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Transition to asymmetry in pipe flow of shear-thinning fluids: a linear instability? DAVID DENNIS, CHAOFAN WEN, ROBERT POOLE, University of Liverpool — Previous studies of shear-thinning fluids in pipe flow discovered that, although the time-averaged velocity profile was axisymmetric when the flow was laminar or fully turbulent, contrary to expectations it was asymmetric in the laminar-turbulent transition regime. We reveal that in fact the asymmetry is not induced by the laminar-turbulent transition process, but is an instability of the laminar state. Furthermore, the transition process is responsible for returning symmetry to the flow (i.e. the opposite to what was previously believed), which explains why the fully turbulent case is axisymmetric. The experiment was performed using an aqueous solution of xanthan gum (0.15%), an essentially inelastic shear-thinning polymer solution. Stereoscopic particle image velocimetry was used to measure the 3C velocity vectors over the entire circular cross-section of the pipe, 220 pipe diameters downstream of the inlet. The deviation from the axisymmetric laminar state is observed to develop in the form of a supercritical bifurcation with square-root dependence on Reynolds number. The asymmetry is non-hysteretic and reversible, not only having a favoured location, but a preferred route between axisymmetry and asymmetry, which it adheres to regardless of the direction of the transition.

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