Newsletter of the Physical Acoustics Group 2009

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This newsletter reviews what has happened since October 2008, the date of our last newsletter. The main events organised by the Group have been our annual international Physical Acoustics Conference, AFPAC09, the AGM and Tutorial Day. Reports on each of these are below and follow the notices of our forthcoming events – our next conference AFPAC10 and nominations for our Bob Chivers' Prize. At the end of this newsletter is a notice of a forthcoming event to be held at the National Physical Laboratory.

Anglo French Physical Acoustics Conference 2010

This will be called GDR - AFPAC10, see below, and will be held on the 18 - 22 January 2010 at the Castle Green Hotel, Lake District, UK.

This will be called GDR-AFPAC and is the 6th conference of the GDR 2501 Research on Ultrasound Propagation for NDT jointly with the 10th Anglo-French Physical Acoustics Conference (AFPAC). As usual this conference is supported by The Physical Acoustics Group of the IOP together with the French society GAPSUS (part of the SFA - Le Groupe d'Acoustique Physique, Sous-Marine et Ultra-Sonore. This year we are also pleased to be supported and sponsored by Groupe de Recherche, (GDR), a network of the French scientific funding agency CNRS now linked to the UK with EPSRC funding.

GDR is a research network, which has been running in France since January 2002, and whose purpose is to link university researchers in ultrasonic Non Destructive Testing (NDT) with each other and with interested industrial organisations.

Because GDR conferences are normally a week long but AFPAC conferences are normally only on three days, the format of the conference will be such that the AFPAC part will be concentrated into the period Monday (18 January) afternoon up to Wednesday (20 January) lunchtime. A social event will take place on Wednesday afternoon with talks that day also in the evening. Everyone, whether GDR or AFPAC attendee, is encouraged to stay for the whole week. Arrival on the Sunday afternoon (17 January) will be possible.

The website is open for submission of abstracts of 250-300 words: http://afpac.iop.org/

Bob Chivers Prize

Every two years since 2006, (2008, 2010, 2012, etc.), the Group awards the Bob Chivers' prize for the best paper published as a results of their studies by a doctoral student at a UK university. The paper has to be principally the work of the student in connection with their doctoral studies. The paper must have been accepted for publication, but not necessarily published, by the cut-off date in the two year cycle. Nominations are requested for work in any area of Physical Acoustics for the next award. Nomination is by submitting a copy of the paper in pdf form to the Hon. Secretary, Mike Lowe m.lowe@imperial.ac.uk by the cut off date, which will be the end of April 2010. The paper must have been published, or accepted for publication, during the window April 2008 to end of April 2010. The prize is £300 plus a certificate and will next be awarded at our Tutorial Day in September 2010.

Previous winners

2008	Dr Marco Morbidini	Prediction of the thermosonic signal from fatigue cracks in metals using vibration damping measurements
2006	Dr Christopher Lowis	Determining the strength of rotating broadband sources in ducts by inverse methods.

Anglo French Physical Acoustics Conference AFPAC09

To avoid a conflict with other physical acoustics conferences, our AFPAC09 was held between 8-10th December, 2008, rather than in January 2009. The venue was Arcachon, France and followed our usual format of starting on the afternoon of the first day, followed by a full day and then finishing at lunchtime on the third day. Fifty-five attendees (34 from France and the 21 from the UK) were treated to invited talks by: Michel Castains – Non-destructive testing of composites; Jérome Vasseur – Phononic crystals, examples and applications; Dick Hazelwood – Noise issues in underwater acoustics and possible environmental impacts; Michel Bruneau – Viscous and thermal boundary layers in fluid-filled acoustic cavities, fundamentals and applications; Tony Kent – Terahertz acoustics in semiconductor nanostructures; Dame Ann Dowling – The *silent aircraft* initiative. In addition authors presented another 28 talks covering a wide range of physical acoustic topics.

