International Congress on Ultrasonics

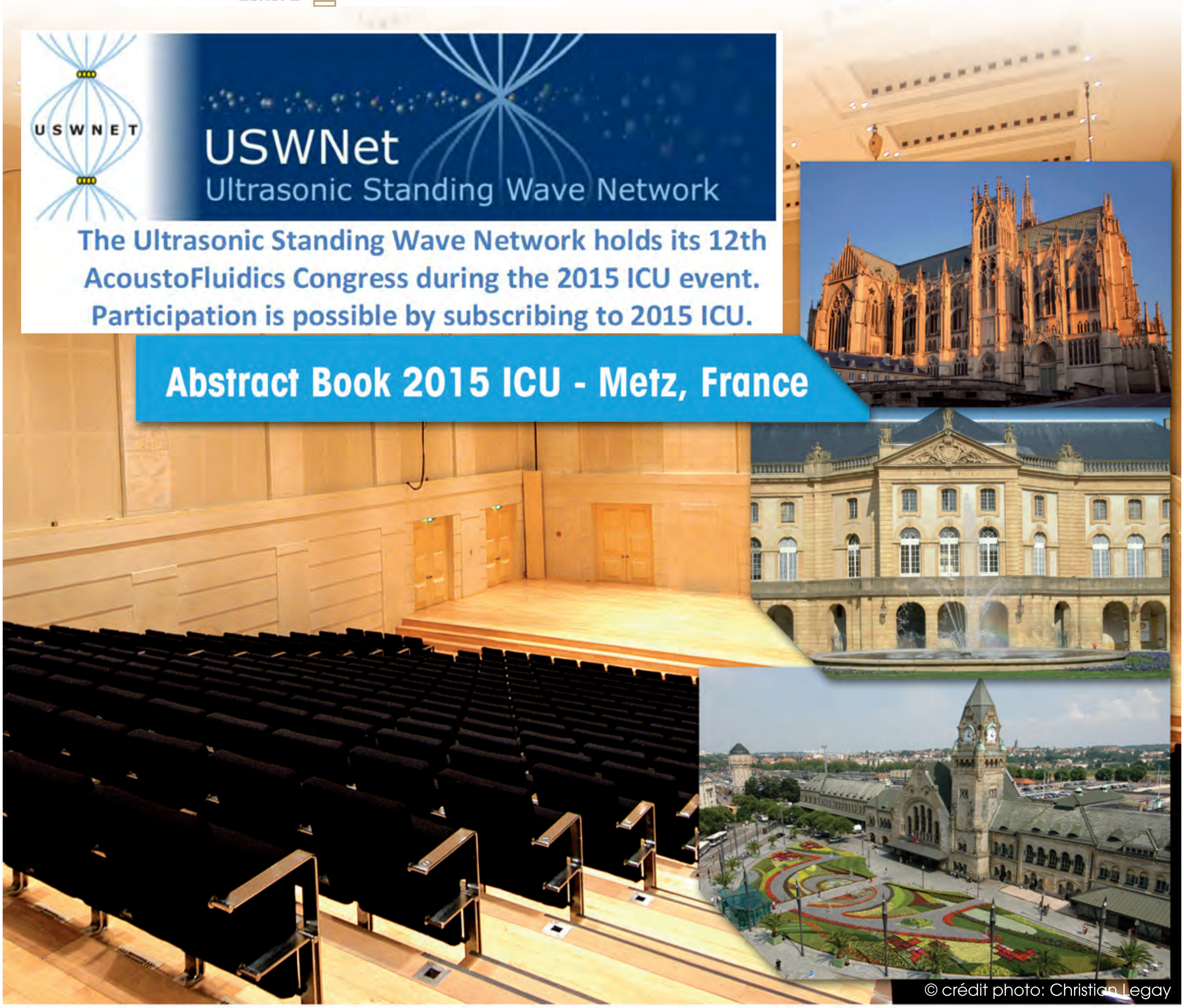
Metz, France,
May 11-14, 2015

hosted by

Georgia Tech EUROPE | Lorraine Georgia Institute of Technology

in collaboration with

SFA



With the financial support of:

UNION EUROPÉENNE · La Région Lorraine · Département Moselle Conseil Général Réussir ensemble ! · Metz Métropole COMMUNAUTÉ D'AGGLOMÉRATION · Georgia Tech EUROPE Lorraine Georgia Institute of Technology

Reference to this book

2015 ICU International Congress on Ultrasonics Abstract Book, Metz, France, Declercq N. F. editor (2015)

Publication year

2015

Acknowledgement

The compilation of this book has been made possible with the help of Didier Cassereau, Bertrand Dubus and John Fritsch with support from the Scientific and Technical Committee of 2015 ICU.

ISBN

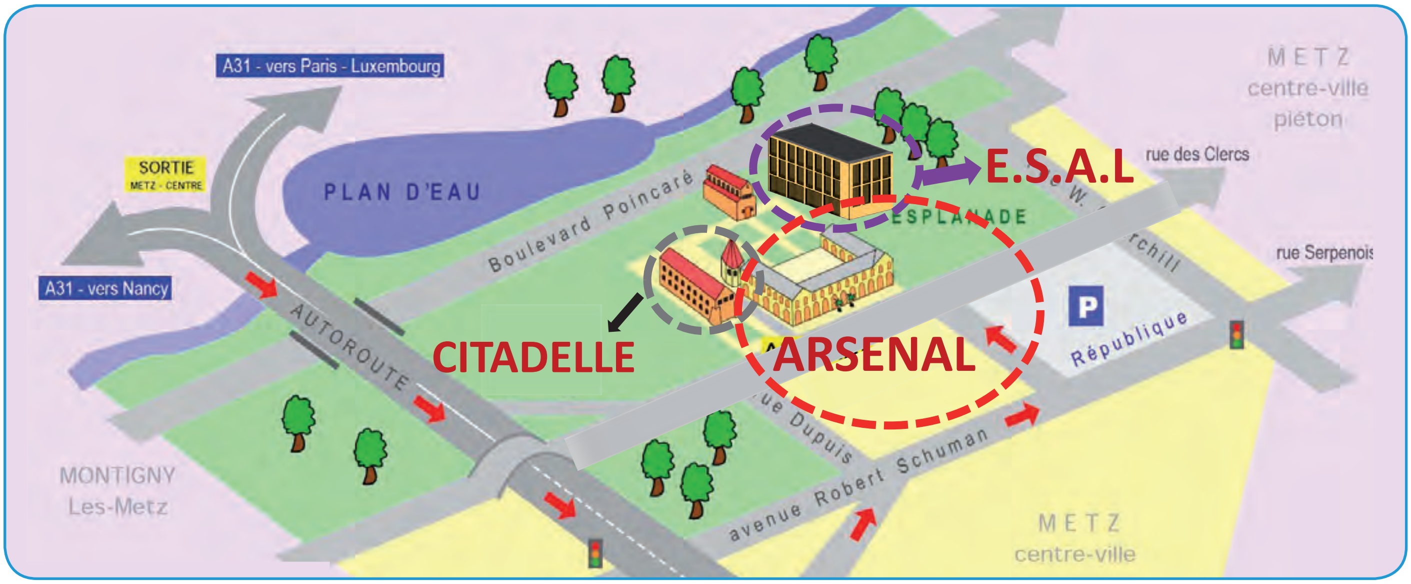
978-0-692-43231-0

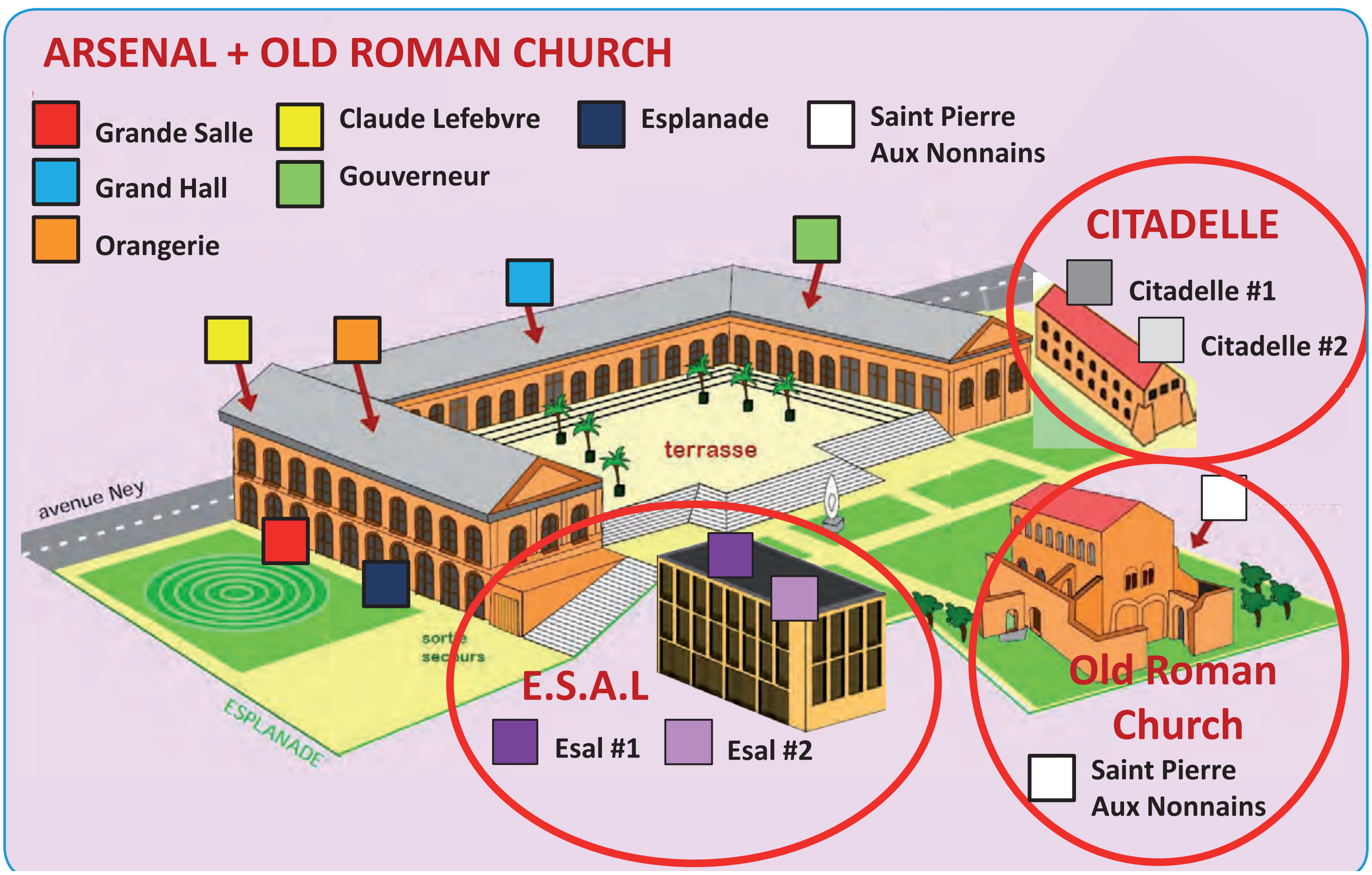
ISBN 978-0-692-43231-0

90000>

9 780692 432310

Meeting facilities at: Arsenal - E.S.A.L. - La Citadelle





Word from the 2015 ICU President

Dear Participants,

Welcome to the 2015 International Congress on Ultrasonics (2015 ICU), hosted by Georgia Tech Lorraine in collaboration with the French Acoustical Society. It is with thankfulness to everyone at all levels who have been involved in the realization of the scientific and social program that we are offering you a congress program book for the coming week. It is equally with sincere gratitude that we welcome all participants and sponsors without whom this week would not be possible.

