UNIVERSITY OF MARYLAND

The Burgers Program for Fluid Dynamics

Eighteenth Annual Symposium

Friday, October 8th, 2021, 1:00 to 5:00 pm
J. M. Patterson Building
Room 2116 and on Zoom:
https://go.umd.edu/BurgersSymposium2021

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

Program:

1:00 – 1:05

Welcoming Remarks

Jim Duncan
The Burgers Program for Fluid Dynamics
Department of Mechanical Engineering and the Institute for Physical Science and Technology
University of Maryland

1:05 – 1:50

Some Fascinating Aspects of Shallow Flows — Laboratory Experiments, Numerical Simulations, and Geophysical Applications (to be presented online)

GertJan van Heijst
Fluid Dynamics Laboratory
Department of Applied Physics
Eindhoven University of Technology

1:50 – 2:10

Break, informal discussions

2:10 – 2:55

Magnetized Stratified Shear Flow and the Search for Supermassive Binary Black Holes (to be presented in person)

Scott Noble
Gravitational Astrophysics Laboratory
NASA Goddard Space Flight Center

2:55 – 3:15

Break, informal discussions

3:15 – 4:00

Flow Mechanisms Affecting Cavitation Inception in Boundary Layers and in Turbulent Shear Flows (to be presented in person)

Joseph Katz
Department of Mechanical Engineering
Johns Hopkins University

4:00 – 5:00 ***Reception***

ABSTRACTS and BIOGRAPHIES

Some Fascinating Aspects of Shallow Flows — Laboratory Experiments, Numerical Simulations, and Geophysical Applications

GertJan van Heijst

Abstract: Many flows in environmental and in industrial situations can be characterized as 'shallow', with the horizontal scales being essentially larger than the vertical size of the flow domain. Examples are flows in rivers, estuaries, the coastal region, harbors, fresh water reservoirs, but also in settling chambers for water treatment. Shallowness implies a rather specific flow dynamics.

Our interest in shallow flows originates from attempts to generate quasi-two-dimensional (qusi-2D) turbulent flows in the laboratory, aiming at studying their characteristics experimentally. It turned out, however, that shallow-layer flows do show significant three-dimensional effects.

The lecture will discuss some basic properties of 2D flows, such as self-organization, which will be illustrated by laboratory experiments and numerical simulations. Results of studies of flows in shallow fluid layers will also be presented and compared with those of purely 2D flows. Finally, the lecture will address experimental and numerical studies of tidally-induced flushing of semi-enclosed basins, such as harbors and estuaries.

Biography: GertJan van Heijst is professor in fluid dynamics at Eindhoven University of Technology, the Netherlands. His research interests include geophysical and environmental fluid mechanics, in particular vortices and turbulence in rotating and stratified flows, two-dimensional turbulence, dispersion in turbulent flows, and erosion and sedimentation processes.

He has been an associate editor of Physics of Fluids and of Geophysical and Astrophysical Fluid Dynamics, and co-editor-in-chief of the European Journal of Mechanics B/Fluids. He is a member of the Royal Netherlands Academy of Arts and Sciences (since 1997), member of the Russian Academy of Natural Sciences (since 2010), and recipient of the Dutch Physica Award (2006). From 2013 he served as President of EUROMECH, and since 2018 he is Vice-President of that society. Since 1991 he has been one of the local directors of the J.M. Burgers Centre, the national research school for fluid dynamics in The Netherlands. He served as scientific director of the Burgers Centre from 2014 to August 2021.

Magnetized Stratified Shear Flow and the Search for Supermassive Binary Black Holes

Scott Noble

Abstract: The accretion of gas onto black holes is one of the universe's most powerful and efficient processes for converting mass into energy, and powers such exotic astrophysical phenomena as x-ray binaries, gamma-ray bursts, active galactic nuclei, kilonova, and tidal disruption events. Internal dissipation of gas clouds about central gravitational sources leads to the gas settling into so-called "accretion disks" about the central object, like a black hole or star. The accretion disk naturally forms a near-circular, Keplerian shear flow in the plane orthogonal to the cloud's net angular momentum, and is stratified off the plane by buoyant forces. Accretion disks about black holes are so hot that the gas is ionized and are described well through ideal magnetohydrodynamics. We will show how internal magnetic stresses lead to significant angular momentum transport outward, and accommodate efficient mass accretion onto the central object. At the centers of galaxies black holes may grow to be millions to billions times the Sun's mass. At least one supermassive black hole resides at the center of most galaxies. When galaxies merge, their giant black holes often settle into a close binary system and emit powerful gravitational waves, or ripples of spacetime. Observing these ripples from star-sized black holes for the first time, with terrestrial observatories, lead to a recent Nobel Prize in Physics and has revolutionized the field of astrophysics. In the 2030's, European Space Agency and NASA plan to launch into space the Laser Interferometer Space Antenna (LISA) to detect the supermassive variety. Because supermassive binaries are the only kinds of binary black holes expected to have sufficient ambient gas available to be electromagnetically bright, they are better sources for multi-messenger science. We will report on how our 3-dimensional general relativistic magnetohydrodynamics simulations of circumbinary accretion disks have provided realistic predictions for the dynamics of these systems and their electromagnetic emission. We will also describe how the predictions may be used to discover these systems for the first time before LISA flies through conventional astronomy techniques, and what important science may be accomplished with observing light and gravitational waves in tandem.

