TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	September 23 Fundamentals	September 24 Internal Flows	September 25 External Flows	September 26 Droplets	September 27 Droplets
9.00 - 9.45	Registration	Hodes	Quéré	Quéré	Crowdy
9.45 - 10.30	Hodes	Hodes	Quéré	Quéré	Lyons
11.00 - 11.45	Lyons	Papageorgiou	Papageorgiou	Lyons	Quéré
11.45 - 12.30	Lyons	Papageorgiou	Bahadur	Lyons	Quéré
14.00 - 14.45	Bahadur	Crowdy	Lyons	Hodes	
14.45 - 15.30	Bahadur	Crowdy	Hodes	Papageorgiou	
16.00 - 16.45	Hodes	Bahadur	Crowdy	Bahadur	
16.45 - 17.30	Papageorgiou	Papageorgiou	Crowdy	Bahadur	
18.00	Welcome Aperitif				

ADMISSION AND ACCOMMODATION

The registration fee is 600.00 Euro + VAT*, where applicable (bank charges are not included). The registration fee includes a complimentary bag, four fixed menu buffet lunches (on Friday upon request), hot beverages, downloadable lecture notes and wi-fi internet access.

Applicants must apply at least one month before the beginning of the course. Application forms should be sent on-line through the following web site: http://www.cism.it. A message of confirmation will be sent to accepted participants. Applicants requiring assistance with the registration should contact the secretariat at the following email address cism@cism.it.

Applicants may cancel their course registration and receive a full refund by notifying CISM Secretariat in writing (by email to cism@cism.it) no later than two weeks prior to the start of the course.

Cancellation requests received during the two weeks prior to the start of the course will be charged a 50.00 Euro handling fee. Incorrect payments are also subject to a 50.00 Euro handling fee.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered lodging and/or board, if available, in a reasonably priced hotel or student guest house.

Requests should be sent to CISM Secretariat by **July 23, 2019** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

Information about travel and accommodation is available on the web site www.cism.it, or can be mailed upon request.

* Italian VAT is 22%.

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ACADEMIC YEAR 2019
The Ladyzhenskaya Session
Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

TRANSPORT PHENOMENA ON TEXTURED SURFACES: FUNDAMENTALS AND APPLICATIONS

Advanced School
coordinated by

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UK

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Tufts University
Medford, MA, USA

Udine ***September 23 - 27*** **2019**

TRANSPORT PHENOMENA ON TEXTURED SURFACES: FUNDAMENTALS AND APPLICATIONS

In the past two decades numerous laboratories have microfabricated surfaces with the chemical and textural properties to mimic superhydrophobic surfaces (SHs) found in nature, the most well-known being the self-cleaning properties of the lotus leaf. This has been made possible by the continuing advances in nano/micro fabrication technology. This Advanced School will bring together engineers, physicists, chemists and applied mathematicians in a multi-physics framework.

Adopting a holistic approach coupling momentum, heat, mass and charge transport phenomena the lecturers comprise 2 applied mathematicians, 2 mechanical engineers, a physicist and a chemist: together they bring theoretical and experimental perspectives to the topic.

The fundamentals of the physical and chemical phenomena exploited to suspend liquids in the Cassie (unwetted) state on SHs will be covered. We address the conditions required, and technologies developed, to maintain the Cassie state and those which cause transition to the (sometimes desirable) Wenzel (wetted) state. Transport phenomena physics related to droplets on SHs and flows of liquids over them will be emphasized.

For droplets on SHs, the fundamental microfabrication principles including those based on polymer processing technology will be surveyed. Ice prevention and enhancing boiling and condensation heat transfer will be points of emphasis, as will electrowettability-based dynamic control and enhancement of general phase change phenomena. Various approaches to suppress or exploit Leidenfrost phenomena to, e.g., suppress critical heat flux or pump droplets, will be studied. SHs with multifunctional properties such as photo-catalytic activity, anti-reflectivity, abrasion resistance and antisoiling characteristics will be treated.

In studying external/internal flows over SHs, the course will include a rigorous derivation of the governing equations and boundary conditions, resolution of surfactant, Marangoni, thermocapillary and molecular phenomena and possible meniscus deformations. Comparison of theoretical models to experiments will be made with implications for key engineering parameters.

The course is suitable for graduate students, academics, engineers in industry. The techniques used will span mathematical modelling ideas and numerical schemes, through to experimental procedures and understanding the fundamental physical principles. Applications will be emphasised throughout.

