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Stochastic resonance in a noise triggered relaxation oscillation model of Earth's magnetic field reversals

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One of the most interesting features of Earth's magnetic field reversals is their pronounced asymmetry, including a slow dipole decay and a fast recreation of the reversed dipole. This asymmetry indicates a possible connection with relaxation oscillations as they were early studied by van der Pol.

A simple mean-field dynamo model (Phys. Rev. Lett. 94 (2005), 184506) is analysed with view on this similarity, and a comparison of the time series and the phase space trajectories with those of paleomagnetic measurements is carried out. For the case of highly supercritical dynamos a very good agreement with the paleomagnetic data is achieved (Earth Planet. Sci. Lett. 143 (2006), 828; Geophys. Astrophys. Fluid Dyn. 101 (2007), 227).

Deviations of both numerical and paleomagnetic reversal sequences from Poisson statistics are touched upon (Phys. Earth Planet. Inter. 164 (2007), 197). The observed clustering property of reversals is interpreted as a feature of "punctuated equilibrium" which is, in turn, typical for metastable systems. We show that both metastability and the relaxation oscillation character have their common root in the typical spectral behaviour of the non-selfadjoint dynamo operator.

In addition, we try to constrain the most essential parameters of the dynamo model by the typical time scale of individual reversals, the clustering characteristics, and the stochastic resonance phenomenon (arxiv.org/0709.3932). The latter was recently shown to appear with a time period typical for the Milankovitch cycle of the Earth's orbit eccentricity.