

Environmental Science

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Selected Topics of Computational and Experimental Fluid Mechanics

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Preface

Fluid dynamics is a highly developed branch of science that has been the subject of continuous and expanding research activity both theoretically and experimentally for more than a century and a half. In particular, the relatively recent development of fluid dynamics has been strongly influenced by its numerous applications in a plethora of research fields as well as industrial and technological processes. Current research in physics, biology, engineering, medicine, and environmental sciences rely more and more on the use of the principles of fluid mechanics. While improvements to the nineteenth-century technologies were possible on the basis of common sense, the new technologies require the knowledge of fluid flow behavior under conditions that go beyond our everyday experience.

This book presents recent experimental and theoretical advances in fluid dynamics applied to physics and engineering. It includes invited lectures given during the International Enzo Levi Spring School held at Cinvestav-Abacus, Estado de México, Mexico, May 15–16, 2013, and seminars presented at the XIX National Congress of the Fluid Dynamics Division of the Mexican Physical Society, held at the Mexican Institute of Water Technology, Jiutepec, Morelos, Mexico, November 13–15, 2013.

The Spring School is organized every year in honor of Prof. Enzo Levi, a well-known Mexican scientist, who dedicated his research to the study of fluids. He was one of the founders of the Instituto de Ingeniería (Engineering Institute) of the Universidad Nacional Autónoma de México (UNAM), and of the Instituto Mexicano de Tecnología del Agua (Mexican Institute for Water Technology) of the National Water Commission. He was the mentor of several generations of Mexican Engineers.

The 2013 Enzo Levi School was held at Cinvestav-Abacus, a recently created Centre for Applied Mathematics and High Performance Computing (HPC) that from early 2015 will host one of the largest supercomputers in Latin America, where scientists and engineers in Mexico and other countries will be able to develop projects on Computational Fluid Dynamics requiring very large HPC facilities.

During the Cinvestav-Abacus two-day school, lectures were given by well-known national and international scientists. The meeting was attended by about 50 researchers and about a hundred graduate and undergraduate students.

A wide variety of topics were presented that included asymptotic methods in fluids, convection, computational methods applied to biological systems, interfacial fluid dynamics, colloidal dispersions, and fluid flow in fractured porous media. Among the lectures we want to mention a very interesting description of *Bubble dynamics with biomedical applications* and *Using computers to study fluid dynamics* by Timothy Colonius of the Mechanical and Civil Engineering Department of the California Institute of Technology, two lectures on the *Fluid mechanics of bio-inspired swimming and flying* and *Some problems on the physics of insect-inspired flapping wings* by Ramiro Godoy Diana of the École Supérieure de Physique et de Chimie Industrielles (ESPCI), Paris, France, and Claudio Pastorino of the Departamento de Física, Centro Atómico Constituyentes, CAN-CONICET, Buenos Aires, Argentina, with the two lectures *Polymer brushes exposed to liquid flow: cyclic dynamics, collective behavior and coarse-grained* and *DPD model to simulate soft matter systems in equilibrium and under flow*. Other interesting lectures were *Smoothed Particle Hydrodynamics for free-surface flows: Implementation (CPU and GPU)* and *DualSPHysics code and applications* by Anxo Barreiro, Universidad de Vigo, Spain, *Numerical simulation of multiphase flow* by Leonardo Di G. Sigalotti of the Universidad Autónoma Metropolitana-Azcapotzalco (UAM-A), Mexico and the Instituto Venezolano de Investigaciones Científicas (IVIC), Caracas, Venezuela, *Modeling the dependence of interfacial tension with temperature and ionic strength in mixtures of solvents, organic and water by dissipative particle dynamics* by Estela Mayoral-Villa, ININ, Mexico, and *Surface waves in the vicinity of a singularity* by Gerardo Ruíz Chavarría, FCUNAM, Mexico. Several of these lectures were included in Part I of the book.

