

BCUHA were simply applied bilaterally with the double-sideband modulation method. On the other hand, the localization performances were improved when the inter-lateral intensity and time differences of presenting signals of BCUHA were enhanced on the basis of those of the collected

external sounds and when the “transposed modulation” was employed as the modulation method. Our results suggest the necessity of the inter-lateral cooperative system to modify the spatial parameters of the output signal for accurate sound localization through the BCUHA.

FRIDAY AFTERNOON, 18 MAY 2012

HALL A, 2:00 P.M. TO 2:40 P.M.

### Session 5pAAa

## Architectural Acoustics and Psychological and Physiological Acoustics: Objective and Subjective Parameters of Spatial Impression in Performing Arts Spaces II

Michelle Vigeant, Cochair  
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Jin Yong Jeon, Cochair  
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### Contributed Papers

2:00

**5pAAa1. Subjective experiment on preferable reverberation of a musical practice room by professional players.** Akihiro Nakajima (Graduate School, the University of Tokyo, Ce402, 4-6-1 Komaba, Meguro-ku, Tokyo, Japan, *nakajima@iis.u-tokyo.ac.jp*), Sakae Yokoyama, Sohei Tsujimura, Shinichi Sakamoto (I.I.S. the University of Tokyo, Ce401, 4-6-1 Komaba, Meguro-ku, Tokyo, Japan), Ami Tanaka, and Yoshihide Shiba (Nikken Sekkei LTD., 2-18-3 Idabashi, Chiyoda-ku, Tokyo, Japan)

A musical practice room is very important space for players to improve their skills. However, no architectural design guideline of the musical practice room exists in Japan and the individual room is being designed based on architect's intuition and experiences. For a basic investigation aiming to establish the guideline, we are now investigating appropriate acoustic conditions of musical practice rooms for players by subjective experiments. In this study, we focused on reverberation time of the room and subjective experiments using a three dimensional sound field simulation were conducted for professional players including woodwind instrument players, string players and singers. In the experiment, a room having 6 conditions of reverberation time was virtually simulated in the sound field simulation system established in an anechoic chamber. As a result, a clear tendency of preferable reverberation time dependent on the difference of types of the instruments was found and a range of preferred reverberation time for a practice room was obtained.

2:20

**5pAAa2. Measurement of acoustic characteristics in a traditional Korean Buddhist temple complex.** Edwin Stephen Skorski III (Keimyung University, College of Architectural Studies, 1095 Dalgubeoldero, Dalseo-Gu, Daegu, 704-701, Korea, *sskorski@yahoo.com*)

Traditional Korean Buddhist Temple complexes, typically found in rural, mountainous settings, hold great cultural, historical, and architectural significance in the Republic of Korea. These buildings, constructed primarily of wood, with little or no mechanical fasteners, create unique acoustic environments used for chanting, spoken word, music, and quiet meditation. Within the temple complex there are multiple halls and shrines of varying size and geometry that are utilized for worship. This presentation documents the room acoustic characteristics of a variety of worship spaces within a prototypical traditional Korean Buddhist Temple complex. These spaces include the main Buddha Hall as well as surrounding halls dedicated to additional Buddhas and Bodhisattvas. Using a laptop based measurement system; field measurements were conducted to document reverberation time (RT), clarity (C-50), speech transmission index (STI), and background noise levels. Data gathered is discussed and analyzed in regards to the primary use of each space. This research was conducted utilizing BISA Research Grant funds provided by Keimyung University.

