Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

Spiral vortex formation in cross-slot flow SIMON HAWARD, NOA BURSHTEIN, Okinawa Inst of Sci Tech, ROBERT POOLE, University of Liverpool, PAULO OLIVEIRA, Universidade de Beira Interior, MANUEL ALVES, Universidade do Porto, AMY SHEN, Okinawa Inst of Sci Tech — Fluid flow through bisecting channels (cross-slots) results in the formation of a steady spiral vortex as the Reynolds number (Re) is increased above a modest critical value (Re_c). The value of Re_c is strongly dependent on the channel aspect ratio, $\alpha = d/w$, where d and w are the depth and width of the channel, respectively. Quasistatic experiments and numerical simulations over a range of Re show that for low α this symmetry-breaking bifurcation is supercritical, however subcritical behavior develops as α is increased. The system can be described by a Landau-type 6^{th}-order polynomial potential and we identify a value of $\alpha \approx 0.55$ for which a tricritical point can be found. Dynamic experiments and simulations conducted across the transition indicate a plausible mechanism for the onset of the instability. Our analysis suggests that the transition results from the growth of center-point vorticity induced by random imbalances between two pairs of Dean vortices that form in the channel cross-section. Vorticity growth is governed by two distinct time scales. At short times, viscous diffusion dominates and vorticity grows slowly. Once the vorticity is sufficiently high, vortex stretching dominates and the vorticity grows rapidly until steady state is reached.

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Date submitted: 31 Jul 2016 Electronic form version 1.4