The Annual Fluid Dynamics Congress has a different format compared to its previous episodes. In 2013, it lasted three days and was composed of six plenary lectures and many short oral presentations of students and researchers.

In Part I we also included the plenary lectures given during the congress by national and international well-known invited speakers and some of the most interesting short oral contributions. Among the plenary lectures we can mention the following: *Flow coherence: Distinguishing cause from effect* by F.J. Beron Vera of the University of Miami, Florida, USA, *Flows from bins: New Results* by Abraham Medina of ESIME-IPN, Mexico, *Numerical modeling of the extratropical storm Delta over Canary Islands: Importance of high resolution*, by José M. Baldasano of the Barcelona Supercomputing Center, Barcelona, Spain, *Compositional Flow in Fractured Porous Media: Mathematical Background and Basic Physics*, by Leonardo Di G. Sigalotti of the UAM-A, Mexico and IVIC, Venezuela, *Some aspects of the turbulence role in oceanic currents* by Angel Ruiz Ángulo, UNAM, Mexico, and finally *Alya Red CCM: HPC-based cardiac computational modeling* by Mariano Vázquez of the Barcelona Supercomputing Center, Barcelona, Spain.

The other short presentations are organized by topics: Multiphase flow and Granular Media (Part II), Convection and Diffusion (Part III), Vortex, Oceanography and Meteorology (Part IV), and General Fluid Dynamics and Applications (Part V).

In Part II, Multiphase Flow and Granular Media, we have focused on petroleum-related applications, where we can find interesting contributions on the tracer transport and natural and forced convection with applications to oil recovery, mixed convection around a heated horizontal cylinder and viscous dissipation, characterization of a bubble curtain for PIV measurements, numerical simulations of gas-stirred ladle with applications to metallurgy, and a study of fluid flow through polymeric complex structures using multiscale simulations.

Convection and Diffusion can be found in Part III, with interesting contributions on conjugate convection in an open cavity, and heat transfer in biological tissues. We can also find two applications on fracture-porous media systems in oxygen transport and combustion, and an interesting study of solidification in the presence of natural convection in a Hele-Shaw cell and of thermal convection in a cylindrical enclosure with a wavy sidewall.

In Part IV, Vortex, Oceanography and Meteorology, we can find three contributions on numerical simulations of the flow past a pair of magnetic obstacles, steady and unsteady vortex flow generated by electromagnetic forcing, as well as numerical simulations of the span-wise vortex in a periodic forced flow, of erosion and deposition of particles in a periodic forced flow and of singularities in surfaces waves.

Finally, in Part V, General Fluid Dynamics and Applications, we find several contributions of fluid dynamics applied to various fields such as biopolymers processes, friction stir welding, dynamical behavior of a drop on a vertically oscillating surface, and critical phenomena of a drop through a stratified fluid.

The book is aimed at fourth year undergraduate and graduate students, and at scientists in the field of physics, engineering, and chemistry who have interest in fluid dynamics from the experimental and theoretical points of view. The material includes recent advances in experimental and theoretical fluid dynamics and is adequate for both teaching and research. The invited lectures are introductory and avoid the use of complicated mathematics. The other selected contributions are also adequate for fourth-year undergraduate and graduate students.

The editors are grateful to the institutions that made possible the realization of the International Enzo Levi Spring School 2013 and the XIX National Congress of the Fluid Dynamics Division of the Mexican Physical Society, especially the Consejo Nacional de Ciencia y Tecnología (CONACYT), the Sociedad Mexicana de Física, the Universidad Autónoma Metropolitana-Azcapotzalco (UAM-A), the Instituto Mexicano de Tecnología del Agua, Jiutepec, Morelos, the Universidad Autónoma de México (UNAM), the ESIME of the Instituto Politécnico Nacional (IPN), Cinvestav-Abacus, and the Instituto Nacional de Investigaciones Nucleares (ININ).

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Mexico City, January 2015

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Gerardo Ruíz Chavarría
Abraham Medina Ovando
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