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Numerical continuation for sheared annular electroconvection

We use numerical continuation methods to investigate the flows that occur in a mathematical model of the sheared annular electroconvection experiment. In particular, we study the flow of a liquid crystal film suspended between two annular electrodes, and subjected to an electric potential difference and a radial shear. Due to the Smectic A nature of the liquid crystal, the fluid can be considered two-dimensional, and its motion can be effectively modelled using the 2-D incompressible Navier-Stokes equations coupled with an equation for charge continuity. This system is a close analogue of some laboratory-scale geophysical flow experiments (e.g. the differentially-heated rotating annulus).

For small values of the applied electric potential, a steady axisymmetric flow is observed. As this parameter is increased, a transition to rotating waves, followed by a secondary transition to amplitude-modulated rotating waves, occurs. Subsequently, period-doubling and symmetry breaking bifurcations lead to more complicated flows. Further increase in the parameter leads to flows that resemble a rotating wave with one or two isolated vortices.

We investigate the bifurcation structure of solutions that connects these various types of flow using numerical continuation based on time-integration. In particular, a Newton-Krylov method, which exploits the rotating nature of the flows, is implemented for the continuation of rotating waves and modulated rotating waves, and linear stability analysis of a flow map is used to identify the flow transitions that result due to changes in the model parameters.

This is joint work with Mary Pugh and Stephen Morris (University of Toronto).