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A spherical-Couette dynamo

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We solve for flow and dynamo action of a conducting fluid that fills the cavity between two differentially rotating concentric spheres. The shear flow remains axisymmetric when the differential rotation is weak but becomes becomes unstable ones it exeeds a critical value. The form of these instabilites is reminiscent of convective columns and has a similar helicity structure, suggesting that is can work as a dynamo. This setup is thus considered to be a good candidate for an experimental dynamo in liquid metals, because, unlike convection, very strong super-rotation is easy to produce in laboratory settings. We show that such a flow indeed works as a dynamo and present simulations for Ekman numbers $E = 10^{-3}$ and $E = 10^{-4}$. The differential rotation at the Stewardson shear layer and at the inner sphere gives rise to a strong ω-effect. The majority of magnetic energy is therefore contained in the axisymmetric toroidal field. The poloidal field is dominated by the axial dipole component and is concentrated inside the tangent cylinder formed by the Stewardson layer. This concentration if part of the backreaction of the magnetic field on the fluid flow limiting magnetic field growth. The presented solutions are fairly close to onset of flow and dynamo instabilities. Magnetic Prandtl numbers are as low as $Pm = 0.2$ for $E = 10^{-4}$, the RMS magnetic Reynolds numbers are of the order $R_m = 10^2$. These values suggest that the dynamo experiment currently being build may indeed work as a self-sustained dynamo.