

TIME TABLE

(Registration on Monday at 8:30)

TIME	Monday July 7	Tuesday July 8	Wednesday July 9	Thursday July 10	Friday July 11
9.00 - 9.45	Franc	Franc	Tsujimoto	Saurel (Workshop)	Salvetti
9.45 - 10.30	Franc	Avellan	Tsujimoto	Saurel (Workshop)	Salvetti
11.00 - 11.45	d'Agostino	Ceccio	Ceccio	Goncalvés (Workshop)	d'Agostino
11.45 - 12.30	d'Agostino	Ceccio	Ceccio	Goncalvés (Workshop)	d'Agostino
14.00 - 14.45	Avellan	Tsujimoto	d'Agostino	Salvetti (Workshop)	
14.45 - 15.30	Avellan	Tsujimoto	Ceccio	Saurel (Workshop)	
16.00 - 16.45	Franc	Avellan	Tsujimoto	Saurel (Workshop)	
16.45 - 17.30	Franc	Avellan	Tsujimoto	Goncalvés (Workshop)	

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 subject to numbers), hot beverages, 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 **May 7, 2014** 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.

For further information please contact:

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

ACADEMIC YEAR 2014
 The Simo Session

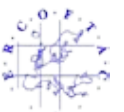


CAVITATION INSTABILITIES AND ROTORDYNAMIC EFFECTS IN TURBOPUMPS AND HYDROTURBINES

Advanced School
 coordinated by

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 Università di Pisa
 Italy

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 Università di Pisa
 Italy



European Research Community
 On Flow, Turbulence And Combustion

Udine July 7 - 11 2014

CAVITATION INSTABILITIES AND ROTORDYNAMIC EFFECTS IN TURBOPUMPS AND HYDROTURBINES

The attainment of higher power densities in modern hydraulic turbomachinery is invariably obtained by running the impeller at the maximum allowable speed and lower shaft torque. Therefore, operation under cavitating conditions with lighter – but also more flexible – shafts is often tolerated especially in space propulsion applications, exposing the machine to the onset of dangerous self-sustained, cavitation-induced fluid dynamic and rotordynamic instabilities. Since these phenomena actually represent the major source life and reliability degradation of the machine, fundamental information on their nature and behavior is of crucial importance for the effective design of today's high-performance hydraulic turbomachinery. However, the extreme complexity and imperfect understanding of the phenomena involved pose formidable obstacles to the modeling, prediction and control of cavitation-induced instabilities. For this reason, nowadays theoretical

analyses and simulations alone are still of limited value for the solution of specific technical problems and progress in this field must rely on the support of dedicated experimentation. The objective of the course consists in providing the participants with a detailed approach to the physics, fluid dynamics, modeling, experimentation and numerical simulation of cavitation phenomena, with special emphasis on cavitation-induced instabilities and their implications on the design and operation of high performance turbopumps and hydraulic turbines. To this purpose the first part of the lectures will cover the fundamentals (nucleation, dynamics, thermodynamic effects, erosion) and forms of cavitation (attached cavitation, cloud cavitation, supercavitation, vortex cavitation) relevant to hydraulic turbomachinery, discuss the physical mechanisms and occurrence of cavitation erosion phenomena, illustrate modern experimental techniques for the

characterization, visualization and analysis of cavitating flows, and introduce the main aspects of the hydrodynamic design and performance of axial inducers, centrifugal turbopumps and hydro-turbines. The second part of the lectures will focus on the theoretical modeling, experimental analysis, and practical control of cavitation-induced fluid-dynamic and rotordynamic instabilities of hydraulic turbomachinery, with special emphasis on cavitating turbopumps (cavitation surge, rotating cavitation, higher order cavitation surge, rotordynamic whirl forces). Finally, the third part of the course will illustrate the alternative approaches for the simulation of cavitating flows, with emphasis on both modeling and numerical aspects. Examples of applications to the simulation of unsteady cavitation in internal flows through hydraulic machinery will be illustrated in detail. The lecturers will use the background information to introduce the major topics currently

open for cavitation research and stimulate the active participation of the audience by presenting and discussing original findings and results in their areas of expertise. The course is addressed to doctoral/postdoctoral students, researchers, scientists, scholars and professionals from universities, research institutions and industries active in aerospace, mechanical, hydraulic, naval and chemical engineering, applied mechanics, applied mathematics, industrial chemistry and applied physics, who are interested in perfecting their knowledge and understanding of cavitating flow phenomena and research in wide range of engineering applications.