Biography: Dr. Scott Noble, Research Astrophysicist in the Gravitational Astrophysics Laboratory at NASA Goddard Space Flight Center, is a theoretical/computational astrophysicist interested in black holes, their accretion disks, and the radiation magnetohydrodynamics physics inherent to these systems. Dr. Noble's is particularly keen on pushing the frontier of computational methods of general relativistic magnetohydrodynamics, and lately uses them to simulate accreting systems about single and binary black holes. He has also designed novel time-dependent grid techniques (e.g., dynamic nonuniform grids, overlapping misaligned multi-patch methods) to capture the variety of time and space scales often encountered in these systems, and is now expanding his repertoire of methods to include nuclear physics techniques for simulating the bright electromagnetic and gravitational wave signals produced by neutron star mergers. Dr. Noble received his PhD in Physics from the University of Texas at Austin under the supervision of Prof. Matthew Choptuik, and a BS in Physics from Caltech. Scott enjoys outdoor activities such as hiking, kayaking, and running, and traveling to experience different cultures and cuisines.

Flow Mechanisms Affecting Cavitation Inception in Boundary Layers and in Turbulent Shear Flows

Joseph Katz

Abstract: The presentation summarizes several experimental studies aimed at elucidating flow phenomena affecting cavitation inception. The first reveals the mechanisms sustaining attached cavitation inception on curved surfaces having pressure minima followed by regions of adverse pressure gradients, which either thicken the boundary layer or cause local flow separation. Microbubbles originated from the collapse of occasional travelling bubble cavitation are trapped in the thin low momentum regions close to the wall. These bubbles migrate slowly upstream either under the influence of the adverse pressure gradients when the flow remains attached or carried by the recirculating flow when the boundary layer is separated. Owing to the low local pressure, these bubbles grow by non-condensable gas diffusion until they reach the thickness of the low-momentum zone. At that time, they are either swept downstream by the external flow or they become nuclei for new attached cavitation events, which generate new microbubbles, allowing the process to sustain itself. These phenomena do not occur when the adverse pressure gradients are too mild to create low-momentum zones with sufficient thickness to facilitate the slow upstream migration and growth. The second study examines cavitation inception in turbulent shear layers, where cavitation inception occurs in multiple points along secondary quasi-streamwise vortices (QSVs) stretched between the primary spanwise vortices. To understand the processes involved, we measure the 3D pressure field generated by QSVs in a shear layer developing behind a backward facing step. The time-resolved volumetric velocity distribution is measured using tomographic particle tracking. Interpolation of data to a regular grid and subsequent integration of the material acceleration provides the pressure distribution. Analysis involving k-means clustering and Lagrangian pressure statistics shows that the pressure minima are indeed lower and last longer within the 1 mm diameter and 2-5 mm long QSVs compared to the surrounding flow. These minima are more likely to appear after a period of axial vorticity stretching and before contraction events. These findings are consistent with features of cavitation inception events observed under controlled nuclei seeding using high speed imaging.

Biography: Joseph Katz received his B.S. degree from Tel Aviv University, and his M.S. and Ph.D. from California Institute of Technology, all in mechanical engineering. He is the William F. Ward Sr. Distinguished Professor of Engineering, and the director and co-founder of the Center for Environmental and Applied Fluid Mechanics at Johns Hopkins University. He is a Member of the National Academy of Engineering, as well as a Fellow of the American Society of Mechanical Engineers (ASME), the American Physical Society, and American society of Thermal and Fluids engineering. He has served as the Editor of the Journal of Fluids Engineering, and as the Chair of the board of journal Editors of ASME. He has co-authored more than 400 journal and conference papers. Dr. Katz research extends over several fields, with a common theme involving experimental fluid mechanics, and development of advanced optical diagnostics techniques for laboratory and field applications. His group has studied laboratory and oceanic boundary layers, flows in turbomachines, flow-structure interactions, swimming behavior of marine plankton in the laboratory and in the ocean, vascular flows, as well as cavitation, bubble, and droplet dynamics, the latter focusing on interfacial phenomena associated with oil spills.