Oscillatory instability in a closed cylinder with rotating top and bottom

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A numerical investigation of oscillatory instability is presented for axisymmetric swirling flow in a closed cylinder with rotating top and bottom. The critical Reynolds number and frequency of the oscillations are evaluated as function of the ratio of angular velocities of the bottom and the top ($\xi = \Omega_{bottom} / \Omega_{top}$). Earlier Linear Stability Analysis (LSA) using the Galerkin spectral method by Gelfgat et al. [Phys. Fluids, **8**, 2614-2625 (1996)] revealed that the curve of the critical Reynolds number behaves like an "S" around $\xi = 0.54$ in the co-rotation branch and around $\xi = -0.63$ in the counter-rotation branch. Additional finite volume computations, however, did not show a clear "S" behaviour.

In order to check the existence of the "S" shape, computations are performed using an axisymmetric finite volume Navier-Stokes code at aspect ratios ($\lambda = H / R$) 1.5 and 2.0. Comparisons with LSA at $\lambda = 1.5$ show that the "S" shape does exist. At an aspect ratio $\lambda = 2$, our results show that the critical Reynolds number curve has a "beak" shape in the counter-rotation region and a much wider "S" shape in the co-rotation region. This transformation of the "S" shape is caused by the change in aspect ratio from 1.5 to 2 and therefore the corresponding topological behaviour of the transition is different.

The bifurcation from a steady to an unsteady regime is governed by Hopf bifurcations in most of the counter and co-rotating regions. In a region close to the top of the "S" shape, however, a discontinuous bifurcation has been detected.

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