Xu, Feng; **Billingham, John**; **Jensen, Oliver E.**

Resonance-driven oscillations in a flexible-channel flow with fixed upstream flux and a long downstream rigid segment. (English) Zbl 1309.76236

J. Fluid Mech. 746, 368-404 (2014).

Summary: Flow driven through a planar channel having a finite-length membrane inserted in one wall can be unstable to self-excited oscillations. In a recent study [the authors, J. Fluid Mech. 723, 706–733 (2013; Zbl 1287.76253)], we identified a mechanism of instability arising when the inlet flux and outlet pressure are held constant, and the rigid segment of the channel downstream of the membrane is sufficiently short to have negligible influence on the resulting oscillations. Here we identify an independent mechanism of instability that is intrinsically coupled to flow in the downstream rigid segment, which becomes prominent when the downstream segment is much longer than the membrane. Using a spatially one-dimensional model of the system, we perform a three-parameter unfolding of a degenerate bifurcation point having four zero eigenvalues. Our analysis reveals how instability is promoted by a 1:1 resonant interaction between two modes, with the resulting oscillations described by a fourth-order amplitude equation. This predicts the existence of saturated sawtooth oscillations, which we reproduce in full Navier-Stokes simulations of the same system.

MSC:

76Z05 Physiological flows
74F10 Fluid-solid interactions (including aero- and hydro-elasticity, porosity, etc.)

Keywords:

biological fluid dynamics; channel flow; flow-structure interactions

Full Text: DOI

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