UNIVERSITY OF
MARYLAND

The Burgers Program for Fluid Dynamics
Eleventh Annual Symposium

Thursday, November 13, 2014
12:45 to 6:30 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

12:45 - 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

Jayanth Banavar
Dean, College of Computer, Mathematical and Natural Sciences
Professor, Physics Dept.
University of Maryland

Darryll Pines
Dean, A. James Clark School of Engineering
Professor, Aerospace Engineering Dept.
University of Maryland

1:15 - 2:15

Burgers Lecture

Convection at Extremely High Rayleigh Numbers

Katepalli Sreenivasan
Executive Vice Provost for Science and Technology
President and Dean, Polytechnic School of Engineering
Professor of Physics and Mathematics
New York University

2:15 - 2:45

Burgers Program/J.M. Burgerscentrum
Cooperation

Gijs Ooms
Former Scientific Director, J. M. Burgerscentrum
National Research School for Fluid Mechanics
Professor, Mechanical Engineering Dept.
Technical University, Delft
The Netherlands

2:45 - 3:15

Turbulence in Wind Farm Boundary Layers

Charles Meneveau
Professor of Mechanical Engineering
Director, Center for Environmental and Applied Fluid Mechanics
Johns Hopkins University

3:15 - 4:00

<u>Student poster session with refreshments</u>

4:00 - 4:30

Quantifying Collective Cell Migration during Cancer Progression

Rachel Lee
Ph.D. Student
Physics Dept.
University of Maryland

4:30 - 5:00

From Chicken Embryos to Mayfly Nymphs: Biological Pumps at Small Scales

Ken Kiger
Keystone Professor, Mechanical Engineering Dept.
University of Maryland

5:00 - 5:30

Bypass Transition in Plain Poiseuille Flow and Boundary Layers

Bruno Eckhardt
Professor, Fachbereich Physik
Philipps-Universität Marburg
Germany

5:30 - 6:30

<u>Reception to celebrate 10 years of The Burgers Program for Fluid Dynamics</u>

Convection at Extremely High Rayleigh Numbers

Katepalli Sreenivasan

After some initial remarks about Johannes Burgers, his career and scientific work, I will discuss our present knowledge of turbulent convection in the Sun at Rayleigh numbers estimated to be as high as 10^{24}. The lecture will juxtapose my work (jointly with Shravan Hanasoge and Tom Duvall) with other activities in this field, and identify a few unanswered questions.

Burgers Program/J.M. Burgerscentrum Cooperation

Gijs Ooms

During the last ten years a close cooperation has developed between the Burgers Program for Fluid Dynamics at the University of Maryland and the J.M. Burgerscentrum (JMBC) in The Netherlands. In the presentation a brief overview will be given about the scientific career of Burgers, about how the JMBC in The Netherlands began and how it is organized, and about the JMBC/Burgers Program cooperation.

Turbulence in Wind Farm Boundary Layers

Charles Meneveau

Similar to other renewable energy sources, wind energy is characterized by low power density. Hence, in order for wind energy to make a significant contribution to our overall energy supply, large wind farms (on or off-shore) need to be envisioned. As it turns out, not much is known about the interactions between large wind farms and the atmospheric boundary layer. A case in point, as wind farms are getting larger, operators have begun to complain about the so-called “wind-farm underperformance” problem. This presentation will summarize our results that focus on understanding how wind turbines, when deployed in large arrays, extract kinetic energy from the atmospheric boundary layer. Large Eddy Simulations (LES) are used to improve our understanding of the vertical transport of momentum and kinetic energy across a boundary layer flow with wind turbines. A suite of LES, in which wind turbines are modeled using the classical 'actuator disk' concept, are performed for various wind turbine arrangements, turbine loading factors, and surface roughness values. The results are used to develop improved models for effective roughness length scales and to obtain new optimal spacing distances among wind turbines in a large wind farm. We introduce the notion of generalized transport tubes as a new tool for flow visualization that is particularly useful to analyze the spatial transport of particular physical quantities (e.g. kinetic energy arriving at a particular wind turbine). Finally, we introduce a new engineering model, the Coupled Wake Boundary Layer model that reconciles wake expansion/superposition models currently used in industry with the vertical structure of the atmospheric boundary layer. This work is a collaboration with colleagues, postdocs and students involved in the WINDINSPIRE project and is supported by the US National Science Foundation.