PRELIMINARY SUGGESTED READINGS

Game, S. E., Hodes, M., Keaveny, E. E., & Papageorgiou, D. T. (2017), Phys. Rev. Fluids, 2(9), 094102.

Hodes, M., Kirk, T. L., Karamanis, G., & MacLachlan, S. (2017), J. Fluid Mech, 814, 301-324.

Krupenkin, T. N., Taylor, J. A., Wang, E. N., Kolodner, P., Hodes, M., & Salamon, T. R., (2007), Langmuir, 23(18), 9128-9133.

Kirk, T. L., Hodes, M., & Papageorgiou, D. T. (2017). J. Fluid Mech, 811, 315-349.

Crowdy, D.G. (2016), J. Fluid Mech, 791, R1.

Crowdy, D.G. (2017), J. Fluid Mech, 822, 307—326.

Philip, J. R. (1972), Z. Angew. Math. Phys, 23, 353-372.

Xu Q. F., Liu Y., Lin F-J, Mondal B., and Lyons A.M., (2013), ACS Appl. Mater. Interfaces, 2013, 5 (18), pp 8915–8924.

Pushalkar S., Ghosh G., Xu Q. F., Liu Y, Ghogare A.A., Atem C., Greer A., Saxena D., and Lyons, A.M., ACS Appl. Mater. Interfaces, (to appear). (DOI: 10.1021/acsami.8b09439).

Quéré D, (2013), Annual Review of Fluid Mechanics 45, 197–215.

Quéré D, (2008), Annual Review of Materials Research 38, 71–99.

Bahadur V. and Garimella S. V., (2008), Langmuir, 24, 8338-8345.

Bahadur V., Mishchenko L., Hatton B., Taylor, J. A., Aizenberg J., Krupenkin T. (2011), Langmuir, 27, 14143-14150.

Shahriari A., Birbarah P., Oh J., Miljkovic N. and Bahadur V. (2017), Nanoscale and Microscale Thermophysical Engineering (Special issue on Micro & Nanoscale Phase Change Heat Transfer), 1-20, 21(2), 102-121.

LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.

INVITED LECTURERS

Vaibhav Bahadur - University of Texas at Austin, TX, USA
6 lectures on: Superhydrophobicity, electrowetting, micro-fabrication, heat transfer applications. Fundamentals of electrowettability on SHs. Ice prevention, the role of surface textures and chemistry in enhancing boiling and condensation heat transfer, electrowettability-based dynamic control and enhancement of phase change phenomena.

Darren Crowdy - Imperial College London, UK
6 lectures on: Mathematical modelling of transport phenomena problems involving SHs and their applications. Complex variable, conformal mapping and transform techniques; techniques from asymptotic analysis and numerical methods. Ridge orientation, distribution, meniscus curvature, subphase fluid and non-Newtonian fluids effects on slip.

Marc Hodes - Tufts University, Medford, MA, USA
6 lectures on: Heat and mass transfer in internal flows through SH microchannels. Derivation of convective transfer equations for heat and species coupled to hydrodynamics. Thermocapillary stress and phase change along menisci. Gas diffusion in Cassie to Wenzel state transition. Analogies with thermal contact resistance. Cooling using liquid metals, novel pumping and propulsion mechanisms.

Alan Lyons - CUNY City University of New York Graduate Center and College of Staten Island, NY, USA
6 lectures on: Chemistry of SHs; effect of chemical and morphological properties on the stability and reliability of the Cassie state; fabricating mechanically durable and chemically stable SHs; fabricating SHs using polymer process technology; applications of SHs with multi-functional properties (e.g. photocatalytic activity, anti-reflectivity, abrasion resistance, anti-soiling).

Demetrios Papageorgiou - Imperial College London, UK
6 lectures on: Hydrodynamics, including stability issues, of internal flows through SH microchannels; computation of meniscus location. Mathematical solutions for apparent slip lengths for range of problems capturing secondary effects such as surfactant-induced Marangoni stresses along menisci and edge effects. Numerical solutions, asymptotics and (spectral) Chebyshev collocation methods.

David Quéré - Physique et Mécanique des Milieux Hétérogènes, ESPCI, Paris, France
6 lectures on: Dynamics of liquids on structured surfaces. Super hydrophilic behavior: how to make liquid impregnate textures, how this generates low-adhesion surfaces, how a liquid inside a texture can be dislodged by another liquid. Water-repellency. Super aerophilicity. Leidenfrost with textures.