The 2015 International Congress on Ultrasonics is part of a long tradition and sequence of congresses, dating back to 1993, including the WCU (the World Congress on Ultrasonics), UI (Ultrasonics International) and “UI+WCU” later renamed as ICU. The event takes place every two years. For 2015 ICU we are welcoming **over 650 participants from 53 countries**. More than **30% are students**. During the congress, we are expecting **almost 600 presentations**, i.e. 410 oral presentations and more than 170 poster presentations. In total we have **95 scientific sessions** with a maximum of **9 parallel sessions**. The congress has invited 9 Plenary and Keynote Speakers. During the ICU congress we also welcome the 12th AcoustoFluidics Congress organized as an integral part of ICU by USWNet, the Ultrasonic Standing Wave Network. In addition a special session on Acousto-Optics is devoted to the career of Oswald Leroy. Congress proceedings will be published online in Elsevier’s Physics Procedia.
The location of the congress is the Arsenal of Metz, France. The Arsenal is a cultural venue dedicated specially to Classical and Erudite music and is located near the Esplanade garden in Metz, capital of the Lorraine region, France. In September 2010, Classica magazine listed the venue among the 20 most beautiful concert halls in the world, qualifying the Arsenal as an ‘acoustic diamond’. The Arsenal is part of a cultural complex along with the chapel of the Knight Templars, constructed in the 13th century; the ancient Saint-Pierre-aux-Nonnains basilica, a Roman basilica of the 4th century, refurbished as showroom and concert hall for the Gregorian chant, respectively.

Our social program consists of an opening ceremony with a musical performance by Françoise Vanhecke on Monday morning, a Welcome Reception on Monday evening, a Musical Concert on Tuesday evening, a Gala Dinner on Wednesday evening and a Closing Ceremony on Thursday afternoon.
Special thanks to our sponsors : ARCELOR MITTAL, INSPECTION TECHNOLOGY EUROPE BV, KIBERO GmbH, MISTRAS Products & Systems, OLYMPUS Corporation, POLYTEC, PVA Tepla, S-SHARP, XARION Laser Acoustics with the financial support of FEDER, Conseil Régional de Lorraine, Le Conseil Général de Moselle, Metz Métropole.

Last but not least I would personally like to express my appreciation for the help and the technical support offered by Didier Cassereau in handling registration, abstract submission and session organization.
On behalf of the International Board of ICU, the French Acoustical Society and Georgia Tech Lorraine represented as members of the Executive Committee, the Scientific and Technical Committee, the Local Operations Committee and everyone else who has in one way or another helped with the organization.

Nico F. Declercq
2015 ICU President

ABOUT THE HOSTING ORGANIZATIONS

Georgia Tech Lorraine

Georgia Tech-Lorraine (GTL) is the European Campus of the Georgia Institute of Technology (G.I.T). Georgia Tech is a public university, worldwide renowned for creating tomorrow's leaders in engineering, science and technology. Georgia Tech is consistently ranked among the best universities in the United States and the world, ranked #6 on Shanghai world ranking. Georgia Tech-Lorraine (GTL) was established as Georgia Tech's first international campus in 1990 in Metz, France, a city recently named by the New York Times as one of the top 44 places to see in the world. Centrally located in eastern France along the Luxembourg and German borders, GTL is less than 90 minutes by train from Paris. Being a highly innovative institution offering year-round undergraduate, Masters and PhD programs, GTL is also home to a strong sponsored research program in key technological areas. GTL fosters the flow of new ideas, creates new opportunities, and develops valuable qualities in our students, such as global leadership and innovative thinking. In today's global economy, Georgia Tech-Lorraine plays a determining role in fulfilling the goals of the Georgia Institute of Technology as stated in its strategic plan. Over 3000 undergraduate and MS students (CS, ECE, and ME) have spent a semester or more on the Metz campus, enriching their education with a global perspective.

Unité Mixte Internationale (UMI) is an international joint laboratory between Georgia Tech and the French 'Centre National de la Recherche Scientifique' (CNRS). Research activities are primarily focused on Non-linear Optics and Dynamics, Smart Materials, Computer Science. Research activities entail: 55 researches, around 40 PhDs, ANR programs, industrial contracts, European Contracts. An open Lab on "Material & process" had been created in 2011 with the largest car manufacturer in France: PSA Peugeot Citroên.

The "Institut Lafayette": is an innovation platform created to develop applications and products in optoelectronics and advanced semiconductor materials within a complete innovation chain starting with a concept, passing through the elaboration of a material, the qualification of prototypes and components, to the validation of the up-scaling of its manufacturing. The new technologies as developed are put on the market by an array of technology transfer services and commercialization tools, serving as a catalyst for economic development in the region, based either on the involvement of the industry groups and entrepreneurship . The *Institut Lafayette* is a third major development of Georgia Tech Lorraine growth in Metz. It is developed with the contribution of two significant institutes in Atlanta *Entreprise Innovation Institute* and *Georgia Tech Global*; and supported by *FEDER, État Français, Conseil Régional de Lorraine, Conseil Général de la Moselle* and *Metz Métropole, Georgia Institute of Technology, Georgia Tech Lorraine*.

SFA The French Acoustical Society

The French Acoustical Society (La Société Française d'Acoustique - SFA) gathers French acousticians from public research and industry. Created in 1948 by Yves Rocard, it includes more than 800 individual members (researchers, teachers, engineers, musicians, audiologists, architects...), as well as institutional members (industrial companies and specialized research laboratories). Its vocation is to facilitate the circulation and any scientific and technical information as well as the contacts between research laboratories and industrial R&D Centers. The activities of the SFA include:

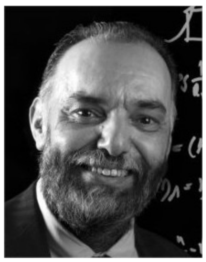
- Organization of CFA congresses and workshops. These events can be regular (the French Congress of Acoustics takes place every even year) or be more specifically organized to deal with novel subjects ;
- Promotion of acoustics. The SFA is a natural interlocutor of numerous national authorities (for example, the

National Noise Council or various standardization committees). It promotes the education in acoustics, notably by providing the list of all existing training courses on its Web site. It supports students' participation at international congresses through scholarships ;

- Diffusion of information through its periodic bulletin or through the magazine "Acoustique & Technique", published by the Noise Documentation and Information Center and in which the SFA participates actively ;
- Relations with other national scientific societies, because acoustics is in the crossroads of numerous disciplines (solid or fluid mechanics, signal processing, cognitive psychology, speech...)
- Relations with the equivalent societies of foreign countries. The SFA is a founding member of the European Acoustics Association (www.euracoustics.org), which gathers thirty European societies. This association edits one of the major world scientific reviews of acoustics (Acta Acustica united with Acustica - http://www.acta-acustica-united-with-acustica.com).

2015 ICU EXECUTIVE COMMITTEE

Nico F. Declercq
2015 ICU President



Abdallah Ougazzaden
Vice-President for GTL

Brigitte Hubert
Vice-President for Operations

John Fritsch
Managing Organizer

Bertrand Dubus
Scientific & Technical Vice-President for SFA

Mathias Fink
Scientific & Technical

Badreddine Assouar
Sponsoring

Yves Berthelot
Scientific & Technical

Vincent Laude
Scientific & Technical

ICU INTERNATIONAL BOARD

Adriano Alippi – Italy
Arthur G. Every- South Africa
Andrea Cardoni- Spain
Bernd Henning- Germany
Bogumil Linde- Poland
Enrique Riera F. de Sarabia- Spain
Ewald Benes - Austria
Gail ter Haar- UK
Hailan Zhang- China
Hiroshi Kanai- Japan

Jens E. Wilhelm- Denmark
Kentaro Nakamura- Japan
Larry Crum- USA
Leonard Bond- USA
Luis Gaete-Garreton- Chile
Marc Dechamps- France
Michiel Postema- Norway
Nataliya Polikarpova- Russia
Nico F. Declercq- Belgium

Oleg Sapozhnikov- Russia
Pascal Laugier- France
Peter Lewin- USA
Sigrun Hirsekorn- Germany
Stefan Radel- Austria
Suk Wang Yoon- South-Korea
Tim Mason- UK
Vitalyi Gusev- France
Wolfgang Sachse- USA
Woon Siong Gan- Singapore

Technical Program and Scientific Committee Chairs

Bertrand Dubus	Mathias Fink	Vincent Laude	Yves H. Berthelot

Technical Program and Scientific Committee members

Topic and Session Organizers

Alain le Duff - France Alain Lhémery - France Andreas Lenshof - Sweden Anthony N. Sinclair - Canada Arnaud Tourin - France Badreddine Assouar – France Bernard Perrin - France Bernd Henning – Germany Catherine Potel – France Cheong Yang Henry Koh – Singapore Chiara Daraio - Switzerland Crescenzo Di Fratta - Italy Cyril Lafon – France Dominique Certon - France	Emilie Franceschini - France Emmanuel Bossy - France Enrique Riera– Spain Frank Balle – Germany Frederic Cegla – U.K. Igor Solodov – Germany Irene Fernandez Villegas - Netherlands James Friend - USA Jean-François Aubry - France Jean-Marc Girault - France Jean-Yves Hihn - France Jennifer E. Michaels – USA Jonathan Mamou - USA	Karim Sabra – USA Koen Van Den Abeele - Belgium Larry Crum – USA Leonard J. Bond – USA Levent F. Degertekin – USA Marc Deschamps - France Marc Lethiecq – France Martin Spies - Germany Massimo Ruzzene – USA Mickael Tanter – France Mike Lowe - U.K. Nataliya V. Polikarpova – Russia	Nico F. Declercq – Belgium, USA, France Oliver B. Wright - Japan Philippe Lasaygues – France Philippe Roux - France Ronald A. Roy – U.K. Sigrun Hirsekorn – Germany Slah Yaacoubi – France Spyretta Golemati – Greece Stefan Radel – Austria Sylvain Ballandras - France Vincent Tournat- France Vitalyi Gusev – France Woon Siong Gan – Singapore Yan Pennec - France

Topic and Session Abstract Reviewers

Abdelkrim Khelif – France Adriano Alippi - Italy Alexandre Locquet – France Andrea Cardoni - Spain Antoni Sliwinski – Poland Arthur G. Every - South Africa Bernard Bonello – France Bertrand Audoin – France Bogumil Linde – Poland Christ Glorieux – Belgium Christian Petrier – France Christophe Delebarre – France David Citrin – France, USA Ewald Benes - Austria Ferria Kouider- Algeria Fodil Meraghni – France	Gail ter Haar - U.K. Guy Feuillard – France Hailan Zhang – China Hiroshi Kanai – Japan Jean-Claude Kastelik – France Jean-Pierre Sessarego – France Jens E. Wilhjelm – Denmark Joachim Herbertz – Germany John Vander Weide- France Juan A. Gallego-Juarez – Spain Kentaro Nakamura – Japan Krishnan Balasubramaniam - India Laurence J Jacobs – USA Leif Bjorno – Denmark	Louis Satyanarayan – France Luis Gaete-Garreton – Chile M.K. Kurosawa – Japan Manell Zakharia – France Mardi Hastings – USA Michael R. Haberman – USA Michel Nogues – France Michiel Postema – Norway Nick Pace - U.K. Oleg Sapozhnikov – Russia Olivier Bou Matar – France Olivier Poncelet – France Oswald Leroy - Belgium Pascal Laugier – France Paul Voss – France	Peter Lewin – USA Peter Rogers – USA Philipe Blanc-Benon – France Philippe Pernod – France Pierrick Lotton – France Rajendra Kumar Singh – India Rayisa Moiseyenko – France, Ukraine Sadayuki Ueha - Japan Sarah Benchabane – France Sarah W. Herbison- USA Suk Wang Yoon - South-Korea Thomas Brunet – France Tim Mason – U.K. Wolfgang Sachse – USA Younho Cho - South Korea

Congress Proceedings Editor

Nico F. Declercq

Secretariat

Alix Bourgeois	Margaryta Kalancha

Other Committees

The congress organization has also been supported by other local organizing committee members specialized on non-scientific matters. Their names can be found on the Congress Website and in the Congress Proceedings.

