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Swirling flow states in diverging or contracting pipes ZVI RUSAK, YUXIN ZHANG, Rensselaer Polytechnic Institute, HARRY LI, U Michigan, SHIXIAO WANG, U Auckland, NZ — We study the dynamics of inviscid and incompressible swirling flows in diverging or contracting long circular pipes. The inlet flow is described by the circumferential and axial velocity profiles together with a fixed azimuthal vorticity while the outlet flow is characterized by a zero radial velocity state. We first solve the Squire-Long PDE for steady-state flows in a pipe and determine the bifurcation diagram of the various possible flow states as a function of pipe geometry. These include states with a decelerated axial velocity along the pipe center line, an accelerated axial velocity along the pipe center line, vortex breakdown states with a stagnation zone around the pipe center line, and wall-separation states. Then, we establish a correlation between the outlet state of these solutions and solutions of the columnar (x-independent) Squire-Long ODE. Numerical simulations based on the unsteady stream function-circulation equations shed light on the stability of the various steady states and their domain of attraction in terms of initial conditions. The results show that pipe divergence promotes the appearance of vortex breakdown states while pipe contraction induces the formation of wall-separation states.

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