18th
afmc

Launceston, Tasmania,
Australia, 3-7 December 2012

AUSTRALASIAN FLUID MECHANICS SOCIETY

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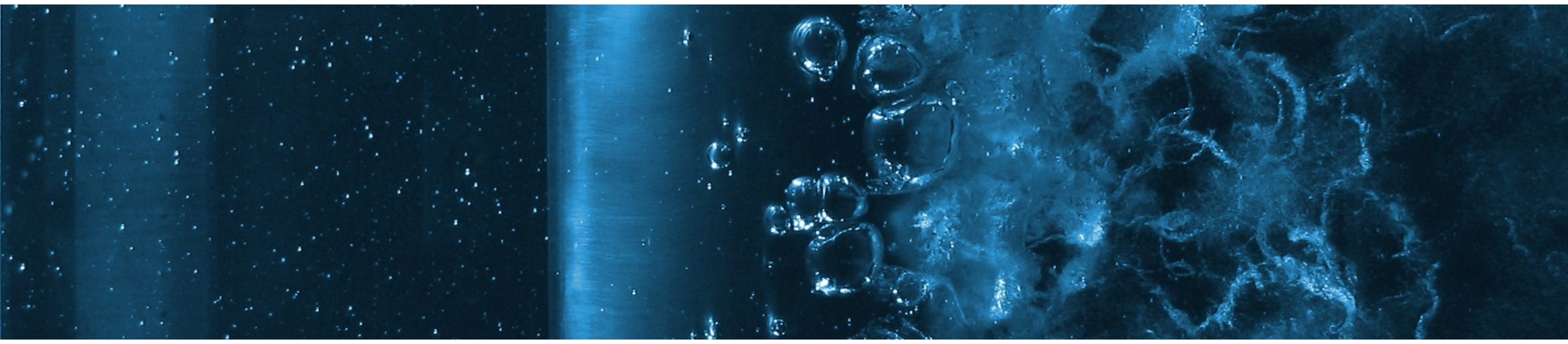

Proceedings of the

18th Australasian Fluid Mechanics Conference

Proceedings of the Eighteenth

AUSTRALASIAN FLUID MECHANICS CONFERENCE

AUSTRALIAN MARITIME COLLEGE

UNIVERSITY OF TASMANIA

LAUNCESTON, AUSTRALIA

3-7 DECEMBER 2012

Editors: P.A. Brandner and B.W. Pearce

The fluid flow graphic for the 18th AFMC is a colored image of cavitation occurrence about a NACA 16–028 hydrofoil - UTAS AMC Cavitation Research Laboratory.

P.A. Brandner and B.W. Pearce (Editors)

Proceedings of the
EIGHTEENTH AUSTRALASIAN FLUID MECHANICS CONFERENCE

Bibliography
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3rd – 7th December 2012, P.A. Brandner and B.W. Pearce (Editors)

University of Tasmania, Launceston 7250, AUSTRALIA

Each paper appearing in these proceedings has been peer reviewed by two independent experts in accordance with Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education requirements.

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Preface

This eighteenth meeting of the Australasian Fluid Mechanics Conference (AFMC) marks 50 years of the series from the first held at the University of Western Australia in 1962. The eighteenth also marks the first to be held biennially under the auspices of the Australasian Fluid Mechanics Society (AFMS). The AFMC series has established a strong tradition of providing a diverse forum for the presentation of the latest Australasian, as well as international, fluid mechanics research.

The diversity of work and participation has been maintained for this meeting with over 250 contributed papers in 36 themes. Of the over 250 delegates more than half are international or graduate student registrants. We are particularly appreciative of the 9 invited speakers presenting experimental and numerical work ranging from traditional to some of the latest applications in fluid mechanics. An ongoing feature of the Conference, initiated at the seventeenth AFMC, is the induction of Fellows of the AFMS in a ceremony as part of the conference dinner.

All papers included in the proceedings have undergone formal peer review in accordance with the Higher Education Research Data Collection requirements of the Australian Government Department of Industry, Innovation, Science, Research and Tertiary Education. Full papers were invited on the basis of submitted abstracts after review by the local organising committee. Submitted papers were externally reviewed by two independent experts in the relevant field under the coordination of the committee. Final acceptance was dependent on satisfactory response to the external review. Presentations on the basis of the committee reviewed abstract were also accepted.