PLENARY SPEAKERS


Peter Cawley - UK


Eitan Kimmel -Israel


Thomas Laurell - Sweden

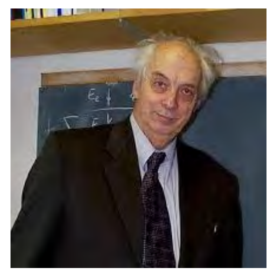

Baowen Li -Singapore


Stefan Radel - Austria


Jose Sanchez-Dehesa - Spain


Vincent Tournat - France


Vitaly Voloshinov - Russia


Victor Georgievich Veselago – Russia

HIGHLIGHTS

USWNet
Ultrasonic Standing Wave Network

The Ultrasonic Standing Wave Network holds its 12th AcoustoFluidics Congress during the 2015 ICU event. Participation is possible by subscribing to 2015 ICU.


A special session is organized on Acousto-Optics in honor and in the presence of Oswald Leroy.

Acoustofluidics 2015 as part of ICU 2015 — 11 - 12 May 2015

Monday 11 may 2015

Keynote Acoustofluidics 2015

Room: Esplanade
Start time: 16:00
Chair Person (s): S. Radel, M. Hill

Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" I

Room: Esplanade
Start time: 16:45
Chair Person (s): T. Laurell, J. Dual

Tuesday 12 may 2015

Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" II

Room: Esplanade
Start time: 10:30
Chair Person (s): M. Hill, I. Gonzalez

Tuesday 12 may 2015

Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" III

Room: Esplanade
Start time: 13:30
Chair Person (s): A. Lenshof, M. Wiklund

Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" IV

Room: Esplanade
Start time: 15:45
Chair Person (s): A. Neild, S. Radel

Tuesday 12 may 2015

Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" (poster)

Room: Main Hall
Start time: 9:30
Chair Person (s):

Tuesday 12 may 2015

Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" (poster)

Room: Main Hall
Start time: 15:00
Chair Person (s):

Abstracts

Mon 16:00 Esplanade Keynote Acoustofluidics 2015

Challenges and opportunities in translating acoustofluidics in to clinical applications – (000640)

T. Laurell
Department of Biomedical Engineering, Lund University, Ole Römers väg 3, S-22363 Lund, Sweden
Corresponding author E-mail: thomas.laurell@bme.lth.se

Microchip based acoustic cell manipulation holds a promising outlook towards medical applications where modalities such as separation and enrichment are key features that may impact the way cell processing and cell lutions should address system throughput as an important parameter. In many applications it is equally important that the processing conditions are such that cells are unperturbed after passing the microfluidic chip and display unchanged phenotype and unimpaired proliferation capacity. Furthermore, the ability of microchip acoustophoresis to separate different cell types based on species specific analysis is done in the future. Key aspects in this respect are that sample processing can be done in a time span that meets clinical requirements or is competitive with current practice. This implies that acoustofluidic soacoustophoretic mobility opens the route to e.g. differentiation of white blood cell subpopulations and rare cell separation. Examples of how all these aspects have been addressed and what still may be challenges for a rapid penetration of acoustofluidics into the clinical domain will be discussed.

Mon 16:45 Esplanade Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" I

Stable Vortex Generation in Liquid Filled Wells by Mode Conversion of Surface Acoustic Waves – (Contributed, 000520)

G. Lindner, K. Schmidt, J. Landskron and M. Kufner
Coburg University of applied sciences, Am Hofbräuhaus 1b, 96450 Coburg, Germany
Corresponding author E-mail: lajo1000@stud.hs-coburg.de

By mode conversion of surface acoustic waves stable vortexes were excited in water filled cylindrical wells made of aluminum. Lamb-type surface acoustic waves with a frequency of 1 MHz were excited by piezoelectric single-phase transducers attached to the outer surface of the bottom of the well. Resulting from mode conversion ultrasound waves were radiated into the water at an angle of 30 degrees with respect to the vertical direction (Rayleigh angle) causing Eckart streaming in the body of the liquid. Vortexes with different rotational orientations were generated depending on the location of the single-phase transducers at the bottom of the well including a symmetric double-vortex configuration with opposite rotational directions of both vortexes ("butterfly pattern"). The stability of the vortexes strongly depended on the liquid level within the well. Further investigations are aiming at the mixing of small amounts of liquids in multi-titer-plates for high-throughput screening without contact of the liquid with moving mechanical parts.

Modal Rayleigh-like streaming in layered acoustofluidic particle manipulation devices – (Contributed, 000052)

J. Lei, P. Glynne-Jones and M. Hill
University of Southampton, University Road, Southampton, UK, SO17 1BJ Southampton, UK
Corresponding author E-mail: j.lei@soton.ac.uk

Streaming in ultrasonic manipulation systems generates fluid flows that can potentially disrupt the ordering of particles with acoustic radiation forces. Eckhart streaming, caused by loses in the bulk of the fluid and Rayleigh streaming, driven by velocity gradients in the thermoviscous boundary layers are well known, and have been extensively studied. We have recently investigated streaming patterns in planar resonators whose mechanism had not previously been understood. These patterns which were in a plane normal to the axis of acoustic propagation were found to be closely related to the pattern of complex acoustic intensity. In this presentation we will describe another type of streaming pattern that we have observed experimentally. This pattern has similarities to classical Rayleigh streaming, however its vortex rolls have sizes related to cavity modes of the fluidic chamber, and can thus be larger than those of Rayleigh streaming. Modelling results confirm our hypothesis and give insight into the physical mechanisms involved.

Measurements of streams agitated by fluid loaded and unloaded SAW-devices using a volumetric 3-component measurement technique (V3V) – (Contributed, 000102)

F. Kiebert[a], J. König[a], C. Kykal[b] and S. Wege[a]
[a]Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstraße 20, 01069 Dresden, Germany; [b]TSI GmbH, Neuköllner Strasse 4, 52068 Aachen, Germany
Corresponding author E-mail: f.kiebert@ifw-dresden.de

The excitation volume of a SAW-device and therefore the wave field of the acoustic wave depends strongly on the position of the device. For a loaded device the acoustic wave is approximately a rectangular function whereas the excitation decays exponentially for an unloaded device. According to the diffraction on a slit one can obtain a rough approximation about the wave field in the near and far field. The state of the art is using the model of the rectangular function for unloaded devices in the approcimation of a far field. To verify this assumption a 2D-PIV system was used by Dentry et al. [1]. But the assumption of a rectangular wave field should be more correct for the loaded device as for the unloaded.
To investigate this fact the position of the SAW-device was varied, so that the device was in one setup loaded and in another unloaded. This should result in a difference of the velocity field agitated by the loaded and unloaded SAW-device. We present for the first time, the unique V3V System from TSI which has been used to investigate the velocity field in a (20x50x50)mm cuvette. This measurement system features high spatially resolved 3-component velocity measurements inside the whole measurement volume of (20x50x50)mm. Therefore near and far field effects are can be observed simultanesously. The measurements showed differences between the velocity field of an unloaded and loaded device. This differeneces can be described by the sundry wave fields and the approximation of a near and far field.

[1] Dentry MB, Yeo LY, Friend JR (2014) Frequency effects on the scale and behavior of acoustic streaming. Phys Rev E 89:013203

A Numerical Study of the Transient Build-up of Acoustic Streaming in Microchannels – (Contributed, 000359)

P.B. Muller and H. Bruus
Department of Physics, Technical University of Denmark, DTU Physics, building 309, DK-2800 Kongens Lyngby, Denmark
Corresponding author E-mail: peter.b.muller@fysik.dtu.dk

Motivation

Handling of sub-micrometer bioparticles, such as bacte-ria, is important in biomedical, environmental, and food analysis applications. Typically, the streaming flow induced by standing acoustic waves prevents focusing of sub-micrometer particles as it counteracts the radiation force [1]. It has been shown experimentally that pulsed acoustic fields can lead to a reduction of the acoustic streaming [2]. To explain this reduction, we present a numerical study of the transient build-up of the acoustic fields and the streaming in a microchannel.

Methods
Extending our previously developed numerical scheme describing steady-state time-averaged streaming [3], our present analysis takes into account the full time dependence of all fields involved. We switch on the acoustic actuation on a quiescent liquid, and study how the time-dependent acoustic resonance field and streaming flow are being established, and, also as a function of time, study how a steady component in the streaming builds up.

Results
Our results show a separation in timescales between the build-up time t_{res} of the acoustic resonance and the build-up time t_{str} of the steady component in the acoustic streaming flow. It may thus be possible to ensure a reduced streaming flow by operating the piezo transducer in pulsed mode with a pulse time t_{pls} fulfilling $t_{\mathrm{res}} < t_{\mathrm{pls}} < t_{\mathrm{str}}$, such that the resonance field and the associated radiation force act in full, before the otherwise detrimental streaming flow has reached any appreciable magnitude.

References

[1] P. B. Muller, R. Barnkob, M. J. H. Jensen, and H. Bruus. Lab Chip **12**, 4617-4627 (2012).
[2] M. Hoyos and A. Castro, Ultrasonics **53**, 70-76 (2013).
[3] P. B. Muller and H. Bruus, Phys. Rev. E **90**, 043016 (2014).

Numerical analysis of the acoustic radiation force and acoustic streaming around a sphere in an acoustic standing wave – (Contributed, 000322)

S. Sepehrirahnama, K.M. Lim and F.S. Chau
National University of Singapore, 9 Engineering Drive 1, Department of Mechanical Engineering, Blk E1 #02-01, 117576 Singapore, Singapore
Corresponding author E-mail: shahrokh.sepehri@u.nus.edu

The main driving force in acoustophoretic applications is commonly attributed to the acoustic radiation force. This force can be obtained by integrating the time-averaged second-order stresses on the surface of the object under analysis. Calculation of acoustic radiation force has been investigated for the past few decades, and several formulae have been proposed, with the recent ones modified to add viscosity and thermal effects. Those closed-form formulae are only valid for a small sphere (compared to the wavelength). The acoustic streaming induced by the scattered waves is also neglected in their derivations.
The acoustic streaming is governed by equations similar to compressible Stokes flow where the volumetric body force is a quadratic function of the harmonic (first-order) velocity and pressure. By converting the equations to a set of Laplace equations of scalar and vector potentials, streaming velocity and pressure can be obtained numerically. Then, the total second-order stresses would be the sum of both the streaming-induced and the Reynolds stresses. We, hereby, propose a numerical scheme for calculation of acoustic streaming and, subsequently, radiation force on a sphere in a viscous fluid. Series expansion of eigenfunctions of Helmholtz and Laplace equations were used for solving the first and second order (streaming) equations, respectively. The boundary conditions were imposed using the weighted residual technique. For small sizes of the sphere, the results match very well with Doinikov's solution (the relative error is less than 1%). For larger sizes, high-order eigen-functions are required for better accuracy. The proposed numerical scheme can be extended to the case of multiple spheres in a viscous fluid.

