Astrophysical Dynamos (AstroDyn) — ERC Advanced Grant awarded to Professor Axel Brandenburg, Nordita.

ERC Advanced Investigators Grant

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Non-technical summary of the AstroDyn project:

In the last 10 years the dynamo group at Nordita, led by Professor Brandenburg, has been involved in major advances in dynamo theory, i.e. the theory that explains the conversion of kinetic into magnetic energy. In the Sun, for example, an oscillatory magnetic field is generated, but new research now shows that at large magnetic Reynolds numbers this can only happen if the Sun sheds small-scale magnetic twist through the surface while regenerating an interlinked assembly of large-scale poloidal and toroidal magnetic fields. The Sun is believed to accomplish this through coronal mass ejections, which are known to shed approximately the required amount of magnetic twist or helicity.

The work at Nordita involves large-scale three-dimensional computer simulations that are suited for making contact with turbulence theory and for improving our physical understanding. The ultimate goal of this research is to understand the solar cycle based on well founded turbulence processes rather than ad hoc assumptions that are untenable. Most of the simulations done within this project make use of the Pencil Code, which is a public domain code that is constantly being improved by around 20 scientists world wide and is being maintained under a central versioning system at Nordita.

The inclusion of the effects of coronal mass ejections into the model is believed to be one of the key factors of future solar dynamo models. Other factors include the recently discovered near-surface shear layer of the Sun, where the shear has the opposite radial gradient than in the bulk of the convection zone, and can lead to equatorward migration of sunspot activity, which was another major problem in understanding the solar dynamo. Finally, the discovery that convection pumps magnetic fields downward and thus opposes magnetic buoyancy losses is another factor that makes so-called distributed dynamo model viable. Here, the magnetic field resides in the entire convection zone, and is thus not confined to the thin layer just beneath the convection zone, which is still assumed in many models.