Special thanks are due to the organising committee for their technical oversight, particularly Bryce Pearce for his unerring commitment over the last two years, the invited speakers for their valuable contribution and to contributing authors, reviewers and participants for continuing to make the AFMC such a success. We acknowledge the enthusiast support of the Australian Maritime College and the University of Tasmania in making the bid and providing the venue. Thanks also to the sponsors and exhibitors and last but not least the conference managers Leishman Associates, namely Paula, Jenna and Natasha for all their hard work and assistance.

It is our privilege and honour to host the AFMC in Tasmania for the second time and trust the Conference is an enjoyable and interesting experience for all.

P. A. Brandner, Conference Chair
Australian Maritime College
University of Tasmania

Organisation

The conference is jointly hosted by the Australian Maritime College and the University of Tasmania under the auspices of the Australasian Fluid Mechanics Society.

Organising Committee

A/Prof. Paul Brandner	AMC, University of Tasmania (chair)
Dr Bryce Pearce	AMC, University of Tasmania (secretary)
Prof. Neil Bose	AMC, University of Tasmania
Dr Laurie Goldsworthy	AMC, University of Tasmania
Dr Irene Penesis	AMC, University of Tasmania
Dr Jonathon Binns	AMC, University of Tasmania
Dr David Clarke	Defence Science and Technology Organisation
Dr Alan Henderson	School of Engineering, University of Tasmania
Dr Jessica Walker	School of Engineering, University of Tasmania
Prof. Mike Davis	School of Engineering, University of Tasmania
Dr Jason Roberts	Antarctic Climate & Ecosystems CRC
Dr Ben Galton-Fenzi	Antarctic Climate & Ecosystems CRC
Prof. Jim Denier	University of Auckland (AFMS rep)
Prof. Gordon Mallison	University of Auckland (AFMS rep)

Australasian Fluid Mechanics Society www.afms.org.au

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Australasian Fluid Mechanics Society

About the AFMS

AFMS is an independent non-profit society that supports and fosters interest in fluid mechanics and related disciplines in the Australasian region. This is done by providing a forum for people with a common interest, and by publishing or promoting relevant material. The Society aims to actively represent the views of its members to Government, institutes and the public. It supports all those with an interest in fluid mechanics including researchers and professionals. The AFMS is charged with overseeing and supporting the Australasian Fluid Mechanics Conference (AFMC) series.

The membership consists of those members of the Society who have indicated their wish to join the Society and who annually retain membership though the payment of designated dues. The AFMS was incorporated in Victoria, Australia on 14 October 2008.

This is the second AFMC since the Society was incorporated and biennial society membership has been factored into the conference registration fees.

Society Fellowships

Ten inaugural fellows were inducted at the 17th AFMC and another five elected fellows will be announced at the 18th AFMC dinner.

2012 AGM

The Annual General Meeting of the Society will be held during the 18th AFMC at 17:30 Tuesday 4 December.

Previous Conferences in the AFMC Series

The 18th AFMC is the first in the series to be held biennially with all previous held triennially.

Australasian Conferences on Hydraulics and Fluid Mechanics

1962	University of Western Australia
1965	University of Auckland
1968	University of New South Wales
1971	Monash University
1974	University of Canterbury
1977	University of Adelaide
1980	University of Queensland

Australasian Fluid Mechanics Conferences

1983	University of Newcastle
1986	University of Auckland
1989	University of Melbourne
1992	University of Tasmania
1995	University of Sydney
1998	Monash University
2001	University of Adelaide
2004	University of Sydney
2007	The University of Queensland
2010	The University of Auckland

The AFMS maintain an archive of AFMC proceedings on the Society website: www.afms.org.au

Sponsors and Exhibitors

The organising committee of the 18th Australasian Fluid Mechanics Conference would like to thank the following sponsors and exhibitors for their support:

Plenary Speakers

Professor Ivan Marusic

University of Melbourne

Ivan Marusic is a Professor and Australian Laureate Fellow in the Department of Mechanical Engineering at the University of Melbourne, Australia. He received his PhD from the same institution in 1992. From 1998-2006 he was on the faculty at the University of Minnesota where he was a recipient of a Packard Fellowship in Science and Engineering, and a US National Science Foundation Career Award. He returned to Melbourne in 2007 as an Australian Research Council Federation Fellow. He presently serves as an Associate Editor for the Journal of Fluid Mechanics, and the Journal of Hydraulic Research. He is on the Editorial board of Measurement Science and Technology, and the Chair of the National Committee for Mechanical Sciences. He is President of the Australasian Fluid Mechanics Society, and was elected Fellow of the American Physical Society in 2010.

