Instabilities of surface tension driven flows between counter-rotating disks

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Instabilities of surface tension driven flows between counter-rotating disks were investigated by using the linear stability analysis method. The basic flow equations are solved by a numerical scheme based on a pseudo-spectral Chebyshev method. The perturbation equations are solved based on a discretization using the Chebyshev polynomials for expansion of variables.

For the case of counter-rotating disks with small Prandtl number liquids (Pr = 0.001 and 0.01), instabilities are purely hydrodynamic. The perturbation of the temperature on the free surface is not important for the instability mechanism. The bifurcation is from the axisymmetric steady state to a non-axisymmetric steady state when no rotation is applied. The most unstable mode is a stationary secondary flow circulating around a stationary horizontal axis. When rotations are applied, the bifurcation is from the axisymmetric state to an oscillatory state. The most unstable mode becomes a traveling hydrodynamic wave. For Prandtl number of 0.1, the thermocapillary effects on the free surface become relevant for the onset of instabilities and the bifurcation mode depends on the liquid volume when no rotation is applied. For Prandtl number of 1, the thermocapillary effects on the free surface become important and the bifurcation mode is a hydrothermal wave. The critical Reynolds numbers are functions of Prandtl number, the aspect ratio and the rotation Reynolds number. The rotation Reynolds numbers for the current calculations are in the range of 0 and 100. For cylindrical liquid bridges, the critical Reynolds number exhibits a maximum at certain rotation Reynolds number.