The aim of the Workshop session is to provide an overview of state of the art models and numerical methods for the simulation of cavitating flows with a more fundamental ND broader perspective than the SPECIFIC application to turbopumps and hydroturbines.

PRELIMINARY SUGGESTED READINGS

Brennen C. E., 1995, "Cavitation and Bubble Dynamics", Oxford University Press, excellent book on research aspects of bubbly cavitating flows.

Brennen C. E., 1994, "Hydrodynamics of Pumps", Concepts ETI, Inc., P.O. Box 643, Norwich, Vt, USA 05055.

Carey van P., 1992, "Liquid-Vapor Phase-Change Phenomena", Taylor and Francis.

Franc J.P & Michel J.M., 2004, "Fundamentals of Cavitation", Series on Fluid Mechanics and Its Applications, Vol. 76, Kluwer Academic Publisher.

Lakshminarayana B., 1996, "Fluid Dynamics and Heat Transfer of Turbomachines", John Wiley & Sons Inc.

Leveque R.J., 2002, "Finite Volume Methods for Hyperbolic Problems", Cambridge University Press.

Li S.C., 2000, "Cavitation of Hydraulic Machinery", Imperial College Press.

INVITED LECTURERS

François Avellan – EPFL, Lausanne, Switzerland
5 lectures on: Hydrodynamic Design and Performance of Hydraulic Turbines. Cavitation in Hydraulic Turbines. Flow Instabilities in Hydraulic Turbines.

Steven Ceccio – University of Michigan, Ann Arbor, MI, USA
5 lectures on: Innovative Experimental Techniques for Cavitating Flows. Advanced Visualization Techniques for Cavitating Flows.

Jean-Pierre Franc - LEGI, Grenoble, France
5 lecture on: Fluid Dynamics of Cavitation: the cavitation bubble and the various types of cavitation and their main features. Fluid Dynamics of Cavitation Erosion: introduction and testing methods; the various stages of the cavitation erosion process. Solid Mechanics of Cavitation Erosion.

Luca d'Agostino - Università di Pisa, Italy
5 lecture on: Cavitation Fundamentals in Hydraulic Turbomachinery, Hydrodynamic Design and Performance of Inducers and Radial Impellers, Experimental Identification of Cavitation Instabilities, Dynamic Transfer Matrix Characterization of Cavitating Inducers, Rotordynamic Force Experiments in Cavitating Inducers.

Maria Vittoria Salvetti - Università di Pisa, Italy
2 lectures on: Numerical Simulation of Cavitating Turbopump Inducers.

Yoshinobu Tsujimoto - Osaka University, Japan
6 lecture on: Flow Instabilities in Cavitating Inducers and Turbopumps, Suppression of Cavitation Instabilities in Inducers and Turbopumps, Backflow and Tip Leakage Cavitation, Rotordynamics of Turbopumps and Hydroturbines, 3-D Simulations of Cavitation Instabilities.

A workshop on Numerical Modeling of Cavitating Flows is planned for Thursday with the following contributions:

Eric Goncalves - LEGI, Grenoble, France (Workshop)
3 lecture on: Turbulence Models in Cavitating Flows, Cavitation models, 1D, 2D and 3D Numerical Simulations of Cavitating Flows with Different Cavitation Models, Thermodynamics Effects.

Richard Saurel - Aix Marseille University and University Institute of France, France (Workshop)
4 lectures on: Diffuse Interfaces Modelling with or without Phase Transition. A Relaxation Hyperbolic Solver for Interfacial and Cavitating Flows. Low Mach Number Algorithm and Exact Reference Solutions of Cavitating Flows. Application to Cavitation in Nozzles, Flashing Flows and to the Direct Numerical Simulation of Boiling Flows.

Maria Vittoria Salvetti - (Workshop)
1 lecture on: Numerical Schemes for Simulation of Cavitating Barotropic Homogeneous Flows.

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.

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Udine, July 7 - 11, 2014

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 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 _____

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 _____