The G.K. Batchelor Lecture

The logarithmic region of wall turbulence: Universality, structure and interactions

The logarithmic region, also referred to as the inertial subrange in physical space, or the turbulent wall region, is arguably the most important region of wall-bounded turbulent flows due to the multi-scale processes that take place. In this paper we review recent studies that report on the universality of this region in terms of the scaling laws for the mean velocities and turbulence intensities. New high Reynolds number experimental data from a variety of flows are shown to be consistent with universal von Kármán and Townsend-Perry constants. This is in support of classical theory but contrary to the prevailing view that has emerged over the past decade or so. The nature of the logarithmic region is further discussed in terms of large and very large superstructures, and their role in interacting across the boundary layer is considered, with particular emphasis on their role in modulating and altering the fluctuating wall-shear stress.

Professor Christer Fureby

The Swedish Defence Research Agency – FOI

Christer Fureby is a research director at the Swedish Defense Research Agency, FOI, in the Defence & Security, Systems and Technology division. He is also an associate professor in fluid mechanics at Lund Institute of Technology and until recently held a time-limited position as adjoint professor in hydrodynamics at Chalmers University of Technology. He received his M.Sc. in civil engineering at Lund Institute of Technology in 1989 and his Ph.D. in engineering physics, in particular combustion physics, also at Lund Institute of Technology in 1995. After that he worked as post-doctoral fellow at the mechanical engineering department at Imperial College in London. Since 1997 he has been working at FOI, first as a researcher, then as a senior researcher and since 2003 as research director in the field of computational fluid dynamics and combustion. Dr. Fureby is the head of the Computational Fluid Dynamics and Combustion (CFD'n'C) group at FOI which conducts applied research in the areas of hydrodynamics and acoustics, reactive flows and contaminant transport. The main objective of the group is to provide computational support to applied projects and to help solve problems with relevance to military and civilian technology. Technological developments pursued at the CFD'n'C group include novel computational methods and models to represent turbulent flows and other physical processes (acoustics, fluid structure interactions chemical reactions, etc.) around ships, submarines and propellers, in gas-turbine, ram, scram and PDE engines, astrophysics, weapons physics as well as in urban canopies. Dr. Fureby is an associate fellow of the AIAA and a member of the Combustion Institute.

LES – An accessible and useful tool for complex engineering applications in fluid dynamics

This paper is dedicated to describe the current state-of-the-art in Large Eddy Simulation (LES) of practical engineering systems. As LES is used in a wide range of applications (aerodynamics, hydrodynamics, combustion etc.) an attempt is made here to provide a compact but still comprehensive description of the LES methodology and an overview of how LES is utilized to provide knowledge about practical engineering systems. Both theoretical aspects of LES, such as subgrid modeling and numerical methods, as well as examples of LES computations in the fields of aerodynamics, hydrodynamics and combustion are presented and discussed. In order to support these applied LES predictions some results for building block flows, for which experimental data is available, are also presented. In addition the issues of verification, validation and uncertainty quantification are also briefly described and discussed. The main conclusion is that LES provides a very useful computational tool for fluid mechanics that can and should be used together with other simulations models and experiments to advance the understanding of fluid flow and to aid the design of engineering systems. With present computational capabilities it is already now possible to gain fundamentally new insight into e.g. car, train and aircraft aerodynamics, ship hydrodynamics and combustion in a range of systems from gas turbines and IC engines, to scramjet engines and White Dwarf stars.

