9:18AM FN.00007 Initial- value problem for the two-dimensional growing wake , S. SCARSOGLIO, D. TORDELLA, Politecnico di Torino, W.O. CRIMINALE, University of Washington — A general three-dimensional initial-value perturbation problem is investigated as to effects in a two-dimensional but growing wake. The linearized perturbation analysis considers both the early transient as well as the asymptotic behavior of the disturbance (Blossey, Criminale & Fisher, JFM 2006 submitted). The representation of the mean flow is physically accurate, since it has been obtained by considering the lateral entrainment process and associated streamwise evolution of mass flow (increase) and kinetic energy (decrease) (Tordella & Belan, PoF 2003). This base model is combined with a change of coordinate (moving coordinate trasform) (Criminale & Drazin, Stud. Appl. Math, 1990). The evolution analysis considers inviscid disturbances that are expanded in terms of small values of the wavenumber. The long time behavior is represented by means of a multiple spatial and temporal scale description of the velocity and vorticity perturbations. The limit for small wavenumbers has been studied. It is seen that an increase of the entrainment in the base flow yields instability and grows algebraically in time. This result is also obtained when considering a more general problem where larger wavenumbers, wavelengths of the order of the thickness of the variable shear region, are allowed. Comparison with a recent spatio-temporal multiscale Orr-Sommerfeld analysis of the 2D wake instability (Tordella, Scarsoglio & Belan, PoF 2006). is presented. The perturbation dynamics is examined for different base flow configurations.

9:31AM FN.00008 3D vortical structures of wake behind a ring with helical disturbances , JUN SAKAKIBARA, Department of Engineering Mechanics and Energy, University of Tsukuba, Japan, GUN SHIMIZU, Oriental Land Co., Ltd., Japan — Wakes behind a circular ring with/without helical disturbances were investigated. Cross-section of the ring was rectangular, and $D/W = 5$, where D is outer diameter and W is radial width of the ring. Reynolds number based on W was order of 100. Stereo-PIV was used to measure the three-component of velocity vectors in a plane normal to the free-stream direction. Taylors frozen field hypothesis was applied to reconstruct three-dimensional vorticity field. Under the unexcited condition, a series of vortex ring were shed from outer and inner side of the ring. In the case of $Re > 200$, streamwise vortices connecting successive vortex rings were observed. Above $Re = 300$ a recirculation zone was formed just behind the ring. Under the excited condition, where the ring was slightly tilted and direction of the tilting was rotated in time around the center of the ring, helical vortex structures were observed. In this case, the recirculation zone was not formed and drag applied to the ring was approximately 10% higher than the unexcited case.

9:44AM FN.00009 A physical mechanism for the primary instability of axysymmetric wakes past bluff bodies , JACQUES MAGNAUDET, CNRS/IMFT — The occurrence of the primary instability of the axisymmetric wake past an oblate bubble with a stress-free condition at its surface was studied by means of DNS (Magnaudet & Mougin, J. Fluid Mech. in press). The results suggest that the base flow becomes unstable when the derivative of the vorticity in the direction perpendicular to the symmetry axis vanishes within a small subregion of the near wake where the iso- vorticity lines have to turn sharply. Existence of this region is specific to axisymmetric flows and results from the combination of the Prandtl-Batchelor constraint within the standing eddy and the condition of weak vorticity on the rear part of the body surface. Examination of the azimuthal vorticity balance indeed suggests that the flow cannot remain stable at high enough Reynolds number when the above condition is fulfilled. The generality of this mechanism is discussed.

9:57AM FN.00010 Free fall of a Möbius band. , THOMAS LEWEKE, CNRS-IRPHE, Marseille, France, KERRY HOURIGAN, MARK C. THOMPSON, Monash University, Melbourne, Australia — A Möbius band is a 3D surface with the particular feature of having only one side and one edge. A simple geometrical model consists of a circular centerline, and surface elements which are locally tangent to this line and continuously twist around it, completing one half turn going once around the circle. From an aerodynamic perspective, such a Möbius strip presents a profile that is locally a flat plate with an angle of attack smoothly varying between -90 and 90 degrees, and this regardless of the orientation of the object. Clearly a most peculiar bluff body and irresistible to being studied, in this presentation for its free fall trajectory, body motion and wake dynamics. The governing parameters are the Reynolds number based on the width of the band and the average descent speed, the aspect ratio (perimeter / width) and the mass ratio (band density / fluid density). Free-fall experiments were carried out at low Reynolds numbers in a water tank with Möbius bands made of different plastic materials, having aspect ratio 14 and mass ratios of around 1.2. The band is found to rapidly adopt a bluff leading edge orientation and to follow a spiral path with an independent frequency of pitching.