**Session 5pAAb****Architectural Acoustics and Psychological and Physiological Acoustics: Psychoacoustics in Rooms III  
(Lecture/Poster Session)**

Philip Robinson, Cochair  
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Bernhard Seeber, Cochair  
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***Invited Papers*****2:40**

**5pAAb1. Effects of interaural level differences on the externalization of sound.** Jasmina Catic, Sebastien Santurette, Torsten Dau (Centre for Applied Hearing Research, Technical University of Denmark, Lyngby, Denmark, *jac@elektro.dtu.dk*), and Jörg Buchholz (National Acoustic Laboratories, Chatswood, Australia)

Distant sound sources in our environment are perceived as externalized and are thus properly localized in both direction and distance. This is due to the acoustic filtering by the head, torso, and external ears, which provides frequency-dependent shaping of binaural cues such as interaural level differences (ILDs) and interaural time differences (ITDs). In rooms, the sound reaching the two ears is further modified by reverberant energy, which leads to increased fluctuations in short-term ILDs and ITDs. In the present study, the effect of ILD fluctuations on the externalization of sound was investigated. A psychoacoustic experiment was performed in a standard IEC 268-13 listening room by normal-hearing listeners. Individual binaural room impulse responses were used to simulate a distant speech source delivered via headphones. The speech signal was then processed such that the naturally occurring fluctuations in the ILDs were compressed, while the ITDs were preserved. This manipulation reduced the perceived degree of externalization mainly for broadband and highpass filtered speech. In the case of lowpass filtered speech, the compression of ILD fluctuations did not affect externalization. Overall, for sounds that contain frequencies above about 1 kHz the ILD fluctuations were found to be an essential cue for externalization.

**3:00**

**5pAAb2. Auditory localization in realistic environments by normal-hearing and hearing-impaired listeners.** Jorg M. Buchholz, Virginia Best, and Gitte Keidser (National Acoustic Laboratories, Australian Hearing, Chatswood NSW 2067, Australia, *jorg.buchholz@nal.gov.au*)

The ability to correctly localize sounds is important for general awareness of the auditory scene and communication in adverse acoustic conditions. However, most localization studies are performed in rather simple and artificial conditions. In particular, very few studies have considered localization in reverberant environments or in the presence of complex interferers, and no studies have systematically investigated the effect of distance. In the present study, localization performance was therefore measured as a function of source-receiver distance using a virtual auditory environment. With increasing source-receiver distance the direct-to-reverberation energy ratio decreases and the auditory system increasingly relies on mechanisms related to the precedence effect. Both aspects may be particularly problematic for hearing-impaired listeners. The acoustics of a cafeteria was simulated with the room acoustic software ODEON for a large number of source-receiver locations. Signals were generated for a 3D array of 41 loudspeakers using the loudspeaker-based room auralization (LoRA) toolbox. Localization performance was measured in normal-hearing and hearing-impaired listeners with a bilateral hearing loss in the simulated cafeteria with and without a multi-talker speech background. The experimental results were correlated with a number of acoustic measures derived from dummy head recordings of the different acoustic conditions.

**3:20**

**5pAAb3. Explorations by the visually impaired of real and virtual rooms.** Brian Katz (LIMSI-CNRS, BP 133, Université Paris Sud, 91403 Orsay, France, *brian.katz@limsi.fr*), and Lorenzo Picinali (Faculty of Technology, De Montfort University, The Gateway Leicester, LE1 9BH, UK)

Virtual acoustic simulations of two interior environments were presented to visually impaired individuals. Interpretations of the acoustic information, through block map reconstructions, were compared to reconstructions following in-situ exploration as well as playback of binaural and Ambisonic walkthrough recordings. Simulations used off-line HOA RIR synthesis and a hybrid rendering combining pre-convolved signals and real-time convolutions for sounds related to user displacement and self-generated noise. Results showed that listening to passive binaural playback or Ambisonic playback, which also included interactive head-movements, provided less usable information than a virtual simulation with respect to the acquisition of spatial information of an interior architectural environment. The presence of both dynamic cues relative to displacement and controlled events such as finger snaps, as included in the virtual condition, were deemed highly valuable by the participants. Virtual acoustic simulations provided acoustic information that allowed for highly

correlated detailed map reconstructions relative to a real exploration condition. Some differences were found between the two experimental corridors, with the more complex environment offering better results than the corridors with more diffuse noise sources. This study was supported in part by a grant from the European Union (STREP Wayfinding, No. 12959).

### *Contributed Paper*

The following abstract will be presented in poster format. The poster will be on display and the author will be at the poster from 3:40 p.m. to 4:00 p.m.