Professor Steven Ceccio

University of Michigan

Steven L. Ceccio is the Chair of Naval Architecture and Marine Engineering and a Professor of Mechanical Engineering and Applied Mechanics at the University of Michigan. He received his B. S. degree in mechanical engineering from the University of Michigan in 1985. He received his M. S. degree in 1986, and his Ph. D. in 1990 both in mechanical engineering from the California Institute of Technology. Upon completion of post-doctoral studies, also at the California Institute of Technology, he was appointed as an Assistant Professor in Mechanical Engineering at the University of Michigan, Ann Arbor in 1990. He was promoted to Associate Professor with tenure in 1996, and Professor in 2003. He served as an Associate Vice President for Research at the University of Michigan from 2004 to 2009. He is currently the Director of the Naval Engineering Education Center. Prof. Ceccio's research focuses on the fluid mechanics of multiphase flows and high Reynolds number flows. Specific research topics include flow in propulsors and turbomachinery, cavitating flows, vortical flows, friction drag reduction using bubble and polymer injection, the dynamics of liquid-gas, gas-solid, and three-phase disperse flows, and the development of flow diagnostics. He has served as an Associate Editor of the Journal of Fluids Engineering. He has also acted as a consultant to government and industry. Prof. Ceccio is a fellow of the American Society of Mechanical Engineers and of the American Physical Society.

Cavitation inception and bubble dynamics in vortical flows

The liquid in the core of a vortex can be at a significantly lower pressure than the surrounding fluid, and possibly in tension. Small bubbles (nuclei) exposed to this tension can rapidly enlarge to fill the radial extent of the vortex core and then grow along the vortex axis. Such vortex cavitation can readily occur in the shed vortices of lifting surfaces or in turbulent shear flow such as jets and wakes. Incipient and developed vortex cavitation bubbles can exhibit complex dynamics as the bubble interacts with the surrounding flow. As the bubble changes volume within the vortex core, the vorticity distribution of the surrounding flow is modified, which then changes the pressures at the bubble interface. This coupling can produce volume oscillations with a period of the order of the vortex time scale, $\tau_v = 2\pi r_c / u_{\theta max}$, where r_c is the vortex core radius and $u_{\theta max}$ is its maximum tangential velocity of the vortex. However, the volume oscillation amplitude and frequency are quite sensitive to variations in the vortex properties, the rate and magnitude of the local pressure core pressure, and the nuclei's critical pressure. The axial and radial growth of elongated cavitation bubbles is also strongly coupled, especially near the axial extents of the bubble. Such complex growth, oscillation, and collapse of vortex cavitation bubbles can lead to both broadband and tonal sound emissions. Moreover, it is possible to understand the formation and dynamics of vortex cavitation as the result of vortex dynamics, vortex breakdown, and vortex-vortex interactions. And, finally, it may be possible to mitigate the inception of vortex cavitation on lifting surfaces through both passive and active means.

Professor Ralf Greve

Institute of Low Temperature Science
Hokkaido University

Ralf Greve is a professor for glacier and ice sheet research at Hokkaido University's Institute of Low Temperature Science in Sapporo, Japan (since 2004). He is a physicist by training, earned his doctor degree in 1995 at Darmstadt University of Technology, Germany, with a theoretical, analytical, and numerical study on the dynamics and thermodynamics of polythermal ice sheets, and has continued with related research since then. Until 2003 he worked as a scientific employee, scientific assistant and lecturer at the Department of Mechanics, Darmstadt University of Technology. Ralf Greve is the author/coauthor of more than 60 peer-reviewed scientific papers and two textbooks on ice dynamics and continuum mechanics. Further, he serves as Scientific Editor for the Journal of Glaciology and is the current head of the division "Planetary and Other Ices of the Solar System" of the International Association of Cryospheric Sciences (IACS).

Ice sheet modelling and applications to Greenland, Antarctica and the Martian polar ice caps

Ice sheets, ice shelves, ice caps and glaciers are active, dynamic components of the climate system of the Earth, and they deserve the same scientific attention as the atmosphere and the oceans. Since the late 1970s, numerical modelling has become established as an important technique for the understanding of ice dynamics. Ice sheet models are particularly relevant for predicting their possible response to climate change and consequent sea level rise, and thus a number of such models have been developed over the years. Recent observations actually suggest that ice dynamics could play a crucial role in predicting future sea level rise under global warming conditions. Despite this great relevance, ice sheet modelling is still underrepresented within the international climatology communities, compared to the large efforts made into atmosphere and ocean research. In this contribution, I will review the state of the art and current problems of ice sheet modelling. An outline of the underlying fluid-dynamical theory will be given, and crucial processes (basal sliding, calving, interaction with the solid Earth) will be discussed. Further, I will present selected applications to problems of past, present and future glaciation of Greenland, Antarctica, and also the polar ice caps of the planet Mars.

