UNIVERSITY OF MARYLAND

The Burgers Program for Fluid Dynamics

Twelfth Annual Symposium

Wednesday, November 18, 2015
1:00 to 5:30 p.m.
Jeong H. Kim Engineering Building
Rooms 1107 & 1111

Institute for Physical Science and Technology
College of Computer, Mathematical and Natural Sciences
A. James Clark School of Engineering
University of Maryland, College Park

Program

1:00 - 1:15

Welcoming Remarks

Jim Wallace
Director, The Burgers Program for Fluid Dynamics
Emeritus Professor, Mechanical Engineering Dept. &
Insitute for Physical Science and Technology
University of Maryland

1:15 - 2:15

Burgers Lecture

Synchronization and complex networks: Are such theoretical approaches useful for Earth Science?

Juergen Kurths
Humboldt University of Berlin
Potsdam Institute for Climate Impact Research
Germany

2:15 - 2:50

Vortex identification issues in turbulent boundary layer modeling

Luca Moriconi
Department of Physics
Federal University of Rio de Janeiro
Brazil

2:50 - 3:50

Graduate and post-doctoral poster session with refreshments

3:50 - 4:25

Unsteady lift production in separated flows

Anya Jones
Department of Aerospace Engineering
University of Maryland

4:25 - 5:00

*Regular and irregular shock-wave/
boundary-layer interactions*

Stefan Hickel
Department of Aerospace Engineering
Delft University of Technology
The Netherlands

5:00 - 5:30

Reception and announcement of best poster awards

Synchronization and complex networks: Are such theoretical approaches useful for Earth Science?

Juergen Kurths

Complex networks science is a powerful approach for understanding large systems in various areas ranging from physics via neuroscience and engineering to social sciences. First, I will give an introduction into this strongly evolving field. Next, we apply this concept to a continuous spatio-temporal system, the climate. This leads first to an inverse problem: Is there a backbone-like structure underlying the climate system? For this we propose a method to reconstruct and analyze a complex network from data generated by a spatio-temporal dynamical system. This approach enables us to uncover causal gateways and mediators in such a system and interpret them in relation to global circulation patterns in oceans and atmosphere. This concept is then applied to Monsoon data; in particular, we develop a general framework to predict extreme events by combining a non-linear synchronization technique with complex networks. Applying this method, we uncover a new mechanism of extreme floods in the eastern central Andes which could be used for operational forecasts. These techniques can also be applied to Neuroscience and Engineering.

Juergen Kurths

Vortex identification issues in turbulent boundary layer modeling

Luca Moriconi

A structural description of turbulent boundary layers (TBLs) has been a promising direction of research, strongly supported by an increasing number of fluid dynamicists in recent years. We discuss in this talk a particularly simple statistical vortex model, inspired by the picture of the TBL as a “gas” of hairpin-vortex configurations, which is able to reproduce, with remarkable agreement, important qualitative features of streamwise velocity fluctuations. In order to refine the model, with the help of numerical and experimental feedback, it is absolutely necessary to work with vortex identification methods, which, however, lose accuracy in a dramatic way in the inner layer of TBL flows. Focusing on one of the most popular vortex identification methods - the swirling strength criterion - we critically discuss its main problematic issues as (i) vortex image deformation and suppression due to near presence of intense vortical structures; (ii) artificial vortex merging; (iii) introduction of “ghost” vortices in many-vortex configurations and (iv) in the presence of background shear. We then propose an alternative vortex detection criterion, based on the curvature properties of the vorticity profile, which is shown to be a clear improvement over the results obtained with the swirling strength criterion in a number of relevant two-dimensional case studies.

Unsteady lift production in separated flows

Anya Jones

Unsteady aerodynamic forcing is common in a wide variety of applications from insect flight to high speed helicopters, but large transients in lift and drag can reduce efficiency, incite vibrations, and ultimately result in component fatigue. Unsteady lift commonly occurs when there are large variations in the magnitude or direction of the relative flow due to variations in the freestream or wing kinematics. Both of these cases ultimately result in large-scale flow separation and the formation of vortical structures near the lifting surface. A variety of experiments have been performed in wind and water tunnels to quantify the formation of these structures, leading to the development of new low-order models to predict unsteady forcing.

Regular and irregular shock-wave/boundary-layer interactions

Stefan Hickel

We will first review classical gas dynamics theories for the interaction of two and three shock waves and a generalized form of the free interaction theory. The theories will then be applied to the interaction of strong oblique shock waves with turbulent boundary layers, and a particular emphasis is put on the derivation of stability criteria for regular shock-wave/boundary-layer interaction and Mach reflection (irregular interaction). We will analyze well-resolved large-eddy simulations (LES) for a free-stream Mach number of Ma = 2, where perturbations related to the turbulent boundary-layer cause bi-directional transition processes between regular and irregular shock patterns at a critical incident shock deflection angle. Computational results show that the incident shock wave and can be accurately modeled by the generalized free interaction theory. On the basis of these observations, and the von Neumann and detachment criterion for the asymmetric intersection of shock which the shock pattern may/must become irregular. The theory predicts the existence of a dual solution domain, which has been confirmed by LES data for a free-stream Mach number of Ma = 3.

Burgers Board

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