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Towards understanding geomagnetic reversals

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Field reversals are the most dramatic episodes in the geomagnetic history. Several hundreds of them have been recorded by paleomagnetists, but our understanding of these exceptional events is still very sketchy. Patchy spatial and temporal resolution of paleomagnetic data prevent us from constructing global field models that would bear valuable information of the dynamics at the top of Earth's core. Even todays highly resolved field models may tell us little about what is going on deeper into the core. Dynamo simulations, on the other hand, are condemned to run at unrealistic parameters but provide a complete picture of the internal processes. However, unravelling the complex interaction of magnetic and flow field in a time-dependent 3d dynamo simulation remains a formidable task. I have therefore mainly analysed relatively simple dynamo models where both fields are large scale. Over one hundred reversals have been simulated for one particular model. All show a similar dynamics that can also be identified in much complexer simulations. Inverse field is mainly created inside the tangent cylinder [TC] and in the equatorial region. Inside the TC hot rising plumes push normal polarity field away and create inverse field by twisting normal fieldlines in a helical motion. In the equatorial region anticyclons produce inverse field in an outward stretching motion. Both mechanisms are common in dynamo simulations at not too low Rayleigh numbers. When the Rayleigh number is increased the inverse-field producing mechanisms become very time dependent, cumulating in intermittent very strong events. At times these events are powerful enough to cancel the normal polarity field, starting a period with weak and directionally undecided dipole contribution. A recovering dipole of one or the other polarity ends the episode and classifies it as an excursion or a reversal. The rarity of events strong enough to cancel the predominating dipole component explains why reversals are so infrequent.