Professor Gert Jan van Heijst

Eindhoven University of Technology

Gert Jan van Heijst (born 1954) is a professor at the Fluid Dynamics Laboratory of the Department of Applied Physics at Eindhoven University of Technology (TU/e) in the Netherlands. His main area of expertise is (geophysical) fluid dynamics, with special emphasis on vortex dynamics, (2D) turbulence, shallow flows, rotating flows, and stratified flows. He received his PhD degree at Twente University (supervisor: Prof. Leen van Wijngaarden) in 1981, and after a postdoc position at Cambridge (UK) he became lecturer in physical oceanography at Utrecht University. He was appointed as full professor in Eindhoven in 1990. Gert Jan van Heijst has been on the editorial boards of Physics of Fluids and of Geophysical and Astrophysical Fluid Dynamics, and since 1999 he serves as co-editor-in-chief of the European Journal of Mechanics B/Fluids. He is a member of the Royal Netherlands Academy of Arts and Sciences and of the Russian Academy of Natural Sciences. He is also a member of the EUROMECH Council, and is president-elect of this society, taking office per 1 January 2013.

Modelling of vortices colliding with obstacles

This lecture will address the problem of a dipolar vortex approaching solid objects like a cylinder, a row of closely positioned cylinders, or a sharp-edged plate. Vorticity generated at the no-slip surface of the obstacle or due to flow separation at sharp edges is advected away from the wall and may thus interact with the primary vortex structure. This may lead to very complicated behaviour, like splitting and partial rebound of the primary dipole. Laboratory experiments have been performed in a rotating fluid tank, the background rotation providing a mechanism for making the relative flow approximately two-dimensional. The flow evolution has been visualized by adding dye, while quantitative information about the vorticity distribution was obtained by PIV measurements. In addition to numerical flow simulations, some analytical studies have been carried out, which provide important information about the vortex-wall interaction.

Dr Stephen Rintoul

CSIRO Marine and Atmospheric Research

Centre for Australian Weather and Climate Research

Antarctic Climate and Ecosystems Cooperative Research Centre

Wealth from Oceans National Research Flagship

Dr Stephen Rintoul FAA is a physical oceanographer and climate scientist with a long-standing interest in the Southern Ocean and its role in the earth system. His research has contributed to a deeper appreciation of the influence of the Southern Ocean on global climate, biogeochemical cycles and biological productivity. He uses a variety of tools to observe the Southern Ocean, including ships, satellites, floats, moorings and instrumented seals. He has led fourteen oceanographic expeditions to the Southern, Indian and Pacific Oceans. Dr Rintoul is a Coordinating Lead Author of the Oceans chapter in the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). His scientific achievements have been recognised by many national and international awards, including the Georg Wüst Prize of the German Society for Marine Research and appointment as a CSIRO Fellow, the organisation's highest honour for science.

A dynamical recipe for the world's largest ocean current

The Southern Ocean is home to the strongest winds, the biggest waves and the largest ocean current on Earth. The Antarctic Circumpolar Current (ACC) carries about 150 x 10^6 m^3s^{-1} from west to east around the Antarctic continent, roughly equivalent to 150 times the combined flow of the world's rivers. The strong eastward flow of the Antarctic Circumpolar Current (ACC) connects the ocean basins, allowing the existence of a global-scale overturning circulation that dominates ocean heat transport. Hence, the circulation of the Southern Ocean is of particular relevance for climate.

For many years, the dynamics of the current have puzzled oceanographers. Dynamical theory that explained the circulation in closed basins did not apply in the zonally-unbounded channel of the Southern Ocean. In the last decade, however, remarkable progress has been made, built on advances in ocean observations, numerical simulations, and theory.

The core ingredients of the dynamical recipe for the ACC are becoming clear. The tilting of density surfaces associated with the geostrophic flow of the ACC brings dense water to the surface at high latitudes. Water mass transformations where these layers outcrop link the upper and lower limbs of the global overturning circulation. The ACC and overturning circulations are therefore dynamically linked. Wind and buoyancy forcing act together to drive a strong, deep-reaching eastward flow made up of multiple zonal jets; instabilities of the jets spawn eddies with horizontal length scales of O(100 km); the eddies transport heat, momentum, vorticity and other tracers across the ACC, generally opposing the directly wind-driven circulation cell; and topography structures both the mean flow and the eddy field.