Interaction of Two-Phase Flows and Ultrasound in Hypergravity Conditions – (Contributed, 000067)

A. Garcia-Sabaté and R. González-Cinca
Universitat Politècnica de Catalunya (BarcelonaTech), Esteve Terradas, 5, 08860 Castelldefels, Spain
Corresponding author E-mail: anna.garcia.sabate@upc.edu

The presence of air bubbles in certain space systems like fuel tanks, thermal control systems or life support systems can lead to undesired effects which usually lead to a reduction on the efficiency of the systems. These applications usually have to ensure the operation of the systems while undergoing different conditions, which include different gravity levels. Active manipulation of air bubbles in liquids with ultrasound has been shown to be a viable and effective method to control bubbles in the past. Therefore, it is of interest to further investigate the interplay between ultrasound and different gravity levels. A series of experiments to study the effects of ultrasound on rising air bubbles in hypergravity have been carried out. The experiments were conducted at the Large Diameter Centrifuge (ESTEC), in the frame of the ESA "Spin Your Thesis!" 2012 contest, which allowed gravity levels up to $20g_0$. Ultrasound were applied on a cubical test cell filled with water by means of two piezoelectric transducers. Air bubbles were injected inside the test cell by means of a syringe pump, while ultrasound was activated in two different directions: parallel and perpendicular to the axis of gravity, each direction using a different frequency. We have observed different effects of the ultrasound on the rising bubbles from detachment from the nozzle to reaching the free surface. The obtained data shows that ultrasounds have a strong effect on the formation of the bubbles and their rising trajectory, delaying the time to reach the free surface and even levitating bubbles.

Microchannel Anechoic Corner for Microparticles Manipulation via Travelling Surface Acoustic Waves – (Contributed, 000108)

G. Destgeer[a], B.H. Ha[a], J. Park[a], J.H. Jung[a], A. Alazzam[b] and H.J. Sung[a]
[a]KAIST, 291 Daehak-ro, Yuseong-gu, 305-701 Daejeon, Republic of Korea; [b]Khalifa University, Abu Dhabi Campus, 127788 Abu Dhabi, United Arab Emirates
Corresponding author E-mail: destgeer@kaist.ac.kr

We present efficient microparticle manipulation technique based on microchannel anechoic corner induced via traveling surface acoustic waves (TSAWs). An acoustofluidic device, composed of a pair of slanted interdigitated transducers (SIDTs) and a polydimethylsiloxane (PDMS) microchannel, is used to manipulate particles of different diameters. The SIDTs disseminate tunable TSAWs normal to the microchannel at desired locations, with required frequencies (130∼200MHz) and amplitudes. The TSAWs interact with the particle carrying fluid to selectively deflect hydro- dynamically pre-focused particles (3.2, 4.2, 4.8μm) from their streamlines. A rightward propagating TSAW, with suitable frequency (135MHz), pushes only selected larger particles (4.8μm) from their streamline into a top-right corner of the microchannel while other particles (3.2 and 4.2μm) flow unaffected in the central region. Downstream, a leftward propagating TSAW (175MHz), misses the larger particles in the top-right corner of the microchannel, deflect only the middle sized particles (4.2μm) into the top-left corner while leaving behind the smaller particles (3.2μm). The separation of particles with diameter 3.2, 4.2 and 4.8μm is realized in a continuous flow. The larger particles remain unaffected by the left-propagating TSAW because of the anechoic nature of the top-right corner of the microchannel. This unique phenomenon is called here as *corner effect*. The *corner effect* is a result of TSAW coupling with the fluid at the Rayleigh angle which is approximately 22° with the channel wall such that the fluid is water and the substrate is $LiNbO_3$. The *corner effect* is utilized to separate different diameter particles and exchange medium around them.

Focusing microparticles inside droplets using acoustics – (Contributed, 000077)

A. Fornell[a], H. N. Joensson[b], M. Antfolk[a], J. Nilsson[a] and M. Tenje[c]
[a]Dept Biomedical Engineering Lund University, Box 118, S-22100 Lund, Sweden; [b]Div of Nanobiotechnology and Proteomics KTH Royal Institute of Technology, Science for Life Laboratory, Box 1031, S-17121 Solna, Sweden; [c]Dept Engineering Sciences Uppsala University, Box 753, S-75121 Uppsala, Sweden
Corresponding author E-mail: anna.fornell@bme.lth.se

Motivation
Droplet-based microfluidics has emerged as an exciting tool with applications for single-cell analysis. One obstacle has been the lack of precise methods to control the position of particles or cells *inside* the droplets. The challenge is to overcome the drag force from the internal fluid streams in the droplets. Recently, acoustics have been combined with droplet microfluidics, to control the position of aqueous droplets in microfluidic channels. Here, a method is introduced that uses integrated bulk acoustic standing waves to reproducibly position microparticles inside moving droplets.
Methods
An isotropically wet-etched glass chip with a glued piezoelectric element was used to generate aqueous droplets containing polystyrene microparticles (7 μm) in an organic phase. The channel depth and top-width were 150 μm and 435 μm, respectively, corresponding to a resonance frequency of around 1.9 MHz in water. The total flow rates were set between 3-18 μl/min, and different flow rate ratios were evaluated. At resonance, the microparticles will be moved towards the centre of the microchannel, due to gradients of the acoustic pressure field.
Results
The microparticles were acoustically positioned to the centre of the nanoliter-sized droplets at the resonance frequency, at total flow rates between 3-12 μl/min (water:oil ratio 1:2). At higher flow rates reduced focusing was seen due to insufficient time for the primary acoustic radiation force to act.
This new method to control the position of microparticles inside droplets by bulk acoustophoresis opens up for a range of on-chip droplet-based assays that are not possible to perform today.

Acoustophoresis of Disks – (Contributed, 000090)

I. Leibacher, A. Garbin, P. Hahn and J. Dual
Institute of Mechanical Systems ETH Zurich, Tannenstr. 3, CH-8092 Zurich, Switzerland
Corresponding author E-mail: leibacher@imes.mavt.ethz.ch

Motivation

Unlike acoustophoresis of spherical particles, acoustophoresis of disk-shaped particles causes an acoustic radiation *torque* which induces disk rotations. Hence the present paper aims to study the acoustophoretic dynamics of disks which are exposed to an ultrasonic standing wave in a microfluidic environment. Application potential is expected for disk-reinforced composites and sound intensity measurements similar to the well-known "Rayleigh disk". Relevance is also given for acoustophoresis of blood samples, since red blood cells are disk-shaped, and for the orientation of non-spherical cells e.g. in flow cytometry.

Methods

With a 3D numerical simulation model for acoustic radiation forces and torques, we studied the dynamics of disks with radius≪wavelength in water. The numerical approach in Comsol Multiphysics allowed to calculate forces and torques for arbitrary disk position, orientation, shape, density and stiffness. The simulations were validated with simplified special cases, where analytic solutions exist in literature (by Gor'kov, King, Rasmussen, Awatani, Wei et al.).

Experiments with alumina disks (diameter 7.5 μm), suspended in an aqueous liquid in a silicon microchannel, confirmed the numerical and theoretical results on the microscale and at ultrasonic frequencies around 2 MHz. The microfabricated devices were excited piezoelectrically with a bulk acoustic wave approach.

Results

Numerical and experimental results describe the acoustophoretic rotation of disks towards an equilibrium position, where the disk axis points in the direction of the standing wave. Numerical simulations revealed the mechanism which generates an acoustic radiation torque, and they allowed modeling beyond the scope of analytic solutions, which only exist for certain disk angles and shapes. By means of the simulations, an ellipsoid with optimized maximal torque could be identified. High-speed microscopy videos of disk acoustophoresis on microfluidic chips were characterized by motion analysis, completing the matching triad of numerical, analytic and experimental results on disk acoustophoresis.

Tue 11:30 Esplanade — Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" II

Surface Acoustic Wave Deagglomeration and Alignment of Carbon Nanotubes – (Contributed, 000081)

J. Friend[a] and M. Miansari[b]
[a]University of California, San Diego, 345F Structural and Mechanical Engineering Bldg, Mail Stop 411, La Jolla, 92093, USA; [b]Monash University, Wellington Road, Department of Mechanical and Aerospace Engineering, 3800 Clayton, Australia
Corresponding author E-mail: jfriend@eng.ucsd.edu

Carbon nanotubes agglomerate into 10-100 μm bundles that are difficult to separate, even after suspension in solution. Here a dry and rapid (≈10 s) method to deagglomerate bulk, unbound multi-walled CNT bundles due to surface acoustic waves in a piezoelectric substrate is reported for the first time. The process first forms 1-μm CNT bundles from extremely large mechanical accelerations due to the surface acoustic waves; these bundles are consequently susceptible to acoustic wave-induced evanescent, quasistatic electric fields that couple into the bundles and form a mat of long (1-10 μm) individual nanotubes on the substrate surface. These may then be aligned along the direction of shear, and notably independent of the SAW propagation direction, through sliding of a cover slip in the desired alignment direction. Further, the intrinsic structure of the nanotubes is unaffected as verified using Raman spectroscopy. Uniquely simple, the approach avoids the many shortcomings of other CNT deagglomeration techniques- particularly surface modification and suspension in solution-to rapidly separate and align large numbers of CNTs, thereby overcoming a key limitation in their use for a diverse range of applications.

Tue 11:45 Esplanade — Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" II

Acoustic trapping of microvesicles from small plasma volumes – (Contributed, 000314)

M. Evander[a], O. Gidlöf[b], D. Erlinge[b] and T. Laurell[a]
[a]Lund University, Department of Biomedical Engineering, Box 118, 22100 Lund, Sweden; [b]Lund University, Clinical Sciences, Department of Molecular Cardiology, Box 118, 22100 Lund, Sweden
Corresponding author E-mail: mikael.evander@bme.lth.se

Extracellular vesicles (EVs) are released from many cell types and can be found in different body fluids, e.g. blood, urine and cerebrospinal fluid. They contain proteins, mRNA/miRNA, express antigens and are involved in many cell signaling processes, including RNA transfer between cells. There is currently a focused effort to understand EVs biological function and how they can be used as diagnostic tools.

The process for isolating EVs from blood involves several centrifugation steps leading to low recovery, potential damage to the EVs and sample volumes of several hundred microliters. We present an acoustofluidic method of

particle-enabled acoustic trapping, it enables rapid access to vesicles from small sample volumes. Fluorescent 500 nm polystyrene particles were trapped and enriched from different sample volumes as a feasibility test. Time-lapse images of fluorescent EVs during enrichment demonstrate successful enrichment of Annexin V and CD42 stained EVs. EVs were enriched from human cell-free plasma while experimental parameters (e.g. flow rate, sample volume, plasma concentration) were varied in order to test the system. For each experiment, the enriched EVs were stained and analyzed using flow cytometry. Finally, the concentration of EVs in patients with ST segment elevation myocardial infarction (STEMI) were compared to healthy controls using both the acoustic method and a standard protocol based on serial centrifugation.