Group AGM 2009

This was held in the Hooke room at IOP Headquarters, 76 Portland Place, on 10th September 2009. At the start time of 11:45, there were 16 members present, sufficient for a quorum.

Andrew Temple (Chair) reviewed the Group's two activities since the previous AGM. These were the Tutorial Day 2008 and the Anglo French Physical Acoustics Conference (AFPAC09) held in Arcachon, France. The latter was held in December 2008 rather than in January 2009 to avoid a conflict with another international conference.

Looking to the future, Andrew reminded members about the Bob Chivers' Prize, which the Group will be awarding again in 2010. This prize is awarded every two years for the best paper accepted for publication, or published, by a PhD student at a UK university on any topic within the physical acoustics field, within the two year span of the award (so for the 2010 award, published or accepted for publication in the period April 2008 to April 2010). The nominee does not need to be sole author but the paper needs to be principally the student's work and authorship.

Andrew noted that two long-standing members of the committee, Chris Edwards and Nader Saffari, were standing down from re-election. Andrew thanked both Chris and Nader for their dedication and loyalty to the committee and to the Physical Acoustics community in general.

The Hon. Treasurer, Eleanor Stride, then presented the Group accounts. Eleanor explained that not much had been spent so far in 2009 because our principal expenditure is the Tutorial Day, which is heavily subsidised. Any money remaining after that expense would be allocated towards the GDR-AFPAC conference in January 2010.

Nader Saffari, as Hon. Secretary (retiring) took the chair to run the election to the committee. There were two vacancies, created by Nader and Chris stepping down, and two nominations for new membership from Paul Wilcox (Reader, Department of Mechanical Engineering, Bristol University) and Fred Cegla (Lecturer and Early Stage Researcher, Imperial College, London). Paul Wilcox was proposed by Andrew Temple and seconded by Mike Lowe. Fred Cegla was proposed by Chris Edwards and seconded by Eleanor Stride. There being two vacancies and two candidates, the two candidates were elected.

In addition, as Nader Saffari was stepping down, there was a vacancy for Hon. Secretary. There was only one nomination, Mike Lowe, proposed by Andrew Temple and seconded by Nader Saffari, and Mike was therefore duly elected.

Andrew then asked the meeting if there were any objections to Dave Cartwright being retained as a co-opted member for a second year to help with AFPAC10. There were no objections.

The meeting closed at 12:15, and was followed by lunch.

Tutorial Day – Imaging

As usual, this event followed our Group AGM and was held on the afternoon of 10th September 2009. This year we had an imaging theme. Our three speakers: Dr Jeff Bamber,

Dr Paul Wilcox and Dr Samantha Dugelay presented excellent tutorials on Medical Ultrasound Imaging, Imaging in NDE and Underwater Acoustic Imaging respectively.

Medical Ultrasound Imaging - Dr Jeffrey Bamber

Dr Bamber, who is head of ultrasound and optical imaging research at the Institute of Cancer Research and the Royal Marsden Hospital, became interested in ultrasound in 1972 with an MSc project in acoustic power measurements with calorimetry. He followed this with a PhD in the propagation of ultrasound in biological tissues. His talk took us through an introduction to ultrasonic imaging physics, the techniques currently employed in medical diagnosis, and the main challenges and opportunities which were illustrated with examples of advanced techniques and current research.

In biological media, ultrasound propagates as a longitudinal pressure wave governed by the sound speed, mass density and absorption coefficient of the biological materials and their variation with spatial position, ultrasonic frequency, pressure, and temperature. Variations with spatial position carry information that can be used to form images and importantly give rise to scattering of the sound wave, the backscatter providing the signal that is usually turned into tissue maps. Variations with frequency, temperature and pressure influence imaging system design and have the potential to provide addition information. Variations with pressure embody nonlinear propagation phenomena. Energy lost from the wave can raise the temperature of the tissue, displace it using radiation force, create bubbles for imaging or activate a prepared agent. Ultrasound is mainly used for imaging non-gaseous soft tissues; bone and lung are normally excluded because their acoustic impedance (product of density and sound speed) is very different from that of other tissues, causing most of the acoustic energy to be reflected at their surface. The speed of ultrasound depends on both the bulk and the shear elasticity of the medium, although for soft tissues the shear contribution is small. Both bulk and shear viscosity, and scattering, cause attenuation of ultrasound, which increases with frequency. Depth of the organ to be imaged therefore determines the maximum frequency that may be used, which in turn determines the best achievable image resolution.

