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Wave generation in rotating and non-rotating MHD Spherical Couette Flow with an applied vertical magnetic field

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We study direct numerical simulations of rotating and non-rotating Couette flows in a spherical shell under the influence of an applied vertical magnetic field. We restrict ourselves to a parameter regime with Elsasser number $\Lambda = 1$, which allows to investigate the action of the Magneto Rotational Instability in planetary interiors. According to local linear theory, the only relevant unstable mode for the considered parameter regime is the axisymmetric one. However, our numerical calculations show the dominance of non-axisymmetric structures after a short transition time. Our findings are in good agreement with experimental results (Nornberg et al PRL, 104, 074501, 2010). As argued by Nornberg et al., non-axisymmetric structures are caused by Magneto-Coriolis waves (MC-waves) propagating vertically inside the inner core tangent cylinder. Moreover, MC-waves generate helicity and lead to a poloidal field amplification. Consequently, the magnetic field at the outer shell boundary becomes time dependent. These oscillatory properties are also relevant in the low Rossby numbers regime and could correspond to some observed Earth's magnetic variations on short timescales.

In order to better understand our non-linear 3D calculations, we consider modified equations. Using linearized MHD equations, we succeed in getting insight into the conditions for the development of MC-waves. The generation of axisymmetric poloidal field is investigated by means of an induction equation with a fixed velocity field. The background state and the prescribed velocity field are inferred from 3-D non-linear simulations.