The results show that the acoustic trapping system can enrich platelet-derived EVs from human plasma using samples volumes down to 10 μl with a significantly higher recovery than the centrifugation-based protocol.

Dynamics of Polymer-coated and Lipid-coated Microbubbles in an Acoustofluidic Device – (Contributed, 000499)

G. Memoli[a], C. Fury[b] and K. O. Baxter[a]
[a]National Physical Laboratory, Acoustics Department, Hampton Road, TW11 0LW Teddington, UK; [b]University College London, Department of Physics and Astronomy, Gower Street, WC1E 6BT London, UK
Corresponding author E-mail: gianluca.memoli@npl.co.uk

In this paper, we investigate the ultrasonic-driven dynamics of lipid-coated microbubbles in a custom microfluidic device, designed to host simultaneously optical and acoustic manipulation of microbubbles (6-10 μm diameter). In particular, we describe three experiments: 1) Acoustical manipulation of commercially available, polymer-coated microbubbles at 160-175 kHz, to provide initial benchmarking data. Here we conclude that, in the explored range of frequencies, such bubbles cease to behave like solid particles when a certain threshold pressure is exceeded. We measure secondary Bjerknes forces above the threshold.
2) Calibration of the acoustofluidic device at pressures above the threshold, conducted to have reliable pressure data when classical Gork'ov theory may not apply. We obtain a self-calibration by image processing, monitoring the Brownian motion of trapped polymer-coated microbubbles.

3) Repeat of experiments 1 and 2, but using custom-made lipid-coated microbubbles. In this part of the study, we observe differences with the previous case, attributable to the different coating, and from these infer characteristics of the coating itself. We also discuss the formation of subwavelength structures, different for the two types of bubbles, in the context of different theories for their . Finally, we use high-speed cinematography to highlight volume oscillations, when present.

Findings are interesting for the general acoustofluidic community, but in particular to those researchers already working with microbubbles or moving from solid particles to compressible ones.

On-Demand Production of Size Controlled Droplets Using Surface Acoustic Waves – (Contributed, 000555)

J. Brenker, D. Collins, A. Neild and T. Alan
Monash University, Department of Mechanical & Aerospace Engineering, CLAYTON, 3800 Vic, Australia
Corresponding author E-mail: jason.brenker@monash.edu

In the field of microfluidics the ability to perform complex fluid handling relies on precise control over discrete packets of fluid. The objective of this work is to realise this through the production of size controlled droplets within a microfluidic device utilising a single nozzle. Our group has previously demonstrated that a pressure source generated by high frequency Surface Acoustic Waves (SAW) can be used as the driving mechanism behind microfluidic droplet production in a water/oil device. By designing a microfluidic device containing a nozzle smaller than the channel height, a stabilised oil-water interface was produced. Through precise control of the power levels and pulse lengths applied using SAW, we are able to precisely manipulate the pressure field applied to the oil-water interface. Thus the velocity and displacement of the interface can be modulated to produce a range of droplet sizes down to 12μm in the devices presented in this paper. Depending on the flow rates induced within the device, droplets can be produced in squeezing, dripping and jetting regimes. Critically, the size and number of droplets can be modified on demand simply through tuning of the SAW parameters, giving this device a high degree of flexibility.

Characterization of Adhesive Properties of Red Blood Cells Using Surface Acoustic Wave Induced Flows for Rapid Diagnostics – (Contributed, 000053)

N. Sivanantha, C. Ma, D. Collins, M. Sesen, J. Brenker, R. Coppel, A. Neild and T. Alan
Monash University, Department of Mechanical & Aerospace Engineering, CLAYTON, 3800 Vic, Australia
Corresponding author E-mail: nsiv11@student.monash.edu

Current conventional methods used to research potential disease diagnostics focuses heavily on the biological and immunological aspects. However, the study of biomechanics of pathogenic diseases allows for both intrinsic and extrinsic study at a cellular level to be carried out. For instance, malaria infection is confronted with several limitations with its diagnostic approaches which include a lack of reproducibility, limited throughput and reduced sensitivity when examining mixed infections or early stages of invasion. Furthermore, logistic issues such as adequate staff training and the ability to maintain good quality visualization apparatus and techniques in remote areas, where the disease is most prominent is an added challenge. The ability to exploit acoustic properties within microfluidic systems allow for a new simple approach that has the potential to increase the efficiency of diagnostic methods. Here, we examine the biomechanics of cell de-adhesion in both healthy and malaria-infected red blood cells using surface acoustic waves (SAW). Unlike techniques which have focused on blood flow forces and detachment rates in microchannels and chambers, a method which requires small fluid samples and low power, thus highlighting potential capacity for rapid diagnosis is presented. Specific analysis was conducted on the shear stresses required to selectively peel healthy cells from diseased cells for varying power inputs. Experimental results demonstrated a strong relationship between cell type and adhesive strength. Moreover, various cell populations contained in a 9 μl droplet were differentiated utilizing acoustic streaming within a short time period (i.e. 30 seconds). More specifically, the percentage of red blood cells (healthy, treated, Malaria infected) remaining on the substrate after excitation were 85%, 60%, 9% respectively, hence, giving rise to a proficient, yet simple technique that can be used as a surveillance tool for effective diagnosis.

An integrated acoustic sample preparation system for rapid sepsis diagnosis from blood – (Contributed, 000318)

M. Evander[a], K. Petersson[a], P. Ohlsson[a], L. Mellhammar[b], A. Lehmusvuori[c], U. Karhunen[c], M. Soikkeli[c], T. Seppä[c], E. Tuunainen[c], A. Spangar[c], P. Von Lode[d], K. Rantakokko-Jalava[e], G. Otto[b], S. Scheding[f], T. Soukka[c], S. Wittfooth[c] and T. Laurell[a]
[a]Lund University, Department of Biomedical Engineering, Box 118, 22100 Lund, Sweden; [b]Department of Infectious Diseases, Skåne University Hospital, Box 117, 22100 Lund, Sweden; [c]University of Turku, Department of Biochemistry, Tykistökatu 6 A 6th floor, 20014 Turku, Finland; [d]Abacus Diagnostica Ltd, ElectroCity Tykistökatu 4 D, 2nd floor, 20520 Turku, Finland; [e]Turku University Hospital, Tykslab os.938, Turun kaupunginsairaala PL 28, 20701 Turku, Finland; [f]Department of Hematology, University Hospital Skane, Box 117, 22100 Lund, Sweden
Corresponding author E-mail: mikael.evander@bme.lth.se

Sepsis is an acute inflammatory response to an infection, usually caused by bacteria. It is one of the most common reasons for admission to intensive care units in Europe and the United states and has a mortality rate of around 30%. To survive, it is important to be administered an effective antibiotic treatment as fast as possible. The current gold standard for detection of sepsis-causing bacteria is blood culture - a method that takes on average 15h and requires several subsequent steps resulting in a total identification time that may go well over 24 hours. Clearly, there is a need for a faster method of identifying sepsis-causing bacteria in blood.

We now present the ACUSEP-system that based on acoustic forces separates bacteria from blood, enriches the bacteria and finally releases the bacteria to a dry-reagent PCR-chip for detection. The process from blood sample to bacteria identification takes less than 2 hours per PCR-chip and the system is mostly automated to reduce contamination risks through manual sample handling. The system was tested both using Pseudomonas putida spiked into whole blood and in an 11 week long clinical study on patients with suspected sepsis. A detection limit of 1000 bacterial/ml was determined for the P. putida tests and the system was capable of detecting Escherichia coli in half of the confirmed cases in patients. This indicates that the ACUSEP-system is capable of detecting bacteria in clinical blood samples in the upper range of clinically relevant bacteria concentrations.

Acoustic Impedance Matching Enables Separation of Bacteria from Blood Cells at High Cell Concentrations – (Contributed, 000470)

P. Ohlsson, K. Petersson and T. Laurell
Department of Biomedical Engineering, Lund University, Ole Römers väg 3, S-22363 Lund, Sweden
Corresponding author E-mail: pelle.ohlsson@bme.lth.se

Time is critical when diagnosing sepsis, since mortality increases with every hour of delay of appropriate treatment. Still, the gold standard to identify sepsis-causing bacteria is blood culture, which usually takes 6-130h. To reduce time to diagnosis, we have developed an acoustophoresis-based method to directly sort out bacteria from blood samples. We here demonstrate a 40x increase in throughput by acoustic impedance matching and flow rate increase.

Blood is hydrodynamically laminated along the sidewalls of a separation channel by a central buffer inlet. The red blood cells (RBCs) are acoustically focused to the central buffer, whereas smaller bacteria remain along the sidewalls due to the size dependence of the acoustic force.

At 1% blood concentration the bacteria recovery was 99.7%. Increasing the blood concentration to 20% increased the acoustic impedance (density times speed of sound) of the sample, causing the entire sample fluid to be acoustically focused. This was successfully prevented by increasing the acoustic impedance of the center buffer. With impedance matched buffers bacteria recovery was found to be 89.8% at 20% blood, showing a small decrease in recovery since red blood cells hydrodynamically pulled neighboring bacteria with them at the higher cell concentration.

By using acoustically matched fluids we were able to reduce the time to process 1ml whole blood from over 8h to 12.5min using acoustophoresis. The throughput for a single channel was found to be higher than any comparable microfluidic method, providing a possible sample preparation method for the development of a new sepsis diagnosis system.

Dynamic Acoustic Field Activated Cell Separation (DAFACS) for Regenerative Medicine – (Contributed, 000155)

G.-D. Skotis[a], D. R. Cumming[a], J. N. Roberts[b], M. O. Riehle[b] and A. L. Bernassau[a]
[a]University of Glasgow, 74 Oakfield Avenue, RANKINE BUILDING 79 85, OAKFIELD AVENUE, G12 8LT Glasgow, UK; [b]University of Glasgow, B3.08 Centre for Cell Engineering, Joseph Black Building, G12 8QQ Glasgow, UK
Corresponding author E-mail: g.skotis.1@research.gla.ac.uk

We demonstrate a novel approach utilizing on dynamic acoustic field that is capable of separating an arbitrary size range of cells. Advances in diagnostics, cell and stem cell technologies drive the development of application specific tools for cell and particle separation. In this presentation, we demonstrate the Dynamic Acoustic Field (DAF) method with separation of different diameter and different density of particles/cells in a heterogeneous medium. In a flow-less cavity two opposing transducers were excited, consequently a linear interference pattern of nodes and antinodes was formed in the interstitial media. As a result the micro-particles were trapped at the minima of the potential acoustic energy density. Electronically shifting the excitation phase of one of the transducers from 0° to 360°, proportionally translates that pattern in the direction of the added phase delay. Within each cycle the phase is swept completely through 360° over a time tramp and then allowed to rest for a period trest before commencing the next cycle. Sets of polystyrene particles were subjected to dynamic acoustic field. The measured performance showed high purity (up to 100 %), and high efficiency (up to 100 %). We also tested the separation performance against particle density. Then we applied the dynamic acoustic field to separate porcine dorsal root ganglion (DRG) neurons from a freshly isolated mixture containing myelin debris and other non-neuronal cells. By experimental result it is demonstrated that the DRG cells follow the shifted acoustic field while the debris exhibits minimal displacement of the original node.