**5pAAb4. A modulation-transfer-function-based method for restoring sub-band power envelope from noisy reverberant speech.** Shota Morita, Masashi Unoki (School of Information Science, JAIST, 1-1 Asahidai, Nomi, Ishikawa 923-1292, Japan, s-morita@jaist.ac.jp), Xugang Lu (National Institute of Information and Communications Technology, 3-5 Hikaridai, Seika-cho, Soraku-gun, Kyoto 619-0289, Japan), Yang Liu, Masato Akagi (School of Information Science, JAIST, 1-1 Asahidai, Nomi, Ishikawa 923-1292, Japan), and Ruediger Hoffmann (Laboratory of Acoustics and Speech Communication, Dresden University of Technology, Helmholtzstrasse 10, Dresden 01069, Germany)

The concept of the modulation transfer function (MTF) can be successfully applied to evaluating the quality of speech transmission in room acoustics (noisy reverberant environments) as functions of reverberation (reverberation time) and additive noise (signal to noise ratio) (Houtgast and Steeneken, *J. Acoust. Soc. Am.*, 77, 1069-1077, 1985). This paper proposes

a method of restoring the power envelope from noisy reverberant speech based on the MTF concept. The proposed method does not need the impulse response and noise conditions in room acoustics to be measured to enhance speech. The proposed approach suppresses the effects of reverberation and noise on the power envelopes by restoring the smeared MTF. We carried out massive simulations of noise-suppression and dereverberation on noisy reverberant speech to objectively evaluate the proposed method. The results revealed that the proposed method could simultaneously work well with both the suppression of noise and dereverberation. We further tested the proposed method as a front-end processor for ASR systems in noisy reverberant environments, and compared it with other methods (MFCC, CMN, spectral subtraction, and RASTA filtering on a constant-bandwidth filterbank). The results demonstrated that the improvement in recognition with the proposed method was more effective than that in extremely noisy reverberant environments.

FRIDAY AFTERNOON, 18 MAY 2012

S424, 2:00 P.M. TO 4:40 P.M.

### **Session 5pAB**

#### **Animal Bioacoustics and Acoustical Oceanography: Acoustic Animal Tagging**

David Mellinger, Cochair  
*david.mellinger@oregonstate.edu*

Tomanori Akamatsu, Cochair  
*akamatsu@affrc.go.jp*

#### *Invited Papers*

2:00

**5pAB1. New generation pinger using pseudo noise sequence signal.** Toyoki Sasakura (Fusion Inc. 1-1-1-806, Daiba, Minato-ku, Tokyo 1350091, Japan, sasakura@fusion-jp.biz)

Ultrasonic biotelemetry system is one of the useful methods to observe fish migration and behavior. New generation pinger, which has small size, long life, long distance and high recognition ability was developed using pseudo noise sequence signals. Size, lifetime, distance and collision avoidance are tradeoff relation each other. To solve this, the advanced technology using CDMA mobile phone communication was adopted. Pseudo noise sequence signal was applied for transmitting signal and correlation processing was used for receiving signals. The transmitting signal consisted of 31 bits pseudo noise sequence signal and the correlator of receiving signal was 992 steps using FPGA(Field Programmable Gate Array). As a result, the new pinger has the size of  $\phi 10 \times 35$ mm long including depth sensor, sound transmission lasts 240 days when 30 seconds repetition using the small battery SR626SW 32mAh. The signal could be achieved over 1,000 meters distance in a field validation. A unique set of 32 ID codes of the pseudo noise sequences were found to minimize collision of identification. In addition, depth and temperature information could be transmitted. The new generation pinger contributes not only to the research work of biotelemetry but also to fisheries and aquaculture purposes in the world.