Professor Hugh Blackburn

Monash University

Prof Hugh Blackburn (Mechanical and Aerospace Engineering, Monash University) holds a BE from UniSA (1982) and a PhD from Monash (1993), in the area of bluff body fluid mechanics. Prior to commencing his PhD at Monash in 1985 he worked as a consulting engineer for Kinhill Engineers. At Monash he concurrently worked as a junior academic until the end of 1993. He joined CSIRO in 1994 where he carried out both fundamental and applied research in fluid dynamics. In 2007 he re-joined Monash University. His principal research area is the physics of unsteady flows and associated computational methods. He is a Fellow of the Institution of Engineers Australia.

Computing optimal flow disturbances

We outline methodologies for computation of the spatial distributions of energy-optimal linear initial and boundary disturbances to incompressible flows. The theory presented here is based in techniques developed for constrained optimisation, but we show that there are equivalent eigenvalue interpretations. As a result the computations may be carried out either by optimisation or eigensystem methods, leading to the same outcomes though typically the eigensystem approaches converge more rapidly for optimal initial condition calculations. We show how the methods have been applied to example open flows.

Associate Professor Evatt Hawkes

University of New South Wales

Evatt Hawkes is an ARC Future Fellow and Associate Professor at the University of New South Wales. Prior to arriving at UNSW in 2007, he received his PhD from the University of Cambridge in 2002, and then worked as a post-doctoral fellow at the Combustion Research Facility of Sandia National Laboratories, USA. At UNSW, he leads a program of computational energy research focussing on turbulent multi-physics flows with applications in combustion, solar thermal energy and solar thermochemical energy technologies. His work in turbulent combustion spans applied studies of low-emissions and alternatively fuelled engines through to fundamental direct numerical simulations executed on massively parallel supercomputers.

Petascale numerical simulations of turbulent combustion

To achieve very low NOx emissions, recent generations of stationary gas-turbine systems have adopted lean premixed combustion modes. Lean operation reduces the combustion temperature and suppresses the formation of thermal NOx. However, relative to stoichiometric flames, lean flames are thicker and propagate more slowly. When combined with industry trends of increasing combustion chamber pressures, which increases Reynolds number, a situation can arise where turbulence penetrates the inner structure of the flame, i.e. the Karlovitz number is high. The nature of combustion in this situation is relatively less well understood compared with the situation where turbulence does not penetrate the flame. In this paper, I will discuss the use of a set of petascale direct numerical simulations (DNS) of lean hydrogen combustion to examine high Karlovitz number flames. The simulations considered a detailed model of hydrogen oxidation, achieved a turbulence Reynolds number approaching 1000 and were performed on 120,000 processor cores on the Jaguar Cray XT5 at Oakridge National Laboratories. The flames will be examined from the perspective of a fractal model of their geometry. By examining the problem from two different but connected theoretical perspectives, it is proposed that for sufficiently high Karlovitz number, the relevant inner cut-off scale is the Obukhov-Corrsin length scale, while the fractal dimension approaches 8/3. These theories are contrasted with the prevailing views that the Gibson scale or the flame thickness are the inner cut-off and that 7/3 is the upper limit of the fractal dimension. The new results are shown to be supported by the DNS. The findings are then incorporated into a model of the flame surface area required in large-eddy simulations and excellent predictions of the DNS surface area are obtained for two versions of the model, one in which the fractal dimension is determined by a static expression, and another in which it is determined dynamically from the resolved scales by a Germano-like identity.

Dr Philippe Marmottant

Laboratoire Interdisciplinaire de Physique

Philippe Marmottant is a CNRS researcher in Laboratoire Interdisciplinaire de Physique since 2004, Grenoble, France. He defended in 2001 a PhD thesis on spray formation under the supervision of Prof. Emmanuel Villermaux, at INP Grenoble. He then went for a PostDoctoral stay at the University of Twente in the Netherlands, with Prof. Detlef Lohse and Prof. Sascha Hilgenfeldt. He defended an habilitation thesis in 2008. His current interests are oriented towards microfluidic flows and sound emission or action. In particular he is interested in the emission of sounds by cavitation in the wood microchannels. Regarding the action of sounds, he developed a method to focus ultrasonic energy and to manipulate objects without contact, resulting in acoustic tweezers able to manipulate droplets, bubbles or cells.

