8:13AM FI.00002 Contour dynamics with boundaries , DARREN CROWDY, Imperial College London, AMIT SURANA, MIT — Contour dynamics is a well-known numerical method for computing the motion of planar patches of uniform vorticity. Usually, the patches are taken to exist in free space. There is much interest however (e.g. for geophysical applications), in formulating a generalized contour dynamics algorithm for computing vortex patch motion in general fluid domains bounded by impenetrable walls. This talk will present some new theoretical ideas for the construction of such an algorithm.

8:26AM FI.00003 Detection of Lagrangian Coherent Structures in 3D Turbulence , MELISSA GREEN, CLARENCE ROWLEY, Princeton University, GEORGE HALLER, Massachusetts Institute of Technology — Direct Lyapunov Exponents (DLE) are used to identify Lagrangian coherent structures in two different three-dimensional fluid flows, including a single isolated hairpin vortex, and a fully developed turbulent flow. These results are compared with commonly used Eulerian criteria for coherent vortices. We find that the DLE method has several advantages over Eulerian methods, including greater detail and the ability to define structure boundaries without relying on a preselected threshold. As a further advantage, the DLE method requires no velocity derivatives, which are often too noisy to be useful in the study of a turbulent flow. We study the evolution of a single hairpin vortex into a packet of similar structures, and show that the birth of a secondary vortex corresponds to a loss of hyperbolicity of the Lagrangian coherent structures.

8:39AM FI.00004 Transition of a Swirling Vortex from the One-celled to Two-celled Structure , CHIN-CHOU CHU, SHIH-LIN HUANG, CHIEN-CHENG CHANG, HUNG-CHENG CHEN, INSTITUTE OF APPLIED MECHANICS, NATIONAL TAIWAN UNIVERSITY, TAIPEI , TAIWAN, ROC COLLABORATION, DIVISION OF MECHANICS, RESEARCH CENTER FOR APPLIED SCIENCE, ACADEMIA SINICA, TAIPEI , TAIWAN, ROC COLLABORATION — In this study, we investigate the transition of a swirling vortex from a one-celled to two-celled vortex structure during its formation in a rotating tank. The main idea is to initiate the flow by siphoning fluid out of the tank and then lift the siphoning mechanism off the water all of a sudden. This life cycle of the swirling vortex can be roughly divided into three stages. (1) The stage of siphoning induces the formation of the one-celled vortex. (2) The stage of downward jet impingement triggers the transition of the vortex. (3) The stage of detachment of the inner cell leads to a cup-like recirculation zone, pushed upward by an up-drafting boundary layer flow. The sequence of complex flow behaviors enables us to correlate the time history of the swirling vortex to an existing conceptual model for tornadoes, and to uncover some results not confirmed or observed before.

8:52AM FI.00005 Wavelet analysis of a bursting vortex , JORI E. RUPPERT-FELSOT, MARIE FARGE, LMD UMR CNRS 8539 Ecole Normale Supérieure, PHILIPPE PETITJEANS, PMMH UMR CNRS 7636 Ecole Supérieure de Physique et Chimie Industrielles — We study the quasi-periodic turbulent bursting of a laboratory produced isolated vortex immersed in laminar flow [Y. Cuypers et al., J. Turb. **7**, N7 (2006)]. Particle Image Velocimetry measurements of the velocity and vorticity field in a plane perpendicular to the axis of the vortex allowed us to resolve the time evolution of the bursting, from the initial laminar vortex through the buildup of the final turbulent energy spectrum. The scaling exponent of the energy spectrum was found to evolve from -1 to -2, with a -5/3 spectrum recovered from the time average. We separated the flow field into a coherent and incoherent component using the discrete wavelet transform (DWT) applied to the vorticity and velocity fields [e.g. M. Farge et al., Phys. Fluids **11**, 2187-2201 (1999)]. We found that the coherent field retained the dynamical and statistical properties of the total field, such as the evolution of the PDF and turbulent energy spectrum, and was efficiently captured by a small percentage of the large amplitude coefficients of the DWT. The incoherent field, corresponding to the remaining small amplitude coefficients, was insensitive to the bursting.

