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A hemispherical dynamo on Mars?

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Numerous threedimensional MHD models investigated the induction of planetary magnetic fields under the influence of a laterally varying heat flux through the core mantle boundary (CMB). E.g. for the dynamo process in ancient Mars, a planetary scale CMB heat flux anomaly (Y10) reduces the rate of heat escaping the core in the north and increases it in the south, what concentrates the convection and induction into a single hemisphere. On the expense of rapid polarity inversions, it then seemed possible to increase the equatorial asymmetry far enough to correspond to the hemisphericity of the Martian crustal magnetisation.

Within this study we parametrise horizontal extent, latitudinal position and amplitude of the anomaly in a rather comprehensive parameter study. Global flow symmetry properties are justified and used to quantify the influence of the heat flux anomalies and the action of the magnetic field. Our results suggest, that only rather large scale and strong amplitude anomalies are sufficient to induce magnetic fields matching the equatorial asymmetry of the crustal magnetisation pattern. Further all geometrically corresponding dynamo models show the problematic rapid polarity inversions which allow a strong and unidirectional magnetisation only when the crustal built-up time is on the order of the magnetic diffusion time (several kyrs).

In summary, our results suggest that a single mantle hot spot positionend anywhere at the CMB will affect the core dynamics significantly only if its horizontal extent is on the order of the radius of the outer core. For Mars it seemes quite plausible, that the crustal magnetisation pattern was strongly influenced by post-dynamo demagnetisation processes rather than being magnetised by a geometrically corresponding internal dynamo field.