Reversals in Direct Numerical Simulations and Mean-Field Models of the Geodynamo: a Statistical Approach

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Paleomagnetic studies documented several hundreds of sudden and occasional, apparently stochastic, global polarity reversals of the past Earth's dipolar magnetic field. Recent self-consistent 3D numerical dynamo models reproduced many features of the Earth's magnetic field, including reversals. The statistical study of reversals, in both paleomagnetic data and geodynamo simulations, is necessary to assess the validity of such models and to acquire a better knowledge of the physical processes involved.

In this context, we tested several probability distributions fitting the reversal sequences from two numerical dynamo simulations, in different parameter regimes with a total of around 1500 reversals. In our reversing geodynamo models, an exponential distribution (signature of a purely random Poisson process) gives a very good fit of polarity intervals, while a log-normal distribution describes reversal durations themselves. Furthermore, excursions, counted during periods of very low dipole moment, are statistically indistinguishable from reversals. Excursions can be therefore considered as "uncessful" reversals.

In conclusion, according to the numerical simulations, reversals are events which happen completely randomly. The finite time required by the dipole to build up in the opposite polarity (reversal duration) introduce a short-term memory in the time series, modifying the distribution profile accordingly. The comparison with the distribution of Earth's paleomagnetic polarity intervals and its implications are also discussed.

The current development of mean-field dynamo models, based on helicity profiles directly retrieved from 3D geodynamo simulations, can play the key role of discriminating among different physical processes that reproduce the observed distribution profile of polarity intervals.