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Study on the Dynamo Transition in a Self-consistent Nonlinear Dynamo Model

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Using a recently developed dynamo shell model, which couples the evolution of the large scale magnetic field with the turbulent dynamics of the plasma at small scale, we investigate the large scale dynamo instability. The shell model allows to study this problem in a large range of values of the dimensionless parameters which characterize the dynamo phenomenon in many natural systems and which are at today beyond the possibility of Direct Numerical Simulation performed on supercomputers. Under specific conditions of the plasma turbulent state, the field fluctuations at small scales are able to trigger the dynamo instability. Simulations performed with our shell models seem to show that the threshold of the instability is characterized by a critical magnetic Reynolds number which decreases with the increasing of the inverse magnetic Prandlt number Pm^{-1} in the range $[10^{-6}, 1]$ and increases when Pm^{-1} is in the range $[1, 10^{8}]$. It is also shown that the dynamo instability displays a hysteretic behavior across the dynamo boundary, revealing the subcritical nature of this transition. When increasing over the instability threshold, the magnetic Reynolds number of the plasma flow, the model displays different large scale dynamo regimes, including a regime of magnetic field reversals, which is typical of the geomagnetic dynamo. The signature of these regimes can be observed also on the small scale magnetic turbulence, where it is seen that different scaling laws for the turbulent magnetic energy as function of the magnetic Reynolds number are found.