Backscatter images of soft tissue are made using short pulses of sound (2-20MHz) that are beamed into the body at known times. Echoes from scatterers distributed throughout the tissue are localised in range by their time of arrival and in direction by the axis of the sound beam. Such methods exploit the usefully slow (but not too slow) average sound speed (about 1540ms^{-1}) by accomplishing electronic focusing (image reconstruction) and other processing as echoes return in real-time, achieving high frame rates. A constant sound speed is usually assumed for focusing and echo localisation, based on the relative small variation among different soft tissues (±6%). The two most common methods of processing for image display detect either echo amplitude, for anatomical imaging, or time variation of echo phase (Doppler shift), for blood flow imaging. The best-case resolution is determined in range by the bandwidth of the ultrasound transducer and the range-dependent frequency filtering effect of the attenuation in tissue, and laterally by the size of the transducer and the range of the object point. Contrast agents are sometimes used to enhance the echo signal-to-noise ratio for blood. These take the form of gas-filled bubbles a few micrometres in diameter that exhibit resonant and nonlinear scattering at medical ultrasound imaging frequencies and pressures, which can be detected using specialised echo processing schemes. Similar processing is used to detect echoes following nonlinear propagation, which

can help recover some image resolution and contrast when this has been lost due to defocusing by variation of speed of sound in tissue.

Current challenges include rapid three-dimensional data acquisition, two-dimensional electronic focusing, extension to higher frequencies, correction for phase aberrations, quantitative blood flow measurement, increasing the information content of the images especially in terms of functional and molecular characteristics of tissue, using the images to guide and monitor treatment, and improving the delivery and specificity of chemical therapeutics. Some of the cutting edge methods that are being developed in response to these challenges are two-dimensional and high-frequency transducer arrays, highly parallel multi-channel receive processing for ultrafast imaging and adaptive synthetic focusing, full-vector motion measurement, imaging of shear elasticity, temperature imaging, molecularly targeted contrast agents, multi-physics methods such as optoacoustic and magnetomotive imaging, and the exploitation of contrast agents for the transport, localised release and intracellular delivery of therapeutic agents. [Text based on that provided by Dr Bamber, August 2009].

Imaging in NDE - Dr Paul Wilcox

Dr Wilcox, who is a Reader and EPSRC Advanced Research Fellow at the Department of Mechanical Engineering at Bristol University after a PhD at Imperial, vividly brought into focus the use of array scanners for imaging in NDE.

He began by summarising basic NDE imaging techniques using mechanically scanned transducers, but soon focused on imaging using array devices. Standard array imaging techniques, such as B-scans and sector scans, were examined and it was shown how these and all other linear imaging algorithms can be described in a unified framework of phase and amplitude weighting functions. Higher resolution linear imaging techniques, such as Fourier back-propagation, the total focusing method and the wavenumber algorithm were then compared. The equivalence between geometrical and mathematical Fourier-domain representations of imaging problems was discussed. Finally the extension of these ideas to 2D arrays was mentioned. [Text based on that supplied by Dr Wilcox, August 2009].

Particular points made were that phased arrays allow the focal depth to be varied and the beam to be steered more easily than was possible with combinations of single probes. The Total Focusing Method (TFM) does not require any prior knowledge of the target and, although the signal to noise is better with back propagation methods, the resolution of the two techniques is similar. Back propagation also suppresses some of the side lobes compared to TFM. In terms of 2D array design, a hexagonal array is about 20% more efficient than a square array, but a random Poisson disc with some minimum element spacing works best of all.

