Numerical simulation of the Von-Karman-Sodium dynamo experiment

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For the first time, a direct numerical simulation of the incompressible, fully nonlinear, magnetohydrodynamic (MHD) equations for the Von-Karman-Sodium (VKS) experiment is presented with the two counter-rotating impellers realistically represented. Dynamo thresholds are obtained for various magnetic permeabilities of the impellers and it is observed that the threshold decreases as the magnetic permeability increases. Hydrodynamic results compare well with experimental data in the same range of kinetic Reynolds numbers: at small impeller rotation frequency, the flow is steady; at larger frequency, the fluctuating flow is characterized by small scales and helical vortices localized between the blades. MHD computations show that two distinct magnetic families compete at small kinetic Reynolds number and these two families merge at larger kinetic Reynolds number. In both cases, using ferromagnetic material for the impellers decreases the dynamo threshold and enhances the axisymmetric component of the magnetic field: the resulting dynamo is a mostly axisymmetric axial dipole with an azimuthal component concentrated in the impellers as observed in the VKS experiment.