HELICAL AND NON-HELICAL DYNAMOS

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Regeneration of magnetic fields by dynamo effect in the presence of turbulence is of interest both for astro-geophysical applications and because it may produce unwanted effects in large scale fast breader reactors. In such machines magnetic Reynolds numbers R^M of the order of 100 can be reached, possibly in excess of the critical value R_c^M for dynamo action.

Closure-based studies have revealed that the critical magnetic Reynolds number R_c^M is of the order of thirty. They also show that R_c^M can be lowered when the flow is helical, especially when there is a scale separation between the energy-carrying eddies and the largest scale of the flow (Léorat et al., 1981).

Direct numerical simulations of the three-dimensional MHD equations must be performed with a high spatial resolution in order to compute in a reliable way at (kinetic and magnetic) Reynolds numbers of 30 and/or include a good scale separation. Computing with a CRAY 1 on a grid of 64^3 points, one may reach kinetic and magnetic Reynolds numbers up to 100; such a computation takes of the order of 20 hours. Some studies may be performed at a lower resolution (and cost) on a 32^3 grid, for example by using like Gilman and Miller a magnetic Prandtl number in excess of one (Gilman, 1983).

Salient features of the results are now given. For kinetic and magnetic Reynolds numbers of 100 with non-helical forcing, a seed magnetic field with a magnetic to kinetic energy ratio β of 2% grows. After a few eddy turn-over times a statistically stationary state obtains, in which the ratio β fluctuates around 10%. The spatial structure of the magnetic field is strongly intermittent, which may be due to proximity to the transition. Other simulations with helicity gave rise to magnetic fields, well ordered in the large scales and whose energy is at least twice that of the kinetic eddies (Meneguzzi et al., 1981).

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