Improved acoustophoretic circulating tumor cell separation for low target cell numbers in clinical volumes – (Contributed, 000479)

A. Lenshof[a], C. Magnusson[b], P. Augustsson[a], B. Haflidadottir[b], H. Lilja[c] and T. Laurell[a]
[a]Lund University, Biomedical Engineering, BMC D13, 22184 Lund, Sweden; [b]Lund University, P.O. Box 118, 22100 Lund, Sweden; [c]Memorial Sloan Kettering Cancer Center, 1275 York Avenue, New York, New York, 10065, USA
Corresponding author E-mail: andreas.lenshof@bme.lth.se

We have developed a pressure driven system for continuous flow acoustophoretic separation of circulation tumor cells (CTC). This system allows us to process larger volumes, such as full clinical samples of about 7 mL, with an improved flow stability which includes flow sensors and feedback loop for precise flow control. It also offers simplified liquid and sample handling by simply docking the sample tube and buffers to the inlet ports, minimizing CTC losses in the system as well as a user interface that can be handled by a non-skilled operator. All these features are improvements in contrast to our previously reported syringe pump driven microfluidic flow system.

The acoustic separation device includes a 2-dimensional pre-focusing that allowed alignment of all cells in the same flow vector as they enter the acoustophoretic separation zone, which was crucial to enable separation of tumor cells at high purities versus the white blood cells (WBC) background.

The number of CTCs in a clinical blood sample is commonly in the range of <10 cells /mL and hence a CTC separating system must be able to separate CTCs from a WBC background of ≈10^6 WBC/mL at very high recoveries. To investigate the performance of the CTC-separator, sample suspensions of 1mL WBCs were spiked with 10-15 separator. In principle all tumor cells were accounted for with only 0.4% WBC contamination, concluding that our CTC-system demonstrates a performance that now meet the requirements to investigate clinical samples for CTC analyses.

Label-Free Enrichment of Prostate Tumor Cells Using Acoustophoresis and Negative Selection of WBCs with Elastomeric Negative Acoustic Contrast Particles – (Contributed, 000223)

K. Cushing[a], E. Undvall[a], H. Lilja[b] and T. Laurell[c]
[a]Lund University, E-building, LTH Ole Römers väg 3, 223 63 Lund, Sweden; [b]Memorial Sloan Kettering Cancer Center, 1275 York Avenue, New York, New York, 10065, USA; [c]Department of Biomedical Engineering, Lund University, Ole Römers väg 3, S-22363 Lund, Sweden
Corresponding author E-mail: kevin.cushing@bme.lth.se

Motivation
Acoustophoresis can be used for label-free enrichment of tumor cells in human blood samples. Tumor cells have acoustophysical properties allowing them to be separated from WBCs using acoustophoresis. However, contaminating WBCs were identified to have overlapping acoustophoretic mobilities. Elastomeric particles (EP) that 1) function as negative acoustic contrast particles, and 2) bind WBCs in blood samples, can be used to alter the acoustophysical properties of WBCs; leading to reduced amounts of WBCs in the CTC fraction in the central chip outlet. We show that acoustophoresis with negative selection of WBCs using EPs can be used for improved label-free enrichment of tumor cells.
Methods
Elastomeric particles were synthesized using an emulsion process and functionalized using a CD45 monoclonal antibody. Various amounts of EPs were added to solutions containing a 1:1 mixture of WBCs and prostate cancer cells (DU145). Incubation of EPs with cell mixtures occurred at room temp for 1 hour. Acoustophoresis (1.99 MHz at 12 Vpeak-peak) was performed to separate EP bound WBCs from cancer cells. The collected fractions were enumerated using flow cytometry (BD FACSCanto^{TM} II).
Results
Our results showed increased depletion of WBCs within the central fraction as the EP to WBC ratio was increased. A maximum of ≈50-fold WBC depletion from the center fraction was obtained with a tumor cell recovery of 94.6%.

Numerically efficient damping model for acoustic resonances in microfluidic cavities – (Contributed, 000351)

P. Hahn and J. Dual
Institute of Mechanical Systems ETH Zurich, Tannenstr. 3, CH-8092 Zurich, Switzerland
Corresponding author E-mail: hahn@imes.mavt.ethz.ch

Bulk acoustic wave devices are typically operated in a resonant state to achieve enhanced acoustic amplitudes and high acoustofluidic forces for the manipulation of microparticles. Among other loss mechanisms related to the structural parts of acoustofluidic devices, damping in the fluid cavity is a crucial factor that limits the attainable acoustic amplitudes and therefore the effectiveness of the device. Acoustofluidic damping can be traced back to various loss mechanisms related to viscous and thermal attenuation in the bulk as well as viscous and thermal boundary layers at cavity walls or around suspended particles. However, numerical 3D simulations that include all relevant physics are prohibitively expensive. Therefore, researchers typically resort to simplified models with an estimated acoustic loss factor.
We present a way to calculate the individual components of the fluid loss factor based on the real physics. Specifically, we derive analytical and semi-analytical expressions for the loss factor due to viscous and thermal boundary layers at the cavity walls or around suspended particles. Our results and the validity the physical assumptions we make in the derivation are carefully verified by analytical and numerical reference solutions.
For the first time, accurate 3D device simulations become numerically feasible since the boundary layers do not have to be resolved. This is demonstrated by fitting the derived fluid loss factors into the framework of classical linear acoustics to build a numerically efficient 3D device model that allows the realistic prediction of pressure amplitudes. In this sense, our work represents the missing link that will allow to make not only qualitative but also quantitative predictions of acoustofluidic forces in realistic 3D devices.

Generation of Complex, Dynamic Temperature Gradients in a Disposable Microchip – (Contributed, 000147)

B.H. Ha, G. Destgeer, J. Park, J.H. Jung and H.J. Sung
KAIST, 291 Daehak-ro, Yuseong-gu, 305-701 Daejeon, Republic of Korea
Corresponding author E-mail: deepsky@kaist.ac.kr

Temperature gradient (TG) has demonstrated the crucial importance in many applications. However, the TG generation systems to date are not capable of making dynamic profiles in a disposable platform. In addition, these systems fail to localize the temperature control, hampering the integration of multiple functionalities on a single chip. Here we introduce an easy-to-fabricate, transparent, and disposable system for the generation of complex, dynamic TG. The heating mechanism resorts to effective acoustic absorption of polydimethylsiloxane (PDMS) under high frequency (∼MHz) vibrations. In order to generate mechanical waves and couple them with the PDMS microchip, a conventional surface acoustic wave (SAW) system was employed. The key idea is to place a PDMS microchip right on top of a slanted interdigital transducer (s-IDT). We can localize the heating of PDMS by selectively actuating portions of IDT fingers. Alternating current electronic signals having frequencies matching with the IDT finger gaps are applied for the actuation. We created TGs throughout a thin layer of PDMS, which in turn formed TGs in the gas right above the PDMS. Linear, Gaussian, and bimodal profiles of TG with temperature ranging from 40°C to 90°C were successfully created. Dynamic transitions between different profiles were accomplished in less than 30 sec. Nonlinear temperature gradients in rhodamine B solution was also made in a similar fashion. Temperature distribution of the liquid in microchannels was measured based on the calibration curve between fluorescence intensity and temperature. For future work, we plan to perform one-shot DNA melting curve measurements.

Optimal design of silicon-based chips for piezo-induced ultrasound resonances in embedded microchannels – (Contributed, 000213)

F. Garofalo[a], T. Laurell[a] and H. Bruus[b]
[a]Department of Biomedical Engineering, Lund University, Ole Römers väg 3, S-22363 Lund, Sweden; [b]Department of Physics, Technical University of Denmark, DTU Physics, building 309, DK-2800 Kongens Lyngby, Denmark
Corresponding author E-mail: fabio.garofalo@bme.lth.se

Acoustophoretic devices represent an efficient and easy-to-set-up method for the manipulation of biological samples. Despite these advantages, the identification of optimal working conditions is yet entrusted with the presence of the operator, who has to search manually for resonance states that afterwards can be tracked by the aid of electric measurements.
In a theoretical study based on variational principles, we introduce indicators enabling efficient identification by numerical analysis of ultrasound resonances and optimal working conditions for acoustophoresis in microchannels embedded in silicon-based devices driven by piezoelectric actuators. We combine standard theory for elasticity, pressure acoustics, and piezoelectricity with the Lagrangian and Hamiltonian formalism, and implement it in weak form in subsequent finite element method simulations.
We study numerically the response of the system as a function of actuation frequency, and we investigate the dependency of the acoustic power of material parameters and geometry. The results are used to discuss the reliability and robustness of the introduced resonance indicators. Some interesting features of the numerical model in the context of breaking the symmetry for the chip/piezo structure are addressed. The present work represents a first attempt of introducing rigorous quantitative indicators to be used for quality assessments of acoustic resonances by external measurements.

Surface acoustic wave controlled integrated band-pass filter – (Contributed, 000368)

T. Franke
Glasgow University, Oakfield Av, G12 8LT Glasgow, UK
Corresponding author E-mail: thomas.franke@glasgow.ac.uk

We introduce a microfluidic band-pass filter for particles, that is fully integrated in a polydimethylsiloxane (PDMS) based microchannel device. This acoustic filter allows a continuous and label-free separation of particles. To demonstrate the functionality, mixtures of particles with different sizes are exposed to propagating surface acoustic waves (PSAWs) generated by two laterally displaced interdigitated transducers (IDTs), one on each side of the microchannel. Dependent on the frequency used a specific size or even a size range of particles can be extracted. We sort particles of sizes of ∼1-10 μm and estimate the size resolution to be smaller than Δr< 0.88 μm. We examine the performance of the device and achieve a throughput of ∼ 10ˆ 5 particles/s with an efficiency as high as 99%.

Tue 17:15 Esplanade — Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" IV

Analysis of a Non-resonant Ultrasonic Levitation Device – (Contributed, 000280)

M.A. Brizzotti Andrade[a], N. Pérez[b] and J. C. Adamowski[c]

[a]Universtiy of São Paulo, Rua do Matão Travessa R Nr.187, 05508-090 Sao Paulo, Brazil; [b]Universidad de la República, Centro Universitario de Paysandú, 60000 Paysandú, Uruguay; [c]University of Sao Paulo, Department of Mechatronic and Mechanical Systems Engineering, 05508-900 Sao Paulo, Brazil

Corresponding author E-mail: marcobrizzotti@gmail.com

A typical ultrasonic levitator is a resonant device and basically consists of an ultrasonic transducer and a reflector. When the separation distance between the transducer and the reflector is adjusted to a multiple of half- wavelength, a standing wave field is established, allowing the levitation of small particles at the pressure nodes of the standing wave. If this distance is adjusted outside the resonance, the pressure amplitude of the standing wave decreases considerably, and the levitating particle cannot be sustained by the acoustic radiation force. In this study, a non-resonant configuration of ultrasonic levitation device is presented, which is formed by a small diameter ultrasonic transducer and a concave reflector. The influence of each levitator parameter on the levitation performance is investigated by using a numerical model that combines the Gor'kov theory with a matrix method based on the Rayleigh integral. The matrix method is used to determine the pressure and velocity distributions in the air gap between the transducer and the reflector. Then, the pressure and velocity distributions are used in the Gor'kov equation to obtain the potential of the acoustic radiation force that acts on the levitated particle. The numerical simulations show that the standing wave is mainly formed by the superposition of two counter-propagating traveling waves: the emitted wave produced by the transducer and the reflected wave by the reflector. Due to the small transducer radius, high-order reflections are rapidly spread into the surrounding medium. This particular characteristic allows the separation distance between the transducer and the reflector to be adjusted continually, without requiring the separation distance to be set to a multiple of half-wavelength. It is also demonstrated that the levitating particle can be manipulated by maintaining the transducer in a fixed position in space and moving the reflector in respect to the transducer.

