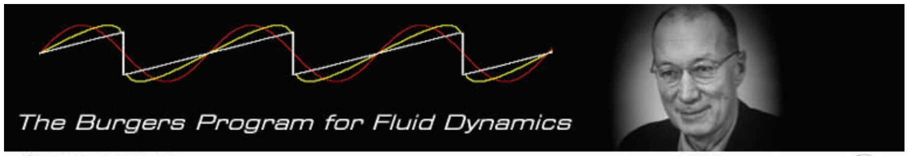

UNIVERSITY OF MARYLAND

Institute for Physical Science and Technology

Seventh Annual Symposium of the Burgers Program for Fluid Dynamics

November 17, 2010
1:00 - 5:30 p.m.
University of Maryland, College Park
Jeong H. Kim Engineering Building
Kay Boardroom, Rms. 1107 & 1111

Institute for Physical Science and Technology
College of Computer, Mathematical and Natural Sciences
A. James Clark School of Engineering
Department of Physics

PROGRAM

1.00 - 1.15: Welcoming Remarks

James M. Wallace

Burgers Program for Fluid Dynamics and Department of Mechanical Engineering
University of Maryland

1.15 - 2.15: **Burgers Lecture:**

Memory and Transient Forces in Soft Matter

W. J. Briels

Computational Biophysics Group
Twente University
The Netherlands

2.15 - 2.50: Oriented Assembly by Capillarity

Kathleen J. Stebe

Department of Chemical & Biomolecular Engineering
University of Pennsylvania

2.50 - 3.50: Student Poster Session with Refreshments

3.50 - 4.25: Dynamics of Coherent Structures in Localized Turbulence in a Pipe

Jerry Westerweel

Laboratory for Aero & Hydodynamics
Delft University of Technology
The Netherlands

4.25 - 5.00: A Description of Hypersonic Effects on Wall Turbulence

Pino Martin

Department of Aerospace Engineering
University of Maryland

5.00 - 5.30: Announcement of Best-Poster Awards and Reception

Institute for Physical Science & Technology

IPST

Jan Burgers grew up, together with his brother, the crystallographer W.G. Burgers, in a remarkable parental home in Arnhem, The Netherlands. His father, a post-office clerk, had been able to become a self-educated amateur scientist who gave public lectures on physics and assembled a large collection of scientific instruments, among others a good microscope that he had received from his wife as a wedding present.

In 1914, Burgers entered the University of Leiden, where he came to know Hendrik Lorentz, Heike Kamerlingh Onnes, Albert Einstein, and Niels Bohr and was part of a group of students of P.T. Ehrenfest that included D. Coster, H.A. Kramers, and D.J. Struik. Burgers, the first of Ehrenfest's students in Leiden to complete a Ph.D. thesis (1918), wrote his dissertation on the Rutherford-Bohr model of the atom, completing Ehrenfest's work on the connection between the Bohr-Sommerfeld quantification rules and the adiabatic invariants of classical mechanics.

At the age of 23, before receiving his Ph.D. degree, Burgers was appointed as Professor in the Department of Mechanical Engineering, Shipbuilding and Electrical Engineering at the Technical University in Delft, where he founded the Laboratory of Aero- and Hydrodynamics. It was probably without precedent that a professor was appointed in a field of study that was practically incognita for the appointee. However, the nominating committee could base its recommendation on the warm appreciation of Ehrenfest, his Ph.D. advisor, the admiration of Lorentz for Burgers' essay on Rutherford's hypothesis concerning the structure of the atom (for which Burgers had won a prize from the Taylor Society) and the testimony of Kamerlingh Onnes that Burgers was a person who could be entrusted with any task he would feel called upon to make his own. In his characteristically modest account of his early years in Delft for the *Annual Review of Fluid Mechanics* (**Vol. 7**, 1975), Burgers wrote that one of his reasons for accepting the position in Delft was his fear of "having insufficient fantasy for making fruitful advances in Bohr's theory".

