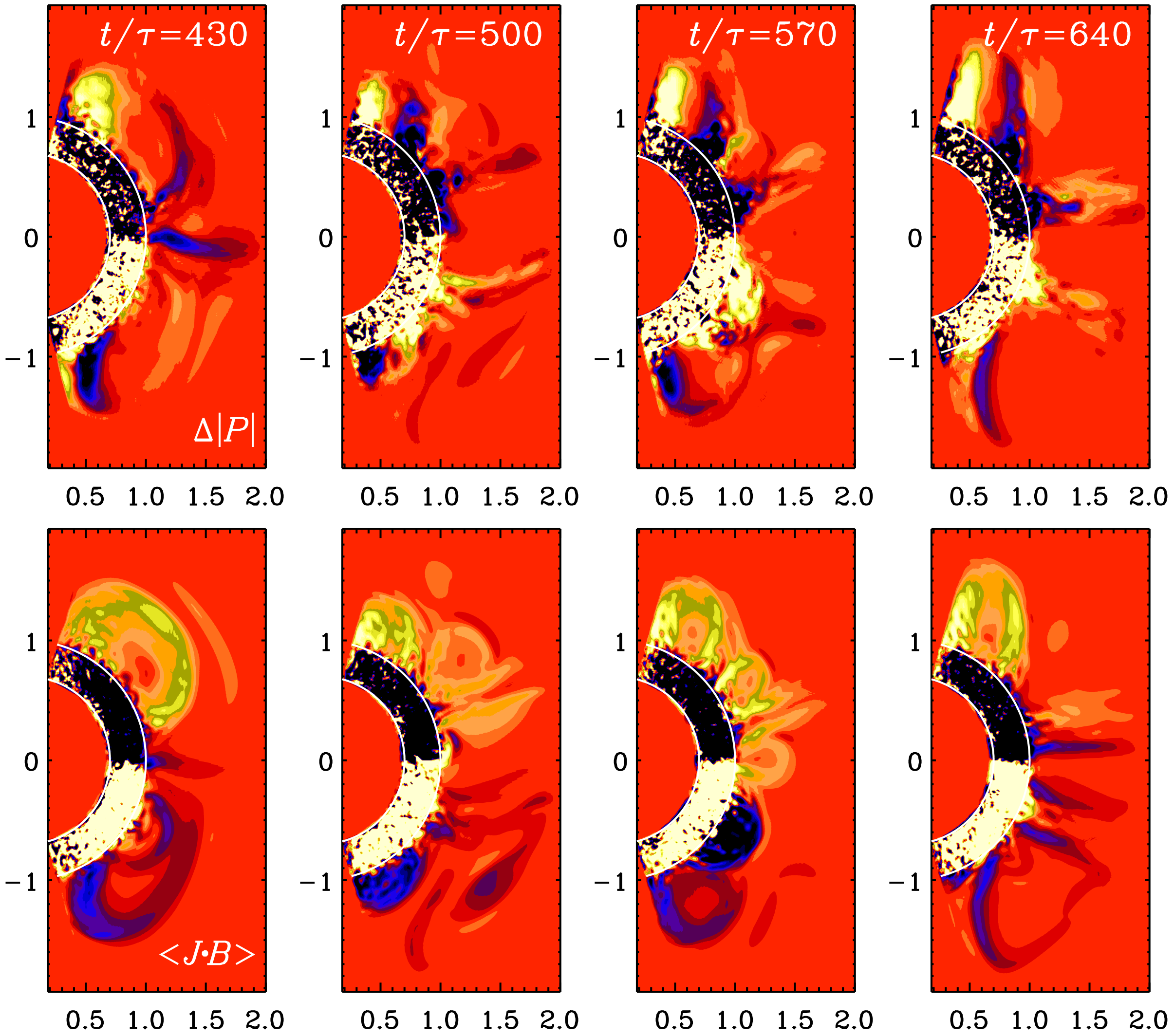

Figure 2: Polarization signature $\Delta|P|$ (upper row) and current helicity $\langle \boldsymbol{J} \cdot \boldsymbol{B} \rangle$ (lower row) in the plane of the observer at four different times.

4 Particles in Turbulence

We have performed a detailed study of Eulerian and modified Lagrangian approaches to multi-dimensional condensation and coagulation [349].

349. Li, X.-Y., Brandenburg, A., Haugen, N. E. L., & Svensson, G.: 2017, "Eulerian and modified Lagrangian approaches to multi-dimensional condensation and coagulation," *J. Adv. Model. Earth Syst.* **9**, 1116–1137

Currently, three more publications are in preparation that show the importance of local energy dissipation in determining the speed of coagulation. We also have performed work that includes the effects of condensation, in addition to coagulation.

5 Turbulent convection in stars

Using numerical simulations, we have tested new aspects of Stellar mixing length theory with entropy rain [340]. This has lead to new collaborative work by Käpylä et al. (2017).

340. Brandenburg, A.: 2016, "Stellar mixing length theory with entropy rain," *Astrophys. J.* **832**, 6

References

Brandenburg, A., & Dobler, W.: 2002, "Hydromagnetic turbulence in computer simulations," *Comp. Phys. Comm.* **147**, 471–475

Käpylä, P. J., Rheinhardt, M., Brandenburg, A., Arlt, R., Käpylä, M. J., Lagg, A., Olspert, N., & Warnecke, J.: 2017, "Extended subadiabatic layer in simulations of overshooting convection," *Astrophys. J. Lett.* **845**, L23