TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	July 4	July 5	July 6	July 7	July 8
9.00 - 9.45	Registration	Spedding	Vlahovska	Stark	Lauga
9.45 - 10.30	Eloy	Spedding	Vlahovska	Stark	Lauga
11.00 - 11.45	Stark	Stark	Lauga	Spedding	Eloy
11.45 - 12.30	Stark	Stark	Lauga	Spedding	Eloy
14.00 - 14.45	Clanet	Clanet	Eloy	Vlahovska	
14.45 - 15.30	Clanet	Clanet	Eloy	Vlahovska	
16.00 - 16.45	Vlahovska	Lauga	Spedding	Clanet	
16.45 - 17.30	Vlahovska	Lauga	Spedding	Clanet	

ADMISSION AND ACCOMMODATION

The registration fee is of 575,00 Euro + VAT taxes*, where applicable (bank charges are not included).

The registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday subject to numbers), 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 our web site: http://www.cism.it or by post.

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

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

If cancellation occurs less than two weeks prior to the start of the course, a Euro 50,00 handling fee will be charged. Incorrect payments are subject to Euro 50,00 handling fee.

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

Requests should be sent to CISM Secretariat by **May 4, 2016** 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 our web site, or can be mailed upon request.

* Italian VAT is 22%

For further information please contact:

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33100 Udine (Italy)
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ACADEMIC YEAR 2016
The Leipholz Session

22th CISM-IUTAM International Summer School on

BIOLOGICAL AND BIO-INSPIRED FLUID MECHANICS

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

Advanced School
coordinated by

Eric Lauga
University of Cambridge
UK

Christophe Eloy
IRPHE, Marseille
France

International Union for Theoretical and Applied Mechanics

IUTAM

Udine, *July 4 - 8* 2016

BIOLOGICAL AND BIO-INSPIRED FLUID MECHANICS

At all scales of Nature, from bacterial flagella to tree branches, biological organisms interact with a surrounding fluid environment. These interactions are generally critical for their survival and are often fully coupled: the organisms modify or create flows around them, and these flows, through surface forces (pressure or viscous forces), exert loads on the organisms that can deform them and modify their behavior. One example is blood flow, where fluid stresses acting on red blood cells have well-studied impact both in normal physiology and disease. Another example is the fluid-based motility of organisms, at all scales, from cells to birds, or fish. Much research efforts have been devoted to understanding the adaptation of biological organisms to resist or exploit aero- or hydrodynamic constraints. One motivation for these studies, beyond the desire to gain a deeper understanding of the natural world, is to design efficient biomimetic artificial systems. This school will teach the fundamental modeling tools required to quantify and understand the fluid mechanics of biological and bio-inspired systems.

The various branches of fluid mechanics can be divided according to the relevant Reynolds number involved. The same classification is applicable to biological fluid mechanics. Although there may be some apparent kinematic similarities between the swimming motion of an eel and a spermatozoon, the Reynolds numbers involved and thus the fluid dynamics are very different. Accordingly, the lectures of this school will be divided into two groups.

Three series of lectures will be concerned with the low-Reynolds number regime and the fluid mechanics around cells. At this scale, important problems include the physics of membranes, thermal fluctuations, elastics instabilities such as cell wrinkling and buckling, flagellar and ciliary locomotion, collective motion of bacteria, chemotaxis, and rheology of non-Newtonian flows.

The second series of three lectures will focus on the large Reynolds number limit and macroscopic locomotion. These courses will address the fluid mechanics and the fluid-structure interactions of flying, swimming, and human motion with emphasis on the importance of unsteady effects, vortex dynamics, boundary layers, efficiency, optimization, and athletic performance in sports.

The objective of this school is to provide an introduction to fluid mechanics for biological and bio-inspired systems with an emphasis on the role of fluid-structure interactions.

The lectures will address both the experimental and theoretical aspects of the field, and will cover the fundamentals as well as recent developments and open questions. This course is aimed at PhD students, postdoctoral fellow, and young researchers in the fields of Physics, Biophysics, Applied Mathematics, Robotics, and Engineering.

PRELIMINARY SUGGESTED READINGS

P.M. Vlahovska, T. Podgorski, C. Misbah, Vesicles and red blood cells: from individual dynamics to rheology, C.R. Phys. 10, 775-789 (2009).