While at Delft, Burgers quickly became one of the world's leading authorities on fluid dynamics. His first work was devoted to Oseen's theory of flow at low Reynolds numbers and its connection with Ludwig Prandtl's work on air-foils. In 1921 he met Theodore von Kármán, with whom he had a long and close professional and personal association that stimulated his work on turbulence. In this field he was a pioneer in using the hot-wire anemometer to probe velocity fluctuations in turbulent flows. His work on the theory of turbulence was devoted in large part to developing a statistical theory of turbulence and to treating theoretical models of turbulent flow. In this connection he studied what has now become known as the Burgers Equation, which is a one-dimensional, nonlinear partial differential equation similar in structure to the Navier-Stokes Equation for the hydrodynamic velocity field, now used also extensively in condensed matter physics and in cosmology.

In addition to his work on turbulence during his years in Delft, Burgers collaborated with his brother in work on dislocation in crystal lattices; in 1939 he introduced the Burgers' vector, which is a measure of the strength of a dislocation in a lattice. He also studied the fluid dynamics of dilute polymer solutions and wrote some of the fundamental papers on the intrinsic viscosity of suspensions. This work, like those on turbulence and on dislocations, provided the foundation for much subsequent work on this topic.

In the 1940's Burgers was instrumental in establishing the International Union of Theoretical and Applied Physics, which was admitted to the International Council of Scientific Unions in 1947. He served as general secretary of the Union from 1946 to 1952, was a member of its general assembly and served as secretary of its Joint Committee on Viscosity and Plasticity.

In 1955, at age 60, Burgers left Delft to join the faculty of the University of Maryland. There he developed his interest in the relation of the Boltzmann Equation to the equations of fluid dynamics. His book *Flow Equations for Composite Gases* (1969) represents some of his work during that period. His studies in plasma physics, shock waves, and related phenomena were recognized at his retirement by a symposium and volume, *The Dynamics of Fluids and Plasmas* (1965), edited by S. I. Pai. At age 79 he published a book on *The Nonlinear Diffusion Equation*.

In addition to his purely scientific work, Burgers found the time to work on subjects of wider social and/or philosophical interest. He always was trying to find ways to use science to improve society, and he had a deep interest in the most fundamental problems – the structure of the universe and the origin and proper description of life. His preoccupation with such philosophical issues led him to the writings of A. N. Whitehead, whose ideas he tried to develop in his own book, *Experience and Conceptual Activity* (1965).

Jan Burgers was an exceptionally kind and thoughtful man. He took seriously anyone who presented an idea to him, and he devoted a large fraction of his time to trying to understand new ideas and new developments. His devotion to both science and society is an inspiration to all of us at the University of Maryland.

Reference:

Selected Papers of J.M. Burgers, edited by F.T.M. Nieuwstadt and J.A. Steketee (Kluwer, Dordrecht/Boston/London, 1995).

Experience and Conceptual Activity; a Philosophical Essay based upon the writing of A.N. Whitehead. MIT Press, 1965.

Flow Equations for Composite Gases. Academic Press, 1969.

Burgers Lecture: Memory and Transient Forces in Soft Matter

W. J. Briels
Computational Biophysics Group
Twente University
The Netherlands

Due to their complex architecture molecules in soft matter systems display (collective) dynamics at a huge range of time scales. As a result it is usually not valid to assume a separation of time scales and to model the interaction between slow and fast dynamics with simple friction and random forces felt by the slow modes. Usually the forces acting on a slow degree of freedom will depend on the entire history of the system, and in particular on the entire configurations of the system during this history. This is what is meant when we say that the system has memory in time and in configuration space.

In this presentation I will argue that memory basically results from non equilibrium of the not sufficiently fast modes and should be described by adding appropriate terms to the free energy of the system. In rheology the relevant degrees of freedom are the positions of the individual molecules. I will show that the rheology of many soft matter systems may be described by dressed particles. The thermodynamic forces result from the potential of mean force, depending on the positions of the molecules, while additional terms to the free energy depend both on the configuration and on a small set of new variables describing the non equilibrium state of the remaining degrees of freedom.

