

TIME TABLE

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	June 7	June 8	June 9	June 10	June 11
9.00 - 9.45	Registration	Hill	Brius	Brius	Sadhil
9.45 - 10.30	Dual	Dual	Dual	Sadhil	Wiklund
11.00 - 11.45	Wiklund	Wiklund	Hill	Sadhil	Wiklund
11.45 - 12.30	Brius	Hill	Sadhil	Hill	Dual
14.30 - 15.15	Sadhil	Laurell	Brius	Wiklund	Hill
15.15 - 16.00	Laurell	Wiklund	Sadhil	Dual	Dual
16.30 - 17.15	Laurell	Brius	Laurell	Hill	
17.15 - 18.00	Wiklund	Laurell	Brius	Discussion	

ADMISSION AND ACCOMMODATION

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.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

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. Requests should be sent to CISM Secretariat by **April 7, 2010** 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.

The Deutscher Akademischer Austausch Dienst (DAAD) and the Deutsche Forschungsgemeinschaft (DFG) offer support to German students. Please contact:

DAAD, Kennedyallee 50, 53175 Bonn
tel. +49 (228) 882-0
e-mail: postmaster@daad.de
web site: <http://www.daad.de/de/kontakt.html>

DFG, Kennedyallee 40, 53175 Bonn
tel. +49 (228) 885 2655
e-mail: ing4@dfg.de
web site: <http://www.dfg.de>

Information about travel and accommodation is available on our web site, or can be mailed upon request.

For further information please contact:

CISM
Palazzo del Torso - Piazza Garibaldi 18
33100 Udine (Italy)
tel. +39 0432 248511 (6 lines)
fax +39 0432 248550
e-mail: cism@cism.it

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

ACADEMIC YEAR 2010
The Lippmann Session



ULTRASOUND STANDING WAVE ACTION ON SUSPENSIONS AND BIOSUSPENSIONS IN MICRO- AND MACRO FLUIDIC DEVICES

Advanced School
coordinated by

Jürg Dual
ETH, Zürich
Switzerland

Jeremy J. Hawkes
University of Manchester
UK

Udine, June 7 - 11, 2010

ULTRASOUND STANDING WAVE ACTION ON SUSPENSIONS AND BIOSUSPENSIONS IN MICRO- AND MACRO FLUIDIC DEVICES

This course is aimed at PhD students and researchers with diverse backgrounds. It should also be of interest to academics and professionals who want to broaden their knowledge of the subject.

Standing wave vibrations are used by many groups to move both biological cells and other types of particles in liquids and gases, and also to move the liquids and gases themselves. Ultrasonic vibrations put larger forces on cells than lower frequencies and are generally preferred but, since their short wavelengths don't actually move the cells very far microfluidic scale systems are the usual choice. In these sub millimeter channels processes have been established for: filtration, separation, transfer between two media, particle

attraction to a wall (used to enhance cell capture by biosensors), mixing of fluids and reactants, forming patterns and stirring for enhanced heat transfer. At microfluidic scales an added advantage is that fluid movement is in the laminar flow regime and can be accurately predicted and modelled, so the potential for very precisely controlled systems exists.

More than 200 years ago Ernest Chladni reported moving particles in resonant fields yet only recently have a large number of potential applications reached the first proof of principle stage. The proofs demonstrate that manipulation by standing waves could accomplish many of the vital requirements for processing industries and also for medical and environmental

monitoring, yet this approach has not been widely implemented. There are many reasons for this slow development, the main one being the large number of complex and interacting subjects which must be mastered to make progress. Since much of the information is not taught at undergraduate level students entering this area faces a steep learning curve. This highly interdisciplinary course will explain how the acoustic radiation force acts on particles, how to identify and control the many forms of acoustic streaming, describe principles of resonance for the successful design of fluid containing resonators, and describe micro-engineering methods, system control and handling of biological samples. The course will also cover more general ground in fluidics

and acoustics. In addition, to give an understanding of the potential applications many of the currently perceived requirements of microbiology, medicine and chemical engineering will be explained.

Work focused on a single purpose such as manipulation of particles is often disrupted by associated effects such as acoustic streaming, cavitation heating or particle-particle interaction. The course will give students sufficient knowledge to understand the many interacting events they will encounter during system development. Fully mastering and controlling all of these effects together is still a goal for the future but the course will show how to select out a phenomenon of interest and control it for many practical purposes.

PRELIMINARY SUGGESTED READINGS

Fahy, F.1994. Sound and Structural Vibration, Academic Press.

Kinsler, L.E. Frey, A.R. Coppens, A.B. and Saunders, J. V. 2000. Fundamentals of acoustics, 4th ed, New York: Wiley.

Riley, N. 1966. On a sphere oscillating in a viscous fluid. Q. J. Mech. Appl. Math. 19:461–72.

Bruus, H. 2008. Theoretical Microfluidics Oxford University Press. Oxford.

Ristic, V. 1983. Principles of Acoustic Devices, Wiley.

Riley, N. 2001. Steady Streaming, Annu. Rev. Fluid Mech. 33:43–65.

INVITED LECTURERS

Henrik Bruus - DTU Lyngby, Denmark

6 Lectures on: Theory of ultrasound standing wave action in microfluidics. Governing equations for flow and diffusion. Perturbation theory of ultrasound including acoustophoresis and acoustic streaming. Emphasis will be placed on basic theoretical concepts and their application to experiments.

Jürg Dual - ETH Zürich, Switzerland

6 Lectures on: Fundamentals of acoustics and vibrations in solids, fluid structure interaction. piezoelectricity, resonant and non resonant modes of excitation, numerical modeling, applications and characterization.

Martyn Hill - University of Southampton, UK

6 lectures on: Single and multi degree of freedom oscillators and resonance. 2 and 3 port transducer representations & equivalent circuits. 1D matrix models and circuit element models. Fundamentals of cell manipulation including filtration, concentration and biosensing.

Thomas Laurell - Lund University, Sweden

5 lectures on: Microfabrication of microchip acoustic resonators and transducer characterisation. Acoustic valving, switching, mixing and chip integrated catalytic microreactors. Free flow acoustophoresis and affinity acoustophoresis in acoustic standing wave chips. Ultrasonic trapping, and coupling to biomedical analysis.

Satwindar Singh Sadhal - University of Southern California, USA

6 Lectures on: "Acoustic streaming with drops, bubbles and particles." The nonlinear interaction of ultrasound standing waves with interfaces gives rise to a mean dc flow known as streaming. This phenomenon has been analyzed for drops, bubbles and particles by singular perturbation.

Martin Wiklund - KTH - Royal Institute of Technology, Sweden

7 lectures on: Applications and practical aspects of ultrasonic manipulation, including instrumentation, optical monitoring, handling of bio-samples, safety and biocompatibility.

LECTURES

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

**ULTRASOUND STANDING WAVE ACTION ON SUSPENSIONS
AND BIOSUSPENSIONS IN MICRO- AND MACRO
FLUIDIC DEVICES**

Udine, June 7 - 11, 2010

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 of Euro 700,00 includes IVA/VAT tax and excludes bank charges

I shall send a check of Euro _____

*Payment will be made to CISM - Bank Account N° 094570210900,
VENETO BANCA - Udine (CAB 12300 - ABI 05418 - SWIFT AMBPIT2M - IBAN
CODE IT83Z 05418 12300 09457 0210900).*

Copy of the receipt should be sent to the secretariat

*I shall pay at the registration counter with check, cash 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 _____

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 _____