Tue 17:30 Esplanade — Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" IV

Optimisation of an acoustic resonator for particle manipulation in air – (Contributed, 000029)

C. Devendran[a], D. R. Billson[b], D. Hutchins[b], T. Alan[a] and A. Neild[a]

[a]Monash University, Department of Mechanical and Aerospace Engineering, Monash University, Clayton, 3800 Melbourne, Australia; [b]University of Warwick, School of Engineering, CV4 7AL Coventry, UK

Corresponding author E-mail: saab.devendran@monash.edu

Advances in micro-electromechanical systems (MEMS) technology and biomedical research necessitate micromachined manipulators to capture, handle and position delicate micron-sized particles, including airborne particles and pathogens. To this end, a parallel plate acoustic resonator system has been investigated for the purposes of manipulation and entrapment of micron sized particles in air. Numerical and finite element modelling was per-formed to aid the design of the acoustic resonator system which consists of 3 layers, namely the piezoelectric sub-strate, a matching layer and the air gap. The matching layer is introduced into the system to enhance the acoustic energy transmission from the piezoelectric substrate into the air gap. In order to obtain an optimised resonator design, careful considerations of the effect of thickness and material properties are required. It is found that at realistic specific acoustic impedance values accommodating for individual layer material quality factors, the thickness of each layer plays a larger role as compared to the material properties which has a minimal influence on the transmission of acoustic energy. Furthermore, the effect of acoustic attenuation which is dependent on frequency is also considered within this study. For the purposes of meaningful comparison, a constant energy density input scenario is considered, leading to an optimum operational frequency range. This frequency range is dependent on the size of the system considered owing to the fact that it is an open ended system and energy losses in terms of

diffraction also plays a role. Finally, experimental results demonstrated good particle levitation and capture of various particle properties and sizes ranging to as small as 14.8 μm.

Tue 17:45 Esplanade Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" IV

Measurement of 3D-forces on a micro particle in acoustofluidic devices using an optical trap – (Contributed, 000375)

A. Lamprecht[a], S. Lakämper[a], I. A. Schaap[b] and J. Dual[a]
[a]ETH Zürich, Tannenstrasse 3, CLA H23.1, 8092 Zurich, Switzerland; [b]Fakultät für Physik, III. Physikalisches Institut Georg August Universität, Friedrich Hund Platz 1, 37077 Göttingen, Germany
Corresponding author E-mail: lamprecht@imes.mavt.ethz.ch

Spatial acoustic manipulation of objects within fluids and fluid-like materials is of fundamental importance in various fields of ongoing-research and application. The expanding ability to manipulate objects, like solid particles, functionalized beads, cells, etc., has strongly contributed to advances in material science, life science and biophysical research.
The effects of ultrasonic standing waves on spherical objects have been described analytically and numerical models help to predict the acoustic pressure distribution in real acoustic devices. Barnkob *et al.* (Lab Chip,2010,**10**,563) showed that it is also possible to experimentally predict the local acoustic pressure amplitudes by particle tracking and a subsequent fitting to a theoretical model. Here we present a method to *directly* measure the total time-averaged force on a dielectric silica particle in the regime of an ultrasonic standing wave.
The particles are strongly diluted in water and a calibrated single-beam gradient laser trap holds one single particle (0.5-10μm) at a specified position within a micro channel. The piezoelectrically excited acoustic standing wave is scattered by the particle and leads to an acoustic radiation force or causes acoustic streaming. Both effects displace the optically trapped particle. We monitor the displacement of the particle from the trap center in three dimensions and subsequently calculate the forces (0.2-50pN) in dependence of the particle position and excitation frequency. From the obtained quantitative data we were e.g. able to determine the real pressure distributions within acoustofluidic devices.
The two dimensional case was investigated by Lakämper *et al.* (Lab Chip,2015,**15**,290) and the derived data correspond exquisitely well with the theory and previous modeling. The three dimensional direct measurement as presented here opens up the possibility to quantify so far inaccessible small scale phenomena such as a.) the effects of local and global acoustic streaming, b.) effects of boundaries or close by objects.

Tue 9:30 Main Hall Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" (poster)

Traveling Surface Acoustic Waves Microfluidics – (Contributed, 000127)

G. Destgeer[a], B.H. Ha[a], J. Park[a], J.H. Jung[a], A. Alazzam[b] and H.J. Sung[a]
[a]KAIST, 291 Daehak-ro, Yuseong-gu, 305-701 Daejeon, Republic of Korea; [b]Khalifa University, Abu Dhabi Campus, 127788 Abu Dhabi, United Arab Emirates
Corresponding author E-mail: destgeer@kaist.ac.kr

In a microfluidic system, standing surface acoustic waves (SSAWs) have been used to manipulate micro-objects. A pair of interdigitated transducers (IDTs) is usually used to generate SSAWs, however, a single IDT has also been reported to produce a similar effect. In a parallel domain, traveling surface acoustic waves (TSAWs) produced by a single IDT have been used to efficiently actuate (mix, pump, nebulize) fluid on a microfluidic platform. Re-cently, TSAWs have shown promising potential in dex-terous handling (separation, sorting, trapping) of micro-objects in a micro-sessile droplet or inside a microchannel. The present study is focused on the use of TSAWs for micro-object manipulation and micro-fluid actuation in-side the microchannel. The actuation of micro-fluids via TSAWs is dependent on the acoustic streaming flow (ASF) generated by the dissipation of acoustic waves in the fluid, whereas the manipulation of micro-objects depends on the acoustic radiation force (ARF) derived from TSAWs' frequency, particles' diameters and relative densities of the fluid and particles. The ASF is produced in conjunction with the ARF. A κ factor, directly proportional to the diameter of the particle and TSAWs' frequency, is used to characterize the different behaviours of the particles under the effect of TSAWs. For κ>1, the ARF on the particles dominates the drag force induced to the parti-cles via ASF. For κ<1, the particles are so small to be effected by the ARF and the effect of ASF dominates. We have taken advantage of these promising effects to sepa-rate microparticles and controllably actuate fluids inside the microchannel.

ultrasonic enrichment of flowing blood cells in capillars: influence of the flow rate – (Contributed, 000296)

I. Gonzalez[a], P. Carreras[b], M. Aleixander[a] and J. Oliveras[a]
[a]CSIC Consejo Superior de Investigaciones Cientificas, Serrano 144, 28006 Madrid, Spain; [b]Mecwings, Santiago Grisolía, 2, 28760 Tres Cantos Madrid, Spain
Corresponding author E-mail: iciar.gonzalez@csic.es

Red Blood cells subjected to standing waves collect at the pressure nodes during their flow motion. Blood is a non-newtonian fluid, whose density and other properties are defined by its flow velocity. Depending on their concentration, the red cell drift motion is governed not only by the radiation forcé acoustically induced, but also by the hydrodynamic conditions established in the sample, defined by the cell concentration and the cell-cell interactions. This work presents a study of the red cell enrichment performed by ultrasounds in a rectangular capillar as a function of their flow motion. Very low flow rates don't favor the cell collection to achieve good results of plasmapheresis. On the contrary, the cell enrichment at the pressure node is enhanced with the flow raise. The cells collect to form a long chain of red cell aggregates along the capillar length in very few seconds of acoustic treatment.

Ultrasonic Microfluidic Actuation with Secondary Bjerknes Forces on Bubbles – (Contributed, 000417)

M. Lanoy[a], A. Tourin[a], C. Derec[b] and V. Leroy[b]
[a]ESPCI Paris Tech, PSL Research University, CNRS, Institut Langevin, 1, rue Jussieu, F-75005 Paris, France; [b]Université Paris-Diderot, Laboratoire MSC, CNRS (UMR 7057), 75205 Paris, France
Corresponding author E-mail: Valentin.leroy@univ-paris-diderot.fr

In the last decade, the development of microfluidics has motivated the search of new actors that could help handling small objects in laminar flows. Combining various force fields has proved to be a good strategy in classical issues such as particles detection and sorting, drop coalescence, mixing, etc. In the area of physical acoustics, the Bjerknes force, that occurs when an immersed compressible medium undergoes a pressure fluctuation, appears as a potential nominee for microfluidic actuation. In this talk, we will present an original experiment that allows us to follow the trajectory of a free bubble attracted or repelled by one or several fixed bubbles, under the action of an external acoustic field. The role of the frequency of the acoustic excitation and the radii of the bubbles will be emphasized. We will discuss a potential application for guiding bubbles through a microfluidic device.

Surface Acoustic Wave Based Cell Measurements in a Disposable Chamber – (Contributed, 000484)

S. Naseer, R. Wilson, J. Reboud and J. M. Cooper
University of Glasgow, Division of Biomedical Engineering, Rankine Building, Division of Biomedical Engineering, College of Science and Engineering, G3 8QP Glasgow, UK
Corresponding author E-mail: s.naseer.1@research.gla.ac.uk

Biophysical properties of tumor cells are important for biomarkers, informing medical diagnostics, as well as biology research. In particular mechanical properties of cells have been linked to tumour aggressiveness. Existing methods to measure these mechanical properties, including atomic force microscopy, are bulky, invasive and require time consuming analysis. Here, we demonstrate a technique to investigate mechanical properties such as compressibility and bulk modulus of human breast cancer cells (MCF-7) in a disposable chamber using surface acoustic waves (SAW). This system was implemented on disposable microchips in a non-invasive fashion. When the commonly used techniques usually give access to the Young's modulus, this technique provides access to the compressibility of the cells (or bulk modulus). We used slanted interdigitated transducers (SIDTs) patterned on a lithium niobate ($LibNO_3$) substrate to generate a wide range of acoustic excitation frequencies (3MHz - 6MHz) using a signal generator (TG5011 TTi) and a power amplifier (Mini Circuits ZHL-5W-1). The waves were cou-pled with a glass coverslip superstrate, using water as the coupling agent and sample was loaded in a 3D printed microfluidic disposable chamber. The system was first characterized using polystyrene beads, enabling us to locate the pressure nodes of the standing wave field created by the reflected waves. We then introduced MCF-7 cells in phosphate buffer in the system. By adjusting the SAW wavelength (400μm to 1000μm) and the power of the excitation (0.252W to 1.585W) the cells were positioned onto the pressure node of standing wave. Tracking the cells under a microscope with a 10x/20x objective lens and camera (Zeiss Axio Observer), enabled us to extract viscous and acoustic force applied to the particles. We found the compressibility of MCF-7 cancer cells of density 1,068 Kg/m^3 to be 4.124±3.24%x$10^{-10}Pa^{-1}$ or the bulk modulus 2.41±3.97% GPa. These results are in close agreement of published works (±2%). The system developed offers a disposable system which can easily be integrated within lab-on-a-chip technologies for studying biophysical properties of cells through non-invasive methods.