I will show examples of simulations and experiments on telechelic polymer solutions. The hydrophobic end-blocks gather together in micelles, while the hydrophilic middle

(Briels, cont.)

blocks form leaves around such micelles or bridges between them. The model consists of single particles dressed with the capability of forming bridges among each other. A great variety of complex flow behavior results. As a second example I will show work on star polymers, described as single particles with the capability to entangle among each other.

In the final part of the talk I will indicate how constitutive models can easily be derived for these systems. The resulting equations automatically contain many of the terms, like for example the shear curvature or stress diffusion term, that have been hypothesized through the last decades and are necessary to describe complex flows.

Oriented Assembly by Capillarity

Kathleen J. Stebe
Department of
Chemical & Biomolecular Engineering
University of Pennsylvania

Particles at fluid interfaces can form highly ordered structures at fluid interfaces spontaneously by capillarity. The understanding of these interactions for spherical particles is well developed and widely exploited to make 2-D and 3-D ordered materials. Anisotropically shaped particles have far greater degrees of freedom, and can orient, align, and assemble into complex structures and networks that depend subtly on the particle shape and the shape of the interface which hosts the particles. In this talk, progress in developing a quantitative understanding of assembly of cylinders in the zero Bond number limit is described.

Dynamics of Coherent Structures in Localized Turbulence in a Pipe

Jerry Westerweel
Laboratory for Aero & Hydrodynamics
Delft University of Technology
The Netherlands

The transition to turbulence in pipe flow is still not completely understood. Recently it was shown that localized turbulent structures (puffs) can survive for hundreds of pipe diameters (or integral time scales) and then suddenly disintegrate. Questions that emerge are: Why is the turbulence localized? What mechanism is required for puffs to sustain itself? What changes in the structure of a puff when it suddenly decays? For the investigation a high resolution DNS is used. The high resolution is required to resolve the localized high energy peaks, which were observed in earlier experimental investigations. We use a stereoscopic planar PIV measurement as initial condition for the DNS and continued the time evolution at Re=1900. The first observation is that the velocity of the structures is higher than the bulk velocity at Re=1900 as opposed to the Re=2500 case, which is in agreement with experimental observations. The peaks in in-plane kinetic energy are reproduced in the DNS, and can be associated with hair-pin vortices.

A Description of Hypersonic Effects on Wall Turbulence

Pino Martin
Department of Aerospace Engineering
University of Maryland

Direct numerical simulations (DNS) provide detailed data to study aspects of wall turbulence, ranging from statistical scaling to the existence and characterization of the structure of wall turbulence. In Martín (J. Fluid Mech. 2007), we validated DNS for subsonic to hypersonic wall bounded turbulence. The simulations rely on robust dynamic shock capturing, minimal dissipation in smooth flow regions, and continuous turbulence inflow. In Duan et al (J. Fluid Mech. 2010), we analyzed the statistical data to characterize the effects of strong wall cooling. In Ringuette et al. (J. Fluid Mech. 2008), we developed a geometric algorithm that identifies hairpin heads, shear layers and hairpin packets associated with turbulent coherent structures on detailed three-dimensional data. The relationship between statistically (Brown & Thomas Phys. Flu. 1977) and geometrically (Ringuette et al.) identified structures can be described. In O'Farrel and Martín (2009), we were able to show that average ideal geometric events correspond to strong statistical ones. In this talk, I will use DNS data, statistical analyses and physics-based pattern identification algorithms to describe turbulent boundary layers over a wide parameter space, focusing on the influence of hypersonic conditions on the scaling of mean and turbulence behaviors, and the structure of turbulent boundary layers. Implications for the modeling and simulation of hypersonic turbulent boundary layers will be discussed.

Burgers Board

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