Distributed European Infrastructure for Supercomputing Applications

STARS Project: Simulation of Turbulent, Active and Rotating Stars (Sun)

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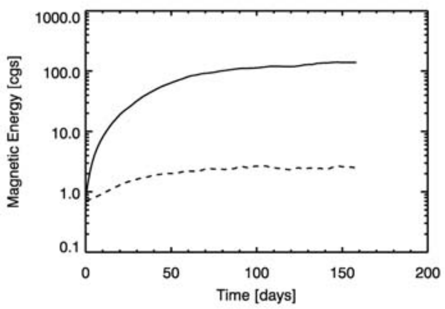
Turbulence and Magnetic Dynamo Processes in the Solar Interior

Our 3-D magnetohydrodynamics (MHD) simulations in spherical geometry using the ASH code seek to understand how turbulent stars like the Sun achieve their convective transport of heat and angular momentum, and how they generate, amplify, store and redistribute magnetic fields. The resolution of such complex and challenging questions requires focused and sustained efforts over multiple years to build a global (integrated) dynamical solar model. Such integrated solar models require large computing resources and correspond to the class of models targeted by the DEISA Extreme Computing Initiative.

The ASH code is a Fortran 90 semi-implicit, pseudo-spectral code that solved the nonlinear MHD equations in the anelastic approximation (Clune et al., Parrallel Computing, 1999, Brun, Miesch & Toomre, ApJ, 2004). ASH uses MPI for global communications and performs very efficiently on massively parallel machines. On the latest architectures, the ASH code has reached a peak performance per cpus of 970 Mflops, with an average performance, over many runs, of 750 Mflops.



DECI-Run:
$N_r x N_{theta} x N_{phi}$=257x768x1536
Reynolds = 3000
Reynolds mag = 2400
Rayleigh = 3 10^6, Taylor = 10^7

Figure 1: Temporal evolution over the 160 days of simulated time of the total and mean (dashed line) magnetic energy in a turbulent DEISA-DECI simulation of the solar convection at a Prandlt number Pm of 0.8.

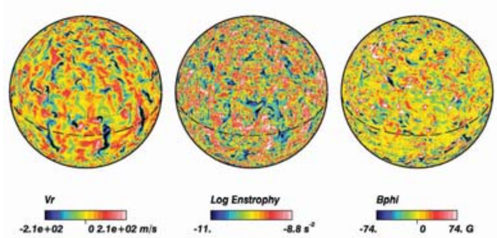


Figure 2: Snapshot of the radial velocity, log of enstrophy and toroidal magnetic field in the bulk of the highly turbulent convection zone of the DEISA DECI run. Highly intermittent convection and magnetic fields are observed in this first low Pm simulation of the solar convective envelope. We note the high degree of vorticity present in the downflows.