2:20

**5pAB2. High resolution data from DTAGS on the response of humpback whales to noise from seismic air guns.** Rebecca Dunlop (School of Veterinary Science, University of Queensland, Gatton, QLD 4343, Australia, r.dunlop@uq.edu.au)

The BRAHSS (Behavioural Response of Australian Humpback Whales to Seismic Surveys) series of experiments uses a multi-platform approach to determine the behavioural and acoustic response of humpbacks to noise from seismic air gun arrays. One of the data collection platforms utilises the DTAG, or acoustic digital recording tag. DTAGs are small suction cup tags which contain a hydrophone as well as x, y and z plane accelerometers, magnetometers and depth sensors. Data from the DTAGs allows fine scale movement data of the tagged whale (dive profile, pitch, roll and heading movements, fluking rates) to be viewed as a pseudotrack whilst simultaneously listening to sound field of the whale (air gun shots and vocal sounds from nearby whales). This paper presents some results of responses of the whales to air gun sounds recorded by DTAGs and comparison with visual observations at the time. Since DTAGs provide a continuous record of whale vocalizations and 3D movements, vocal and physical reactions are detectable immediately as the first air gun shot occurs, whereas visual observation are limited to the appearance of the whales at the surface.

2:40

**5pAB3. On-board telemetry of biosonar sounds from free-flying bats.** Shizuko Hiryu (Faculty of Life and Medical Sci., Doshisha Univ., 610-0321, shiryu@mail.doshisha.ac.jp), Naohiro Matsuta, Shigeki Mantani (Faculty of Engineering, Doshisha Univ., 610-0321), Emyo Fujioka, Hiroshi Riquimaroux, and Yoshiaki Watanabe (Faculty of Life and Medical Sci., Doshisha Univ., 610-0321)

Analysis of the bat's reactions to relevant target echoes enables us to directly assess biosonar performance. Here, we recorded the sonar broadcast and its echoes the bat received during flight by using an on-board telemetry microphone (Telemike) mounted on the bat's back. Telemike recordings confirmed that flying bats adjust the amplitude and frequency of their sonar broadcasts to compensate for increases in echo amplitude and for Doppler-shifts. For insect capturing, the bat exhibited Doppler-shift compensation for echoes from the static target ahead, but not for echoes from the target moth even though the flying bat attended to the moth for capture. Positive and negative Doppler shifts (acoustic glints) caused by insect fluttering were observed in the constant-frequency component of observed echoes, which synchronized with wingbeat cycle of the moth. Combined frequency and amplitude compensation for the static target may be advantageous for detection of acoustic glints of target prey. We also constructed multiple-microphone arrays for tagging wild aerial-feeding insectivorous bats. Not only the location of the bat, but also direction and directivity of the bat's broadcast can be measured. This will allow us to investigate 3-D search algorithm of multiple targets by the bat. [supported by JSPS and ONR]

3:00

**5pAB4. A review on bio-sonar behaviour research of Yangtze finless porpoise using animal bone acoustic data loggers.** Ding Wang (Key Laboratory of Aquatic Biodiversity and Conservation of the Chinese Academy of Sciences; Institute of Hydrobiology of the Chinese Academy of Sciences, Wuhan 430072, P.R. China, wangd@ihb.ac.cn), Tomonari Akamatsu (National Research Institute of Fisheries Engineering, Fisheries Research Agency, Kamisu, Hasaki, Kashima, Ibaraki 314-0408, Japan), Kexiong Wang, and Songhai Li (Key Laboratory of Aquatic Biodiversity and Conservation of the Chinese Academy of Sciences; Institute of Hydrobiology of the Chinese Academy of Sciences, Wuhan 430072, P.R. China)

In recent 10 years, a miniature stereo acoustic data logger (A-tag, W20-AS, Little Leonardo, Japan) has been used to observe the bio-sonar behaviour of free-ranging Yangtze finless porpoise (*Neophocaena phocaenoides asiaeorientalis*). The A-tag is small enough to be attached on the one of the smallest odontocetes by using suction cups. The A-tag with two external hydrophones can record the sonar pulse intensity, inter-click-intervals, and sound source direction measured by time arrival difference of sounds at the two hydrophones. Major outcomes by A-tag were the in situ off-axis sonar beam pattern, attention and approach phase of biosonar behaviour, scanning sonar of rolling animals, and social contacts among free-ranging Yangtze finless porpoises. In addition, frequent ultrasonic sound production was confirmed that seemed to be a reason of high detection performance of this species using passive acoustic monitoring of finless porpoises. This biosonar monitoring method using miniature data logger system developed in a freshwater system in China provided new insights of underwater behaviour of other small odontocetes producing high-frequency echolocation clicks, such as harbour porpoises and white-beaked dolphins.

