Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

Streamwise-constant model of intermittent turbulent pipe flow[1]
JEAN-LOUP BOURGUIGNON, BEVERLEY MCKEON, Caltech — A streamwise-constant model of intermittent turbulent pipe flow is presented, following the work on Couette flow of Gayme et al. 2010. The model consists of two evolution equations derived from Navier-Stokes, one for the streamfunction describing the in-plane velocities and one for the axial velocity. Under stochastic forcing, the model exhibits a quasi-periodic self-sustaining cycle characterized by the creation and subsequent decay of turbulent clusters of coherent structures remarkably similar to turbulent puffs. The flow structures inside these turbulent clusters correspond to the quasi-streamwise vortices and streaks observed in transition experiments. The time traces of the centerline velocity present numerous puff signatures, i.e. the centerline velocity drops suddenly and then increases smoothly nearly up to its laminar value. Under deterministic forcing, our model shows that the main features of turbulent pipe flow are robust and can easily be reproduced by solving a single momentum balance equation.

[1]The support of AFOSR grant # FA 9550-09-1-0701 (program manager John Schmisseur) is gratefully acknowledged.

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Date submitted: 03 Aug 2010 Electronic form version 1.4