F.A. Morrison, Understanding Rheology, Oxford University Press (2001).

E. Lauga, T.R. Powers, The hydrodynamics of swimming microorganisms, Rep. Prog. Phys. 72, 096601 (2009).

M.J. Lighthill, Hydromechanics of aquatic animal propulsion, Ann. Rev. Fluid Mech. 1, 413-446 (1969).

E. Torenbeek, H. Wittenberg, Flight Physics: essentials of aeronautical disciplines and technology, with historical notes, Springer (2009).

T.A. McMahon, Muscles, reflexes, and locomotion, Princeton University Press (1984).

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

Christophe Clanet - Ecole Polytechnique, Palaiseau, France
6 lectures on: Sports & Human motion.
How does a human move? Can we relate his dynamics to the molecular actomyosin cycle responsible for muscle contraction? If we manage to do so, can we understand both his athletic performances and some of his pathological behaviors? These questions will first be addressed in the context of weightlifting and then used to analyze other athletic performances.

Christophe Eloy - IRPHE, Centrale Marseille, France
5 lectures on: Swimming at high Reynolds number.
Classification of swimming modes, scaling laws, potential flow theories, jet propulsion, boundary layers, vortex dynamics, flexible appendages, swimming efficiency, form and function, fish schooling.

Eric Lauga - University of Cambridge, UK
6 lectures on: Complex fluids.
Experiments and rheological data; strong vs. weak flows; normal stresses; shear-thinning behavior; empirical spring-dashpot models; Maxwell models; linear viscoelasticity; analysis in complex plane; storage and loss modulus; objective derivatives; Oldroyd models; generalized Newtonian models.

Geoff Spedding - University of Southern California, Los Angeles, CA, USA
6 lectures on: Flying.
Why Fly? (transport efficiency, modes of locomotion, human-powered flight); basic flight mechanics; why do animals flap their wings? (Re effects, lift and thrust generation, flight control and performance enhancement); flight mission profiles and biomimetics; on optimal configurations; what's next?

Holger Stark - Technical University Berlin, Germany
6 lectures on: Swimming at low Reynolds number.
Basics of the Stokes equations, implications for artificial and biological microswimmers, generic microswimmers such as pushers, pullers, and squirmers, illustrative examples.

Petia M. Vlahovska - Brown University, Providence, RI, USA
6 lectures on: Microhydrodynamics of red blood cells and their mimetics (vesicles and capsules).
Topics include mechanics of biomembranes, dynamics of a membrane-bound particle in linear and quadratic flows, cross-stream migration, rheology of dilute suspensions. The emphasis will be on basic physics, scaling and nondimensionalization, and approximations that can be used to obtain analytical solutions.

BIOLOGICAL AND BIO-INSPIRED FLUID MECHANICS

Udine, July 4 - 8, 2016
Application Form
(Please print or type)

Surname _____

Name _____

Affiliation_____

Address_____

_____

E-mail _____

Phone _____Fax_____

Method of payment upon receipt of confirmation (Please check the box)

The fee is 575,00 Euro + 22% Italian VAT taxes, where applicable (bank charges are not included).

❑ *I shall send a check of Euro _____*

❑ *Payment will be made to CISM - Bank Account No. 094570210900, VENETO BANCA - Udine (CAB 12300 - ABI 05035 - SWIFT/BIC VEBHIT2M - IBAN CODE IT46 N 05035 12300 09457 0210900). Copy of the receipt should be sent to the secretariat*

❑ I *shall pay at the registration counter with check or VISA Credit Card (Mastercard/Eurocard, Visa, CartaSi)*

IMPORTANT: CISM is obliged to present an invoice for the above sum. Please indicate to whom the invoice should be addressed.

Name _____

Address _____

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C.F.* _____

VAT/IVA* No _____

(*) Only for EU residents or foreigners with a permanent business activity in Italy.

Only for Italian Public Companies

❑ *I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).*

Privacy policy: I understand that data received via this form will be used only to provide information about CISM and its activities, within the limits set by the Italian legislative decree no. 196/2003 and subsequent amendments.
Complete information on CISM's privacy policy is available at www.cism.it.

I have read the "Admission and Accommodation" terms and conditions and agree.

Date _____ Signature _____