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REVERSALS OF THE SOLAR DIPOLE

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Solar dipole reverses each 11 years (each cycle). How it happens?

Two options are thinkable:

A. Dipole moment vanishes at the instant of reversal and then it growths in modulus but with the opposite sign.

B. Dipole direction rotates from one pole to the other however dipole moment remains nonvanishing. Substantial nonaxisymmetry is inevitable.

Disagreement between observers and theoreticians

- Practically all teoreticians base explanations of dynamo action on the option A.
- Observers support the option B.

The problem exists for the Earth's magnetic field as well.

It is very difficult (if possible) to excite nonaxisymmetric magnetic field in a rapidly rotating body.

It was known for years however we checked it again.

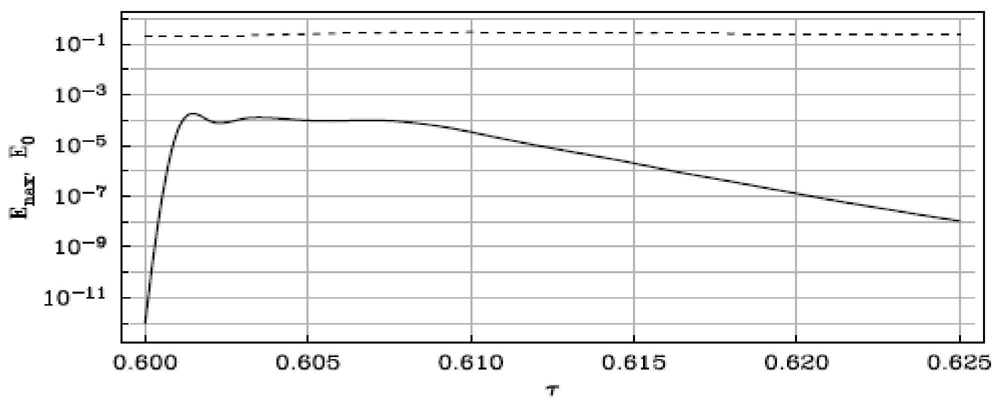

Fig. 1. The evolution of energy in the axisymmetric field (upper curve) and nonaxisymmetric field (lower curve). At dimensionless time 0.6, the steadily oscillating axisymmetric solution (period $P_{\rm E} \approx 0.024$) is perturbed by the addition of a nonaxisymmetric part to alpha between times 0.6 and 0.605. The nonaxisymmetric perturbation is then removed, and the nonaxisymmetric field decays.

A new point: nonaxisymmetry decays however quite slow.

Of course, one can claim that mean-field theory
is inapplicable, however it looks preferable to suggest
Its minimal generalisation.

The crucial break through:

DeRosa, M.L., Brun, A.S., Hoeksema, J.T. 2012, ApJ, 757, 96

Previously people tried to ignore the problem.

DeRosa et al. focus attention on the other side of the problem:
quadrupole component is inevitable at the reversal. It is a point
however quadrupole symmetry is much easier for dynamo rather
nonaxisymmetry.

Our suggestions. The Sun contains a moderate number of convective cellks (say 10 thousands) + Magnetic fluctuations are substantial = fluctuations contribute in the dipole moment.

Observable dipole moment = mean + fluctuations. Mean vanishes at the instant of reversal however fluctuating part remains nonvanishing.

For a cycle phase remote from reversal magnetic moment direction is close to the rotation axis however nearby the inversion mean becomes small and contribution of fluctuations becomes visible.

$$\mathrm{m} = \mathrm{const} \int \mathrm{H} d^3 x = \bar{\mathrm{m}} + a \mathrm{m}_1 b / \sqrt{N}.$$

It is one more point where fluctuations help. The others are Maunder minimum and Waldmeier relations.