Abstract Submitted
for the DFD11 Meeting of
The American Physical Society

Competition between single and double helical vortex breakdown FRANCOIS GALLAIRE, LFMI-EPFL Lausanne, Switzerland, PHILIPPE MELIGA, M2P2-CNRS Marseille, France, JEAN-MARC CHOMAZ, LadHyX, CNRS-Ecole Polytechnique, France — The spiral vortex breakdown of nominally axisymmetric, swirling flows observed in the three-dimensional direct numerical simulations of Ruith, Chen, Meiburg & Maxworthy [JFM 2003, 486, p 331–378] is revisited and interpreted in terms of linearly unstable global modes. We show that increasing the swirl number, which compares the magnitude of the azimuthal and axial velocity components, results in successive Hopf bifurcations involving helical modes of azimuthal wave numbers $m = -1$ and $m = -2$. These modes develop in the lee of the axisymmetric bubble, and correspond to spiral perturbations rotating in time in the same direction as the swirling flow, but winding in space in the opposite direction. The global stability analysis is shown to yield an accurate frequency prediction. We further extend the range of swirl considered in the DNS, and show that the $m = -1$ and $m = -2$ Hopf bifurcations can occur simultaneously, both modes approaching a strong 2:1 resonance. We compute the normal form describing the leading-order nonlinear interaction between modes, and show that it accurately predicts the pattern and symmetries of the solutions observed in the DNS calculations, with satisfactory agreement on the bifurcation thresholds.

Francois Gallaire
LFMI EPFL

Date submitted: 04 Aug 2011 Electronic form version 1.4