Semi-asymptotic methodology for vortex-wave interaction applied to computing equilibria in parallel shear flow

- BIFD 2011 -

Hugh M Blackburn*, Philip Hall[1] and Spencer J Sherwin[2]

[*] Department of Mechanical and Aerospace Engineering
Monash University, 3800, Australia
e-mail: hugh.blackburn@monash.edu, web page: http://users.monash.edu.au/~bburn/

[1] Department of Mathematics
Imperial College London
South Kensington Campus, London SW7 2AZ, UK
Email: phil.hall@imperial.ac.uk

[2] Department of Aeronautics
Imperial College London
South Kensington Campus, London SW7 2AZ, UK
Email: s.sherwin@imperial.ac.uk

ABSTRACT

Vortex-wave interaction has recently been advanced as a theory [1] to which explains equilibrium states observed in shear flows, previously computed directly in DNS via continuation or Newton methods [2,3]. Such equilibria have been advanced as providing organising centres for transition in flows notorious for exhibiting linear stability on the one hand but ready transition to turbulence on the other, e.g. plane Couette flow, Hagen–Poiseuille flow [4]. The distinction between the theory [1] and the direct methods [2,3] is that the theory provides a mechanism to describe how the essential elements (streak, roll, oblique wave) couple to produce a self-sustaining state, as well as a computational methodology, whereas the direct methods provide only a methodology. The theory uses asymptotic methods to decouple the various parts of the problem, and also to provide nonlinear coupling between the wave and the roll. It also provides the previously observed [3] scaling in the high-*Re* limit. The simpler methodology we advance here also uses asymptotic methods to decouple the parts of the problem, but the nonlinear coupling is computed more robustly, and allows us to move on from plane Couette flow to tackle more general problems.

REFERENCES

[1] Hall P & Sherwin SJ 2010 Streamwise vortices in shear flows: harbingers of transition and the skeleton of coherent structures *J Fluid Mech* **661**: 178–205.

[2] Nagata M 1990 Three-dimensional finite-amplitude solutions in plane Couette flow: bifurcation from infinity *J Fluid Mech* **217**: 519–527.

[3] Wang J, Gibson J & Waleffe F 2007 Lower branch coherent states in shear flows: transition and control *Phys Rev Lett* **98** (20): 204501.

[4] Hof B, van Doorne C, Westerweel J, Nieuwstadt F, Faisst H, Eckhardt B, Wedin H, Kerswell R & Waleffe F 2004 Experimental observation of nonlinear traveling waves in turbulent pipe flow *Science* **305** (5690): 1594–1598.