



# International Advanced Course in Liquid Interfaces, Drops and Sprays - 6<sup>th</sup> Edition

## LIDESP VI

Vienna, Austria, September 4– 7, 2018

International Course Directors  
**A. Amirfazli, V. Bertola, M. Marengo**  
Hosting Director  
**A. Soldati**

### COURSE DESCRIPTION

**LIDESP** is an International Advanced Course on the Interface, Drops and Liquid Sprays Physics, which will be held for the 6<sup>th</sup> time at TU Wien (Austria), from 4<sup>th</sup> to 7<sup>th</sup> September 2018. This course has been previously held in Europe and Asia in different locations. The core of the lecture plan is provided by three well-known and highly recognized experts in the field: Prof. Amirfazli, York University, Toronto, Canada, Prof. Bertola, University of Liverpool, UK, Prof. Marengo, University of Brighton, UK. They not only deliver part of the instructional module, but also every year, depending on the venue, different modules of the program are taught by local experts, under the coordination of Host Directors.

The **knowledge** of the physics of liquid drops and sprays is essential for many applications, from aeronautics (icing) to oil extraction (effervescent spray, drop collisions in pipes), from electronics (spray cooling) to agriculture (pesticide distribution), from microfluidics (droplet management) to painting processes (spray coating), from biology (blood droplets, sterilization) to thermal transfer (condensation in heat exchangers), from chemistry (drying tower) to medical applications.

The course **objective** is to provide the participants with the latest detailed knowledge on the physics of drops and sprays based on recent research results and the most updated methods for the prediction of dynamic outcomes, heat transfer, wettability effects, and its applications to technological and industrial areas. Specific attention will be paid to the

applications in life science, such as microdroplet management. Application to chemical processes will be dealt with special care in view of the industrial interest towards this component, while the very recent application of drop management in microscale, including microstructured surfaces will be treated in detail. In terms of mathematics and physics, the course is at the level of a good Postgraduate and Ph.D. degree.

This edition of LIDESP features also a special one-day module on **multiphase flow dynamics and simulation**. This module is available as a stand-alone module for attendance at a reduced registration fee.

The course is addressed to scientists, professionals, company engineers, R&D managers and graduate students in the fields of Engineering, Chemistry, Biology, Medicine, Applied and Fundamental Sciences. This course is especially of interest to those dealing with phenomena involving drops and sprays, in order to get acquainted with the traditional background and the most recent developments of this discipline.

The pre-requisites are a preparation in Mathematics and Physics equivalent to a Master Degree in Engineering. Physics or Chemistry and a good university preparation in fluid-dynamics and heat transfer.

The course is sponsored by the European Institute of Liquid Atomization and Spray Systems (ILASS EUROPE).

## COURSE PROGRAM

	Tue -4/9	Wed -5/9	Thu - 6/9	Fri - 7/9
	Introduction	Drop Physics 1	Drop Physics 2	Numerical modelling of liquid interfaces and multiphase flows
8.30-9.00	Registration			
9.10 - 10.00		D2 – MM3	A1 – AA5	NU1 - AS1
10.00-10.50	I1 – AA1	D2 – MM4	A1 – AA6	NU1 - AS2
10.50-11.10	Coffee break	Coffee break	Coffee break	Coffee break
11.10-12.00	I1 – AA2	D3 – VB2	NN1 – VB6	NU2 – FZ1
12.00-12.50	I2 – MM1	D3 – VB3	NN1 – VB7	NU2 – FZ2
12.50-13.30	Lunch	Lunch	Lunch	Lunch
13.30-14.20	I2 – MM2	D5 – MM5	D6 – MM6	NU3 - FZ3
14.20-15.10	I3 – VB1	Consultation	Consultation	NU3 - FZ4
15.10-15.40	Coffee break	Coffee break	Coffee break	Coffee break
15.40-16.30	D1 – AA3	D4 – VB4	A2 – MM7	HPC1 - IR1
16:30-17.20	D1 – AA4	D4 – VB5	A3 – AA7	HPC1 - IR2
17.20-17.50	<b>Hands-on measurements</b>	<b>Hands-on measurements</b>	<b>SOCIAL DINNER</b>	

\* In green the 1-day module.