Underwater Acoustic Imaging - Dr Samantha Dugelay

Dr Dugelay, who works at Dstl, the Defence Science and Technology Laboratory at Porton Down, is the adviser to MOD on Automatic Target Recognition for Underwater Mine Countermeasures. She has a PhD in mathematics from Orsay, Paris. Dr Dugelay gave an inspired talk on the challenges and rewards of underwater acoustic imaging, complete with audience tests on the detectability of intruders into harbours and the correct identification of various forms of targets on and partially buried in the sea floor.

She explained the basic principles of underwater acoustic imaging and through a few selected examples illustrated the uses of acoustic remote sensing. The acquisition process was described and operational considerations were discussed. Then the use of side scan sonar, forward looking sonar, multi-beam echo-sounders and synthetic aperture sonar were discussed. Examples of the images themselves were presented and their significant features such as pixel statistics made clear. These examples underlined the difficulty of underwater acoustic sensing and the challenges present in the underwater environment. They also exemplified the most recent advances and the rewarding quality of the images that can be obtained in particular conditions. Finally, consideration was given to current automatic processing techniques to facilitate or accelerate image interpretation and automatic target recognition. [Text based on that supplied by Dr Dugelay, August 2009].

Mine countermeasures use frequencies between 1Hz and 1 MHz in seeking targets with dimensions of 1~2m. The seabed type, ambient noise and water column fluctuations all create challenges in both detecting and correctly classifying targets. The worst are being the surf zone because of the trapped air bubbles. The aim is to be able to classify objects as either man-made or natural and therefore posing a potential threat or not. Early work was based on a large insonified area with un-resolvable relief, so the statistics are governed by a Rayleigh law. However, with the advent of low target strength mines, there has been a move towards wideband systems. If this is accompanied by a small insonification area then the statistics change and become K-law dependent.

When a side-scan sonar is used, the samples are equally spaced in time but are not equally spaced when projected onto the seabed. A useful approach has been to adopt the DCPA algorithm from astronomy.

In an interesting finale to the talk, Dr Dugelay invited the audience to locate targets on projected images in easy, medium and very difficult seabed types. This split the audience clearly into those who could not do this and others who clearly had an alternative vocation awaiting them!

Advanced Metrology for Ultrasound in Medicine

12-14 May 2010, National Physical Laboratory, Teddington, UK

AMUM 2010 will be a unique opportunity for the world's ultrasound experts from medicine, industry and academia to explore the measurement challenges presented by new and future clinical ultrasound equipment. The meeting will be held close to London at the National Physical Laboratory (www.npl.co.uk) in Teddington, UK. There will be a range of invited keynote speakers, proffered papers, and ample time for open discussion. In addition there will be a dedicated poster session (with a prize for the most outstanding student presentation), a chance for researchers to display new devices or methods, a commercial exhibition and a visit the new Ultrasonics Laboratories of the NPL. This conference will be held in association with Precision Acoustics Limited. The conference website can be found at http://conferences.npl.co.uk/amum where you can register your interest. To discuss the scientific content, contact Adam Shaw (adam.shaw@npl.co.uk); for more general information about the conference and venue, contact the AMUM secretariat (amum2010@npl.co.uk). Further details and a call for abstracts will be issued in October 2009.

In Memoriam

We are very sorry to announce the death of Bernard Hosten, on 5th October 2009, from cancer. He was Directeur de Recherche of the CNRS, working in the Laboratoire de Mecanique Physique of the University of Bordeaux. He was a distinguished researcher, contributing across a range of topics in ultrasound, with particular emphasis on NDE, and innovating in several new areas including air coupled ultrasound, ultrasound in multilayered composite materials, capacative transducers, and microwave generation of ultrasound. He will be greatly missed by many colleagues and friends in France and internationally.

Andrew Temple

Chair, Physical Acoustics Group

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This newsletter is also available on the web and in larger print sizes

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