Route to Turbulence in Sheared Annular Electroconvection

PE-ICHUN TSAI, STEPHEN W. MORRIS, Dept. of Physics, University of Toronto, ZAHIR A. DAYA, Defence R&D Canada — We studied the route to turbulence of a 2D, electrically-driven annular film, using direct numerical simulation. The film can simultaneously be sheared by rotating the inner edge of the annulus. The simulation models a laboratory experiment which consists of a weakly conducting liquid crystal film suspended between concentric electrodes. The film convects when a sufficiently large voltage $V$ is applied. The flow is driven by a surface charge density inversion unstable to the applied potential. The important dimensionless parameters are a Rayleigh-like number $Ra$, proportional to $V^2$, a Prandtl-like number $Pr$ and the radius ratio $\alpha$, characterizing the annular geometry. The applied shear has Reynolds number $Re$. The simulation uses a pseudo-spectral method with radial Chebyshev polynomials and azimuthal Fourier modes. The numerical results show a suppression of the onset of convection under the influence of shear that quantitatively agrees with previous theoretical and experimental results. Just above onset under shear, the numerical results reveal a Ruelle-Takens-Newhouse scenario in which there are bifurcations between various periodic and quasi-periodic flows. With increasing $Ra$, at constant applied $Re$, we observe subcritical bifurcations, indicated by sudden increases in convective charge transport. These jumps are also seen experimentally, and correspond to bifurcations between different azimuthal mode numbers.

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