## CONTENTS

*I1 Introduction and basic concepts.* Gallery of basic phenomena, micro- to macro- scale (molecular dynamics/continuum approaches), contact angle, Young equation, Laplace pressure, Free Gibbs Energy, Marangoni effects – **Amirfazli**

*I2 Introduction to fluid mechanics of liquid interfaces.* Basic equations, Navier-Stokes equations for capillary flows, liquid jet break-up – **Marengo**

*I3 Surface tension & measurement techniques.* Equilibrium and dynamic surface tension. De Nouy/Wilhelmy, sessile drop and pendant drop (ADSA), maximum bubble pressure. – **Bertola**

*D1 Dynamics of drops deposited on a surface.* Sessile drops, spreading law, apparent and real contact angles. Drop shedding, contact angle hysteresis – **Amirfazli**

*D2 Introduction to drop-wall interactions.* Drop impact on dry and wetted surfaces. Morphology. Shallow and thick layers. Splashing correlations. **Marengo**

*D3 Drop impact with a solid surface.* Impact regimes, impact models, drop rebound. **Bertola**

*D4 Heat and mass transfer in drops.* Mono-component droplet heating and evaporation. Abramzon and Sirignano model. **Bertola**

*D5 Drop impact on heated surfaces.* Introduction to drop impact onto heated surfaces. Impact regime maps. Transitions. Dynamic Leidenfrost temperature. Control of secondary atomization and splashing. – **Marengo**

*D6 Drop-drop collision.* Phenomenology and collision regimes. Survey of modelling and simulation results - **Marengo**

*A1 Superhydrophobicity.* Application of superhydrophobic surfaces. Cassie-Wenzel and competing

theories. Types of SHS and manufacturing techniques.

Impact on SHS surfaces. Impalement transition – **Amirfazli**  
*NN1 Introduction to non-Newtonian fluids.* Constitutive models and practical examples (polymer solutions and melts, gels, etc.). Power-law fluids, viscoplastic fluids, viscoelastic fluids. Non-Newtonian fluid design. Elements of rheological measurements. – **Bertola**

*NN2 Impact of non-Newtonian drops.* Formation of non-Newtonian droplets by capillary breakup. Impact of power-law and viscoplastic drops on solid surfaces. Impact of dilute polymer solution drops. Dynamic wetting. – **Bertola**

*A2/3 Applications of what you learned in the course:* (a) Inkjet technology: Design of printheads, waveforms, ink formulations (b) Metal deposition, (c) 3D printing, (d) Microlens manufacturing, – **Amirfazli, Marengo**


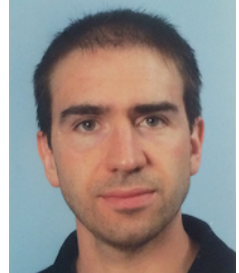
*NU1 Introduction to modeling approaches to simulate interfaces, drops and bubbles.* Introduction and basic modeling concepts, Lagrangian and Eulerian approaches. The Lagrangian Particle Tracking approach: basics and applications. – **Soldati**

*NU2/3 Modeling approaches to simulate interfaces, drops and bubbles in turbulence.* The phase field approach: basics and applications. The sharp interface approach: basics and applications.– **Zonta**

*HPC1 Basics of parallel computing for fluid dynamics.* Introduction to MPI, point to point message passing, blocking/non-blocking, one-sided/two-sided, collectives, shared memory in MPI, groups and communicators, topologies, and parallel I/O. Examples and applications (hands on computer sessions). – **Reichl**



