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Structure and bifurcation properties of spiral vortices

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Abstract

We investigated the structure, dynamics und bifurcation properties of spiral vortices in the Couette Taylor system. Just as the Taylor vortices (TVF), also the spiral solutions (SPI) arise in a primary forward bifurcation out of the basic state (Circular Couette Flow, CCF). As a linear stability anlysis of the CCF shows, the bifurcation threshold of the spirals lies above or below that of TVF, depending on the control parameters (inner/outer Reynolds number $\mathcal{R}_1/\mathcal{R}_2$ and radius ratio $\eta = r_1/r_2$).

Nonlinear solutions were computed numerically using a combination of finite differences and a spectral decomposition in azimuthal direction. Depending on the control parameters, we found regions with monostability in systems with axial periodicity, where both structures (stationary TVF and propagating SPI) exist, but only one is stable, and bistability, where both are stable.

The spiral frequency is strongly influenced by the azimuthal flow of the basic CCF state and can be captured within a simple model. Structural properties of SPI and TVF and their changes with control parameters are compared and analyzed. Furthermore, comparisons with experimental results are presented. In order to investigate the effect of non-rotating lids at the ends of the annulus on the dynamics of the spiral pattern, we also simulated systems with these experimental boundary conditions.