Quantifying Collective Cell Migration during Cancer Progression

Rachel Lee

During cancer progression, tumor cells invade the surrounding tissue and migrate throughout the body, forming clinically dangerous secondary tumors. This metastatic process begins when cells leave the primary tumor, either as individual cells or collectively migrating groups. This collective migration is not yet well characterized. Here we present data on the migration dynamics of epithelial sheets composed of many cells. Using quantitative image analysis techniques, we are able to extract motion information from time-lapse images of cell lines with varying malignancy. Adapting metrics originally used to study fluid flows, such as Finite Time Lyapunov Exponents, we are able to distinguish the migration dynamics of these cell lines.

From Chicken Embryos to Mayfly Nymphs: Biological Pumps at Small Scales

Ken Kiger

As biological systems transition from sub-millimeter to larger scales, they often pass a threshold where diffusive transport alone is insufficient to provide for their metabolic needs, and some form of convective pumping assistance is required. This talk examines two systems that are near this transition region: the formation of the embryonic avian heart through the process of cardiogenesis and external gill-plate pumping arrays found on aquatic mayfly nymphs. In the first case, we developed a technique to measure the shear stress applied to the lumen of the beating heart in vivo, which was subsequently used to help understand the genetic signaling and response important to the development of the heart. In the second problem, we have examined how arrays of oscillating plates can be used with different stroke kinematics to produce effective external pumping. This was inspired by the study of living mayfly nymphs, who exhibit a change in flow pattern and stroke kinematics as they grow through stages that transition from a predominant viscous flow to an inertial regime. We explain this process in the context of the vorticity distribution in the flow relative to the plate spacing and a pumping efficiency based on the cost of pumping the fluid through the gill array.

Bypass Transition in Plane Poiseuille Flow and Boundary Layers

Bruno Eckhardt

Both plane Poiseuille flow and boundary layers show a linear instability to the formation of Tollmien-Schlichting waves and a transition at lower Reynolds numbers that is not connected with a linear instability of the laminar profile but triggered by finite amplitude perturbations, the bypass transition. In the case of plane Poiseuille flow we show how the two processes are arranged in the state space of the system and explain under which conditions the bypass process is the more dominant one, with the linear instability confined to a small set of initial conditions. For the case of the boundary layer, we appeal to the successful modelling of shear flows with probabilistic cellular automata and concepts from directed percolation. We fit an automaton model to data from large eddy simulations of boundary layers with different levels of free stream turbulence (Figure 1). The cellular automaton reproduces the statistics of the simulation data extremely well (Figure 2).

Joint work with T. Kreilos, S. Zammert, T. Khapko, P. Schlatter, Y. Duguet and D. S. Henningson

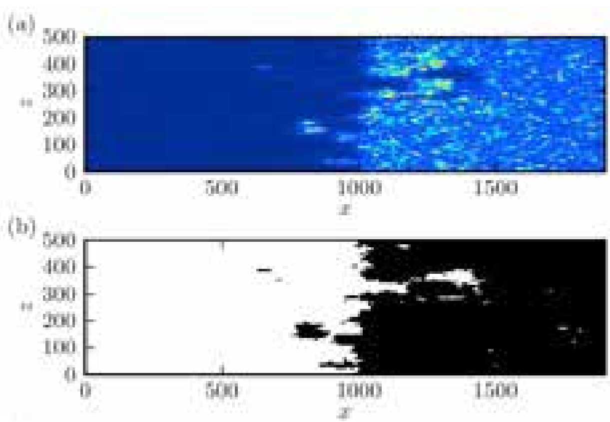

Figure 1

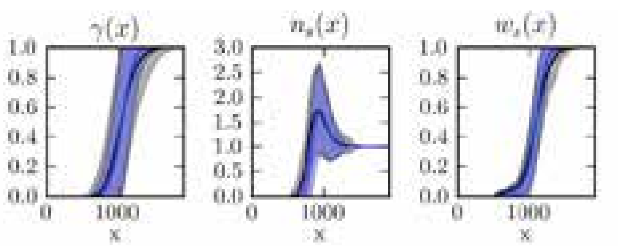

Figure 2

Burgers Board

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