## LECTURERS

	<p><b>Prof. Alidad Amirfazli</b>          Before joining the York University as the founding Chair of the Department of Mechanical Engineering, Alidad Amirfazli held the Canada Research Chair in Surface Engineering at the University of Alberta, Canada. Amirfazli has produced exciting results in wetting behavior of surfaces, drop adhesion and shedding, understanding and application of superhydrophobic coatings. He has more than 250 scientific contributions, many in prestigious peer reviewed journals; he is the <b>Editor for the Advances in Colloid and Interface Science</b>. Dr. Amirfazli has been the recipient of the Martha Cook Piper Research prize, Killam Annual Professorship, and been elected as a Royal Society of Canada's of College of New Scholars, Artists and Scientists. He also served in the board of Professional Engineers of Alberta, and been a consultant with various companies in USA, Europe, and Canada.</p>
	<p><b>Prof. Volfango Bertola</b>          Joined the University of Liverpool in 2011, after holding a Lectureship at the University of Edinburgh (2004-1011) and a Marie Curie Fellowship at the Ecole Normale Supérieure in Paris (2001-2004). In 2009-10 he was Visiting Professor and Lagrange Fellow at Politecnico di Torino (Italy). He has more than 100 scientific publications in the areas of soft matter, multiphase flows, and thermodynamics, including several contributions on non-Newtonian drops and on the dynamic wetting of complex fluids. He has been the recipient of a Royal Academy of Engineering Global Research Award (2009) and the UIT Young Scientist Prize (2001).</p>
	<p><b>Prof. Marco Marengo</b>          Professor of Thermal Engineering at the University of Brighton. Graduated in Physics at the University of Turin cum laude and completed his Ph.D. studies at the Polytechnic of Milan and University of Erlangen with a thesis about "Drop Impingement on Liquid Film". Since 2009 he is European Editor of the Journal "Atomization &amp; Sprays". Visiting Professor at the University of Mons-Hainaut since 2005. He published more than 280 scientific papers, many in peer-reviewed journals about liquid sprays, drop impact, heat pipes, building physics. He has received more than 30 invitations for plenary lectures and department seminars. Prof. Marengo is founder of two spin-off companies and holds seven patents.</p>
	<p>Since 2016 Alfredo Soldati is Professor of Fluid Mechanics at the Technische Universität Wien. Graduated at the University of Pisa, he was research assistant at the University of California at Santa Barbara. Before he was Professor in Udine (Italy). The focus of the research of his Fluid Mechanics group is on multiphase dispersed flows, trying to capture the inherent multiscale aspects from the fundamentals to the applications. Numerical Simulations have been recently complemented by an experimental activity. Researches on turbulent dispersed flows of particles, bubbles, droplets and fibers apply to industrial problems and environmental protection with a recent twist on geophysical and biomedical applications. Prof. Soldati is fellow of the American Physical Society, and the recipient of the 2007 Knapp award and of the 2015 Lewis F. Moody Award from the American Society of Mechanical Engineers. He is currently Editor in Chief of the International Journal of Multiphase Flow.</p>
	<p>Dr. Francesco Zonta graduated in Mechanical Engineering in 2006 at the University of Udine, where he also completed his PhD in 2010. From 2010 to 2016 he has been Research Assistant at the University of Udine and at the University of Torino. In 2014, he has been invited scholar at the University Pierre et Marie Curie (UPMC, Paris). Since 2016, he is Senior Researcher at the Institute of Fluid Mechanics and Heat Transfer of the Vienna University of Technology. His research focuses on turbulence, heat transfer, multiphase flows and computational fluid dynamics. He has obtained a number of grants for HPC (High Performance Computing) applications, and he has recently been the recipient of "Ermanno Grinzato" prize awarded by AIPT (2013).</p>



Dr. Irene Reichl studied Technical Physics at TU Wien. She did her master thesis in quantum field theory (2002) and her PhD thesis in computational materials science (2005). Her post-doc project at the University of Vienna, Institute of Sports Science, focused on the numerical analysis of human knee joint kinematics (2006-2014). Then she started working in the Vienna Scientific Cluster (VSC) team at TU Wien where she is involved in training in parallel computing, especially with MPI and OpenMP.

### REGISTRATION FEES (Euro)

	<b>FULL early bird / std.</b>	<b>EFMC Delegate early bird / std.</b>	<b>1-Day Module early bird / std.</b>
Academic (tenure, post-doc, researcher)	700/800	500/600	250/300
Ph.D students	500/600	300/400	250/300
Industry (VAT exempt)	1000/1,200	800/1,000	450/500

The fees include lunches, social dinner and coffee breaks. Registration is open from 1st March 2018 to **15th August 2018. Early bird registration by 30<sup>th</sup> June 2018.** Maximum number of participants: **50**. Special requests for accommodation will be considered by the organization staff.

**TO REGISTER: Applicants should register online at <http://pcwww.liv.ac.uk/~vbertola/lidesp6>**

### VENUE

The workshop will take place at Vienna University of Technology (address: Technische Universitaet Wien Karlsplatz 13, 1040 Wien, Austria)

### FURTHER INFO:

<http://pcwww.liv.ac.uk/~vbertola/lidesp6>