FLUID MECHANICAL ASPECTS IN SOLAR MAGNETISM: HOW CAN MAGNETIC FIELDS OF 100 KG BE PRODUCED?

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Most studies of stellar dynamos rely on 'mean-field dynamo theory', which is basically a kinematic approach; its main ingredients are the alpha-effect, the Omega-effect and turbulent diffusitity. In most studies it is further assumed that the plasma is incompressible, so that thermodynamic considerations are completely thrown out.

I will review a number of independent arguments indicating that the strength of the stored magnetic field prior to eruption is close to 10^5 Gauss. The evidence for such strong fields at the bottom of the convection zone is quite compelling, but how such field strength can be reached is not a trivial issue.

Flux expulsion by convection should lead to about equipartition field strength, but the magnetic energy density of a 10^5 G field is two orders of magnitude larger than the mean kinetic energy density of convective motions. Line stretching by differential rotation (the classical "Omega-effect") probably plays an important role, but arguments based on energy considerations show that it seems unfeasible that a 10^5 G field can be reached by this process. An alternative scenario for the intensification of the toroidal flux system stored in the overshoot layer is related to the "explosion" of rising, buoyantly unstable magnetic flux tubes.

The "explosion" of flux tubes opens a new possibility for magnetic field intensification. Thermodynamics is at the core of this process.