

The present status of geodynamo theory

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During the past decade there have been many numerical simulations of the geodynamo, and many of these have created magnetic fields that resemble the observed geomagnetic field by, for example, reversing their magnetic polarities at irregular intervals, creating fields that at other times drift westward, etc. The success has been so great that some people now claim that the geodynamo problem is “solved”. On closer inspection, however, it is clear that the numerical simulations have serious deficiencies. Some of the diffusivities they employ are far greater than is plausible for the corresponding molecular diffusivities in the Earth’s core. There are also serious difficulties in supposing that these are turbulent diffusivities, since they are assumed to be scalar diffusivities, despite the fact that the fluid core is almost certainly very turbulent. This turbulence is plausibly highly anisotropic, suggesting that turbulent diffusivities are far more appropriate than scalar diffusivities. The unreasonable success of the numerical simulations may be called the “geodynamo paradox”. It is the resolution of this paradox that is now one of the main thrusts of geodynamo theory.

One particular numerical method has dominated investigations of the geodynamo, namely the spectral transform method. This has many advantages over other methods, but other techniques are now being explored. As assessed by dimensionless measures such as the Reynolds and Peclet numbers, motions in the Earth’s fluid core are lightly damped. Such systems tend to create sharp gradients and exhibit intermittency. Numerical methods have been specially developed to deal with such behaviors, and these will be touched on here. It is hoped that these will go some way towards solving the geodynamo paradox, but there is still a long way to go.