Monday, November 20, 2006 8:00AM - 10:10AM –
Session FO Turbulence Modeling I* Tampa Marriott Waterside Hotel and Marina Meeting Room 11

8:00AM FO.00001 Lagrangian dynamics and statistical geometric structure of turbulence , LAURENT CHEVILLARD, CHARLES MENEVEAU, Johns Hopkins University — The local statistical and geometric structure of three-dimensional turbulent flow can be described by properties of the velocity gradient tensor. A stochastic model is developed for the Lagrangian time evolution of this tensor, in which the exact nonlinear self-stretching term accounts for the development of well-known non-Gaussian statistics and geometric alignment trends. The non-local pressure and viscous effects are accounted for by a closure that models the material deformation history of fluid elements. The system is forced with a simple, white in time, Gaussian noise. The resulting stochastic system reproduces many statistical and geometric trends observed in numerical and experimental 3D turbulent flows. Examples include the non-Gaussian statistics of velocity gradient components, the preferential alignment of vorticity, nearly log-normal statistics of the dissipation, the tear-drop shape of the so-called R-Q joint probability density and anomalous scaling of velocity derivatives.

8:13AM FO.00002 Search for local low dimension in transitional flow behind a bed form , EDUARDO RAMOS, Max Planck Institute Physics of Complex Systems, PEDRO GUIDO, JORGE ROJAS, National University of Mexico, HOLGER KANTZ, Max Planck Institute Physics of Complex Systems — We study experimentally the dynamics of vortices formed behind a bed form in an open channel flow. The Reynolds number is 453 which corresponds to transition flow. On the lee side of the bed form, vortical structures are generated, deformed and shed with no apparent identifiable regularity or predictable shape. This phenomenon is interpreted as a spatiotemporal chaotic system. We determine regions of low dimensionality in this flow by adapting the method Local Bred Vectors originally proposed by Patil et al. (Phys Rev Lett 2001) to analyze the atmosphere. In contrast to the original proposal, with our method no theoretical model is required. Then, we correlate the local dimension field with the predictability of specific regions of the flow. To this end, we use a forecast strategy similar to that described in Kantz and Ragwitz (Int. J. Bif. Chaos 2005). The methodology of the analysis described is general and not restricted to the flow behind a bed form.

8:26AM FO.00003 Dynamics of Episodic POD , DIETMAR REMPFER, PARITOSH MOKHASI, IIT, Chicago — In this talk we will discuss the derivation of evolution equations, which take the form of discrete maps, for the modes of episodic POD. The method of episodic POD is an extension of standard POD that leads to the construction of spatio-temporal POD eigenfunctions called "episodic modes." In contrast to standard POD, this method produces dynamical structures that evolve in space and time. Classical methods of low-dimensional modeling rely on decomposing flow-fields into a set of spatial functions and temporal coefficients. By substituting the expansion into the governing equations, one obtains a finite-dimensional system of ODEs. However, for the case of the Navier-Stokes equations, this method requires finesse, not only because of the nonlinearity of the equations, but also because of the intricacies of the pressure term. Conventional schemes suggest eliminating the pressure term using a vorticity formulation, or a model for the pressure term. In the method of episodic POD, the need for pressure modeling can be eliminated by using the pressure term as a constraint on the expansion coefficients of two consecutive episodes, ensuring spatio-temporal continuity. This method has the advantage that the formulation leads to a non-linear system of algebraic equations. The formulation also enables us to progress over contiguous chunks of time rather than computing the velocity state at every instance in time. Fluid dynamical examples are presented that validate this method.