Tue 9:30 Main Hall Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" (poster)

Acoustic separation of cells and particles in a single laminar flow stream – (Contributed, 000427)

M. Antfolk[a], C. Antfolk[a], H. Lilja[b], T. Laurell[a] and P. Augustsson[a]
[a]Dept Biomedical Engineering Lund University, Box 118, S-22100 Lund, Sweden; [b]Memorial Sloan Kettering Cancer Center, 1275 York Avenue, New York, New York, 10065, USA
Corresponding author E-mail: Maria.antfolk@bme.lth.se

A novel acoustophoresis-based method has been developed that allows for continuous separation of cells and particles in a single flow-stream without the use of hydrodynamic pre-positioning of the sample before separation. The method is characterized demonstrated by separation of 5-μm and 7- μm particles. The usefulness of the method is demonstrated by separating prostate cancer cells from white blood cells.
Acoustophoresis for separation of cells has previously necessitated the use of a cell-free liquid to pre-position the sample before the separation. In this work, cells are instead pre-positioned using two-dimensional pre-alignment into two pressure nodes, allowing for particle separation within the initial suspending medium. In addition to simplifying the fluidic setup, the method eliminates the need for acoustically matched fluids. The extension of this zero-dilution approach holds promise of an increased throughput since the flow velocity in the sorting channel is reduced.
The chip consists of a pre-alignment channel (300 μm by 150 μm) operated at 5 MHz and a separation channel (375 μm by 150 μm) operated at 2 MHz. The sample flow rate was kept at 100 μL/min and the outlet flow rates were 25 μL/min in the centre and 75 μL/min in the sides outlet, as simulations indicated this to be the optimal ratios.
Using this microchip 99.6±0.2% 7-μm particles could be collected though the centre outlet while 98.8±0.5% of the 5-μm particles were collected though the sides outlet. 86.5±6.7% of the cancer cells could be recovered with a contamination of only 1.1±0.2% of white blood cells.

Tue 15:00 Main Hall Ultrasonic particle and fluid manipulation as the "Acoustofluidics 2015" (poster)

Acoustic sorting and concentration of cancer cells – (Contributed, 000429)

M. Antfolk[a], P. Augustsson[a], C. Magnusson[b], H. Lilja[c] and T. Laurell[a]
[a]Dept Biomedical Engineering Lund University, Box 118, S-22100 Lund, Sweden; [b]Lund University, P.O. Box 118, 22100 Lund, Sweden; [c]Memorial Sloan Kettering Cancer Center, 1275 York Avenue, New York, New York, 10065, USA
Corresponding author E-mail: Maria.antfolk@bme.lth.se

This abstract presents an acoustophoresis chip capable of sorting cancer cells (prostate cancer cell line DU145) from white blood cells (WBCs) and subsequently concentrating the recovered cells. The system aims to facilitate the handling and analysis of rare cell or dilute samples.
Circulating tumor cells are rare cancer cells that shed from a tumor into the blood stream and migrate to other tissues where they may form metastases. The number of circulating tumor cells is correlated to the aggressiveness of the tumor and isolation of them may also provide information of the primary tumor that can lead to more specialized treatments. Most isolation attempts today use antibodies targeting specific cell surface markers. No universal cancer cell marker has been found and the use of tissue specific markers involves the risk of losing subpopulations that do not express this marker. The label-free separation method acoustophoresis may thus provide information of new subpopulations otherwise undetected.
The chip, is composed of a pre-alignment channel (300 μm by 150 μm), a separation channel, and a concentration channel (375 μm by 150 μm). The pre-alignment channel was operated at 5 MHz and the separation and concentration channels at 2 MHz. The sample inflow rate was kept at 100 μL/min and the outflow rates were varied to modulate the final concentration of cancer cells.
Using this multifunctional chip 92 % of the cancer cells could be recovered and simultaneously concentrated 24 times with a contamination of only 0.6 % of the WBCs.

Polymer-Shelled Ultrasound Contrast Agents in Microchannel Acoustophoresis – (Contributed, 000036)

S.V.V.N. Kothapalli[a], M. Wiklund[b], B. Janerot-Sjoberg[c], L.-Å. Brodin[a] and D. Grishenkov[a]
[a]Royal Institute of Technology, KTH, Division of Medical Engineering, STH, KTH, Alfred Nobels allé 10, 14152 Huddinge, Sweden;
[b]Department of Applied Physics, KTH Royal Institute of Technology, ROSLAGSTULLSBACKEN 21, 10691 Stockholm, Sweden;
[c]Department of Clinical Science, Intervention and Technology,Karolinska Institute, Alfred Nobels Allé 8, Huddinge, 14152 Stockholm, Sweden
Corresponding author E-mail: vkot@kth.se

The aim of this work is to demonstrate the fundamental physical behaviors of stable micro-sized gas bubbles covered by polymer molecules under the presence of ultrasound standing wave (USW).
The experimental set-up consists of microfluidic chip coupled to the piezoelectric crystal (PZT) having the resonance frequency of about 2.8 MHz. The microfluidic channel consists of rectangle sono-cage and the width, w, of the cage was equal to one wavelength, λ ($\sim$535 μm) of USW. The superposition of horizontal and vertical standing waves in perpendicular to fluid flow resulting in formation of two pressures nodal at w/4 and 3w/4, and three anti-nodal planes at 0, w/2 , and w. The peak-to-peak voltage (Vpp) across the PZT was incrementally increased from 1 and 10.
Experimentally, the particles were translated and focused at the pressure anti-nodal planes under USW as similar to oil droplets. When the particles were dragged to the close vicinity to the pressure anti-nodal planes then the secondary radiation forces actively brings them to clusters at different spots along the channel. At 10 Vpp, the particles were accumulated at the pressure anti-nodal plane of about 0.46 seconds, while 5 μm blood phantom microbeads were accumulated at the pressure node of about 26 seconds. Theoretical prediction of the acoustic contrast factor, ϕ , of these particles was found to be negative and equal to -60.7.
Overall, the polymer-shelled gas bubbles are negative acoustic contrast particles and can be trapped at the antinodal plane. This phenomenon could be utilized to explore the future applications, such as bio-affinity and cell interactions studies.

A Numerical Analysis of Phononic-Assisted Control of Ultrasound Waves in Acoustofluidic Devices – (Contributed, 000428)

R.P. Moiseyenko and H. Bruus
Department of Physics, Technical University of Denmark, DTU Physics, building 309, DK-2800 Kongens Lyngby, Denmark
Corresponding author E-mail: raymoi@fysik.dtu.dk

Motivation
The ability to precisely sort individual microparticles/cells/droplets in suspension is important for various chemical and biological applications such as cancer cell detection, drug screening etc. The past decade, label- free particle handling of particle suspensions by ultrasonic radiation forces and streaming has received much attention, since it relies solely on mechanical properties such as particle size and contrast in density and compressibility. We present a theoretical study of phononic-assisted control of ultrasound waves in acoustofluidic devices.

Methods
Our analysis is based phononic crystals diffraction gratings (PnC diffractors) [1]. These are artificial spatially periodic structures that lead to the formation of band gaps in the acoustic frequency spectrum, for which ultrasound cannot propagate through the crystal. We use a finite element method to design PnC diffractors near a microfluidic channel, and then using our previous methods [2], we calculate the influence of the these diffractors on particle acoustophoresis in the channel.

Results
We propose the use of PnC diffractors, which can be introduced in acoustofluidic structures. These diffractors can be applied in the design of efficient resonant cavities, directional sound waves for new types of particle sorting methods, or acoustically controlled deterministic lateral displacement. The PnC-diffractor-based devices can be made configurable, by embedding the diffractors, all working at the same excitation frequency but with different resulting diffraction patterns, in exchangeable membranes on top of the device.

References
[1] R. P. Moiseyenko, S. Herbison, N.F. Declercq, V. Laude, J Appl Phys **111**, 034907 (2012).
[2] P. B. Muller, R. Barnkob, M.J.H. Jensen and H. Bruus, Lab Chip **12**, 4617 (2012) .

Planar acoustic nodes in large format Acoustofluidic chambers for high flow rate sample processing applications – (Contributed, 000463)

J. W. Elling, J. Gatewood and R. Applegate
Acoustic Biosystems, 3900 Paseo del Sol, Santa Fe, 87507-4072, USA
Corresponding author E-mail: elling@acousticbiosystems.com

Acoustic Biosystems has succeeded in producing a uniform single acoustic node focus region in wide (>15mm) rectangular channels. This capability allows acoustophoretic sample processing at high (>10ml/min) flow rates with quantitative recovery of cells and particles in the focused streams. The resonant acoustic cell enrichment (RACE^{TM}) technology is used for automated sample processing in a continuous flow system that is capable of concentrating and washing cells. RACE will be applied as a cost effective, low power, continuous flow replacement to a centrifuge. This will enable automation of processing and analysis protocol that currently require centrifuge concentration to be deployed in continuous flow systems.
Additional applications for optical imaging of cells focused into the planar acoustic node will be discussed.

Special thanks to our Sponsors

ArcelorMittal

Inspection Technology Europe BV
Allied NDT Engineers

kibero

MISTRAS

OLYMPUS
Your Vision, Our Future

Polytec

PVA TePla

xarion
laser acoustics

#S-Sharp

2015 International Congress on Ultrasonics

Metz, France, May 11-14, 2015 • www.2015icu.fr

SUNDAY 10th MAY		MONDAY 11th MAY		TUESDAY 12th May		WEDNESDAY 13th May		THURSDAY 14th May
	7.00 - 9.00	Registration + Breakfast Grand Hall	7.00-8.30		7.00-8.30		7.30-8.30	
	9.00 - 11.00	Opening Ceremony Grande Salle	8.30-9.30	Plenary session Grande Salle	8.30-9.30	Plenary session Grande Salle	8.30-9.30	Plenary session Grande Salle
	11.00-11.30	Time off	9.30-10.30	Poster sessions + coffee break Grand Hall	9.30-10.30	Poster sessions + coffee break Grand Hall	9.30-10.30	Poster sessions + coffee b Grand Hall
	11.30-12.30	Keynote speakers Grande Salle	10.30-12.00	Technical sessions	10.30-12.00	Technical sessions	10.30 - 12.00	Technical sessions
	12.30 - 14.00	Lunch Break Orangerie	12.00 - 13.30	Lunch Break Orangerie	12.00-13.30	Lunch Break Orangerie	12.00 - 13.30	Lunch Break Orangerie
	14.00-15.00	Plenary session Grande Salle	13.30 - 15.00	Technical sessions	13.30-14.30	Keynote speakers	13.30 - 15.00	Technical sessions
	15.00-16.00	Poster sessions + coffee break Grand Hall	15.00 - 16.00	Poster sessions + coffee break Grand Hall	14.30-15.30	Poster sessions + coffee break Grand Hall	15.00 - 16.00	Poster sessions + coffee b Grand Hall
Registration Grand Hall	16.00 - 18.00	Technical sessions	16.00 - 18.00	Technical sessions	15.30 - 17.30	Technical sessions	16.00 - 17.30	Technical sessions
	18.00-21.00	Welcome Reception Grand Hall	18.00-19.30	Time off	17.30 - 19.30	Time off	17.30 - 19.30	Farewell reception Grand Hall
			19.30 - 21.30	Orchestre national Concert Guthmann Prizes	19.30 - 23.00	Gala diner ICU's Silver and Gold whistle Award Orangerie	19.30 - 23.00	

With the financial support of:

Support from partners:

Concert support:

Technical sponsors: