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Numerical bifurcation analysis of limit cycles and hysteresis in laminar swirling jets[1] CHRISTOPHER DOUGLAS, BENJAMIN EMERSON, TIMOTHY LIEUWEN, Georgia Inst of Tech — This work details a nonlinear bifurcation analysis involving time-periodic solutions in laminar swirling jets. Swirling jets are subject to a wide range of different coherent flow instabilities which manifest themselves in a variety of forms ranging from nearly stationary axisymmetric recirculation regions to unsteady asymmetric vortical structures. Even in the laminar regime, these flows have been shown to exhibit a significant degree of hysteresis among their various states which has largely obscured any comprehensive view of the swirling jet parameter space. To date, bifurcation analyses of strongly swirling jets are quite limited, with most directed toward the phenomenon of axisymmetric vortex breakdown and its stability toward three-dimensional perturbations. We aim to fill this void by tracing branches of three-dimensional nonlinear time-periodic solutions in an unconfined swirling jet for $Re \leq 200$. Our results reveal pre-breakdown $|m| = 2$ and post-breakdown $|m| = 1$ limit cycle states which are consistent with previous experimental observations from the LadHyX group. In addition, the associated bifurcation diagrams offer a clear perspective of the Re-S parameter space, emphasizing the role of saddle-node bifurcations on the observed hysteresis behavior.

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