The sound of cavitation in trees

The sap within trees circulates in tiny microfluidic wood vessels. Under hydric stress, in dry weather conditions, the sap can cavitate. Bubbles appear, which eventually causes an embolism in the circulation. The origin of cavitation is that water can achieve negative pressure (tension) under evaporation. We will focus here on the dynamics of the cavitation bubble, which is of primary importance to understand the resistance of trees. We use the recently developed method of artificial trees, building stiff transparent hydrogels to mimic wood channels. Our experiments on water confined in micrometric channels show an extremely fast dynamics: bubbles are nucleated within a microsecond timescale. The bubble pulsates with transient oscillations at very high frequencies in the MHz range. This rich dynamics can be accounted for by a model we developed, leading to a modified Rayleigh-Plesset equation. The oscillations may be at the origin of the short acoustic emissions that are recorded in real trees under hydric stress.

Conference Program

SUNDAY 2 DECEMBER 2012	
1200	Registration Desk Open – Delegates are encouraged to pre-register Hotel Grand Chancellor, Launceston
1730	Welcome Reception - The Design Centre Corner of Tamar and Brisbane Streets Launceston - 3 minute walk from the Hotel Grand Chancellor

MONDAY 3 DECEMBER 2012					
0730	Registration Desk Open UTAS, Launceston				
0800	**Coaches Depart the Hotel Grand Chancellor Launceston for the Conference Venue**				
0855	Conference Welcome & Opening Address				
0920	**PLENARY SESSION (Room A) - *Professor Ivan Marusic*** The G.K. Batchelor Lecture The logarithmic region of wall turbulence: Universality, structure and interactions				
1010	**MORNING REFRESHMENTS**				
Room	**A**	**B**	**C**	**D**	**E**
	Turbulent Boundary Layers	**Environmental Flows 1**	**Combustion 1 (Engines)**	**Hydrodynamics 1**	**Gas Dynamics 1**
1040	Wall shear-stress statistics for the turbulent boundary layer by use of a predictive wall-model with LES **160** ***Dale Pullin***	A model for the evolution of the thermal bar system. **292** ***Duncan Farrow***	Modelling of Diesel Spray Dynamics using LES **396** ***Laurie Goldsworthy***	Wind tunnel investigation of the interaction between two sailing yachts **279** ***Peter Richards***	Reynolds-Averaged Navier-Stokes Computation of Transonic Projectiles in Ground Effect **156** ***John Young***
1105	Three dimensional conditional structure of large-scale structures in a high Reynolds number turbulent boundary layer **306** ***Murali Krishna Talluru***	Model turbulent floods based upon the Smagorinski large eddy closure **70** ***Meng Cao***	CFD Modelling of Heavy Fuel Oil Spray Combustion **400** ***Vikram Garaniya***	Development of an OpenFOAM Tool for Bubble Transport Studies in a Propeller Flow **252** ***Shuang Zhu***	Development of Functional Relationships for Air-Data Estimation using Numerical Simulations **192** ***Sarah Razzaqi***
1130	Measurements of streamwise and spanwise fluctuating velocity components in a high Reynolds number turbulent boundary layer **168** ***Rio Baidya***	Maximum height and return point velocities of desalination brine discharges **379** ***Adam Crowe***	Transported probability density function modelling of an n-heptane jet at diesel engine conditions **275** ***Yuanjiang Pei***	Numerical Simulation of Spheres in Relative Motion Using Dynamic Meshing Techniques **290** ***Zhi Quan Leong***	Numerical Investigation of Diaphragm Mass and Viscous Effects in Pulse Starting of Axisymmetric Scramjet Inlets **233** ***Hideaki Ogawa***
1155	Implementation of large scale PIV measurements for wall bounded turbulence at high Reynolds numbers **308** ***Charitha De Silva***	Secondary flow in stratified open channel flow on a bend **106** ***Nicholas Williamson***	Multiple stage atomization of fuels for use in combustion applications **130** ***Agisilaos Kourmatzis***	Comparison of fluid forces and wake modes between free vibration and tracking motion of a circular cylinder **319** ***Jisheng Zhao***	Numerical simulation of supersonic impinging jet flows using Reynolds-averaged Navier- Stokes equation and Large Eddy Simulation **157** ***Leon Chan***
1220	Tow-tank investigation of the developing zero-pressure-gradient turbulent boundary layer **221** ***JungHoon Lee***	A numerical study of interaction of laminar air plumes **78** ***Chengwang Lei***	Effect of fuel injection pressure on size and structure of in-cylinder soot particles sampled from an automotive-size optical diesel engine **226** ***Renlin Zhang***	Investigation of wave formation using 3d3c measurement technique **161** ***Yong Chuan Mike Khoo***	Altitude compensation in expansion deflection nozzles **133** ***John Olsen***
1245	Effects of Diverging and Converging Roughness on Turbulent Boundary Layers **198** ***Bagus Nugroho***	Numerical study of the unsteady behaviour in the near-field of pure thermal planar plumes with experimental validation **46** ***Tae Hattori***	The Transient Behaviour of Hot Soot Base in an Optically-Accessible Automotive-Size Diesel Engine **151** ***Alvin Rusly***	On the Break-up of a Turbulent Liquid Wall Sheet **381** ***Thomas Fu***	Reynolds-Averaged Navier-Stokes and Wall-Modelled Large-Eddy Simulations of Sonic Hydrogen Injection into Hypersonic Crossflow **162** ***Rolf Gehre***