9:05AM FI.00006 Vortex breakdown in a closed cylinder: Experiments and control , DAVID LO JACONO, KERRY HOURIGAN, Monash University, JENS SORENSEN, Technical University Denmark, MONASH-DTU COLLABORATION, MONASH-DTU COLLABORATION — The flow within a closed cylinder with a rotating lid is considered. The effect of a thin rotating rod positioned along the center axis has been studied by means of Stereo Particle Image Velocimetry (SPIV). A parametric study for the cavity with a rod has been carried out for several configurations, changing the Reynolds number of the rod and the lid independently. The SPIV technique allows us to compare the obtained vector field with previous numerical work. The co-rotation and counter-rotation of the rod relative to the lid is found to affect the size and existence of the various breakdown bubbles. The results are consistent with previous experimental visualization and numerical work.

9:18AM FI.00007 The role of geometry on the equilibrium configurations of two dimensional, inviscid channel flows[1] , LAI PAN YIP, KWOK CHOW, University of Hong Kong, DAVID GURARIE, Case Western Reserve University — The effect of aspect ratios on the equilibria of channel flows with vorticity is studied. Numerical simulations of two dimensional, inviscid channel flows with no slip boundary conditions are performed. Starting with random initial conditions, the flows undergo self-organization and attain equilibrium with special arrangements of vortices depending on the aspect ratio (ratio of channel width to streamwise period). An inviscid, semi-Lagrangian code is employed, where interpolation mimics the effects of mixing. To study the role of geometry, the aspect ratio of the channel is varied from 0.1 to 1.0 (from very narrow to relatively wide channel). In particular, three or more pairs of vortex dipoles per period appear when the aspect ratio is very small (∼0.1), but there is only one such pair for larger aspect ratio (∼0.5). More exotic configurations, such as triangular diploes and highly asymmetric dipole structures, are found for still larger values of aspect ratios. The relationship between vorticity and stream function is studied through scatter plots. Three types of relations are identified, namely, multi-sinh curves, symmetric sinh curve and highly shifted sinh curve.

[1]Supported by Hong Kong Research Grants Council.

9:31AM FI.00008 Three-dimensional structure of a confined swirling jet at moderately large Reynolds numbers. , ENRIQUE SANMIGUEL-ROJAS, M.A. BURGOS, Universidad Politec. Cartagena (Spain), CARLOS DEL PINO, RAMON FERNANDEZ-FERIA, University of Malaga (Spain) — We have performed a series of three-dimensional (3D) numerical simulations of the incompressible flow discharging from a rotating pipe into a co-axial cylindrical container through a sudden expansion. We have considered several values of the Reynolds number based on the pipe flow rate, Re_Q, between 100 and 400, and an expansion ratio of 8, and have analyzed the emerging 3D flow structures in the swirling jet exiting from the rotating pipe as the swirl Reynolds number Re_θ, based on the circumferential velocity of the discharging pipe, is increased. The results are compared with axisymmetric (2D) numerical simulations of the same problem. Three-dimensional, non-linear instabilities are found in the swirling jet above a critical value of Re_θ, which depends on Re_Q, that obviously do not appear in the axisymmetric simulations. These non-linear instabilities are triggered by the linear instabilities inside the rotating pipe. We characterize the azimuthal wave number, frequency and other properties of these instabilities as Re_θ is increased. There exists another critical value of Re_θ above which 3D (helical) vortex breakdown appears in the swirling jet. But this critical value and the structure of the vortex breakdown flow are both substantially different from the axisymmetric counterparts. *Supported by the Ministerio de Educacion y Ciencia of Spain (FIS04-00538).

Monday, November 20, 2006 8:00AM - 10:10AM –

Session FJ Convection and Buoyancy-Driven Flows IV Tampa Marriott Waterside Hotel and Marina Meeting Room 6