1305	**LUNCH**				
1405	**PLENARY SESSION (Room A) - *Professor Christer Fureby*** LES – An accessible and useful tool for complex engineering applications in fluid dynamics				
1455	**AFTERNOON REFRESHMENTS**				
Room	**A**	**B**	**C**	**D**	**E**
	DNS/LES/CFD	**Aerodynamics 1**	**Jets and Wakes 1**	**Industrial Flows 1 (CFD)**	**Fluid Structure Interaction 1**
1520	Comparison of the dynamics of particles in a flow field with the reynolds and favre filtered flow velocities **320** ***Paul Stegeman***	Experimental Evaluation of the Effect of Flow Deflectors on Helicopter Rotor Wake Vortices **35** ***Kate Bourne***	Large eddy simulation of flow past a circular cylinder at Reynolds number 3900 **243** ***William Sidebottom***	The effect of inlet velocity and temperature on the strength of the swirling induced by a spilt channel: A CFD approach **250** ***Safia Al Atresh***	Numerical simulation of the vortex-induced vibration of an elastic cylinder **189** ***Javad Farrokhi Derakhshandeh***
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0800	**Coaches Depart the Hotel Grand Chancellor Launceston for the Conference Venue**
0855	Morning Welcome & Housekeeping
0900	**PLENARY SESSION (Room A) - *Professor Steven Ceccio*** Cavitation inception and bubble dynamics in vortical flows

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0730	Registration Desk Open UTAS, Launceston				
0800	**Coaches Depart the Hotel Grand Chancellor Launceston for the Conference Venue**				
0855	Morning Welcome & Housekeeping				
0900	**PLENARY SESSION (Room A) - *Professor Gert-Jan van Heijst*** Modelling of vortices colliding with obstacles				
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1400	AMC Technical Tour				
1500	**Coaches depart for City after technical tour**				
1530	Winery Tour to Joseph Chromy Vineyard, coach departs Hotel Grand Chancellor Launceston at 1530				

THURSDAY 6 DECEMBER					
0800	Registration Desk Open UTAS, Launceston				
0800	**Coaches Depart the Hotel Grand Chancellor Launceston for the Conference Venue**				
0855	Morning Welcome & Housekeeping				
0900	**PLENARY SESSION (Room A) – *Dr Steve Rintoul*** A dynamical recipe for the world's largest ocean current				
Room	**A**	**B**	**C**	**D**	**E**
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1900	CONFERENCE DINNER Albert Hall, Launceston				

FRIDAY 7 DECEMBER					
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0800	**Coaches Depart the Hotel Grand Chancellor Launceston for the Conference Venue**				
0855	Morning Welcome & Housekeeping				
0900	**PLENARY SESSION (Room A) - *Associate Professor Evatt Hawkes*** Petascale numerical simulations of turbulent combustion				
Room	**A**	**B**	**C**	**D**	**E**
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1405	**PLENARY SESSION (Room A) - *Dr Philippe Marmottant*** The sound of cavitation in trees				
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1640	**Coach returns to city**				
1700	Farewell Drinks – Hotel Grand Chancellor Launceston				

* Abstract only

** Paper will not be presented

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