3:20

**5pAB5. Sperm whale coda communication studied with multiple acoustic tags.** Peter Teglberg Madsen (Aarhus University, Build 1131, Aarhus, Denmark, peter.madsen@biology.au.dk)

Female sperm whales spend their entire lives in matrilineal groups with long term social bonds. However, contrary to other toothed whale species with a complex, long term social structure, sperm whales seemingly only use stereotyped patterns of clicks, named coda, to radiate acoustic clan identity with little or no signature encoding. Due to their deep diving behavior in offshore water, it is difficult to study the acoustic behavior and source properties of sperm whale communication signals. To alleviate that, multiple acoustic Dtags was deployed on sperm whales to study the behavioral context and source parameters of coda production. It is shown that more than 50% of all codas are produced during deep dives where the active space can cover the entire foot print of the social group despite low apparent source levels of around 180 dB re 1µPa. Intra click information in the form of spectral and IPI information is heavily distorted as a function of aspect with little room for individual encoding. The unequivocal assignment of codas to tagged individuals have demonstrated a large potential for information transfer in the inter click intervals of codas suggesting a much more complex acoustic communication in sperm whales than previously proposed.

3:40

**5pAB6. Acoustic tagging for counting feeding events of captive Amazonian manatees.** Mumi Kikuchi (The Laboratory of Fisheries Biology, The University of Tokyo, 1-1-1, Yayoi, Bunkyo, Tokyo 164-8639, Japan, mumi@cocoa.plala.or.jp), Tomonari Akamatsu (National Research Institute of Fisheries Engineering, Fisheries Research Agency, 7620-7 Hasaki, Kamisu, Ibaraki 314-0408, Japan), Diogo A. de Souza, Fernando C. W. Rosas, and Vera M. F. da Silva (Aquatic Mammals Laboratory (LMA), National Institute of Amazonian Research (INPA), Aleixo, CEP 69060-001, Manaus, Brazil)

The Amazonian manatee is one of four extant species in the mammalian order Sirenia. They are restricted to the freshwater rivers, lakes and floodplains of the Amazonian river basin where they eat floating and emergent aquatic plants. Visual observation of wild manatees is nearly impossible because of the turbid water and tiny exposure of nose at gentle respiration movement, which consequently precludes study of their underwater behaviour. In this study, we applied animal-worn sound recorder (AUSOMS-mini, System Intec Co., Tokyo, Japan) to two captive Amazonian manatees at INPA, Brazil, in order to record their mastication sounds. Five species of aquatic plants were offered to the manatees separately. Mastication-sounds were extracted by custom made software developed on Matlab for off-line analysis. The mastication intervals and temporal sound structure depended on species of plants. In addition, individual difference of mastication intervals observed in the two manatees was probably due to different body sizes. Overnight recording showed that both manatees kept feeding for more than 0.5 hours followed by  $1.6 \pm 1.3$  hours interruption of feeding. Other sounds such as insect calls, rainfall, and vocalizations of other manatees could be useful to understand habitat selection, weather and presence of conspecifics. Acknowledgment Research and Development Program for New Bio-industry Initiatives

4:00

**5pAB7. Using bioacoustic and satellite tags to study sperm whale depredation behavior, and to test new acoustic tracking methods.** Delphine Mathias (Marine Physical Laboratory, Scripps Institution of Oceanography, San Diego, CA 92093-0238, delphine.mathias@gmail.com), Aaron Thode (Marine Physical Laboratory, Scripps Institution of Oceanography, San Diego, CA 92093-0238), Jan Straley (University of Alaska Southeast, Sitka AK 99835), John Calambokidis, Gregory Schorr (Cascadia Research Collective, Olympia, WA, 98501), and Russel Andrews (School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, AK 99775)

Sperm whales have been depredating black cod from demersal longlines in the Gulf of Alaska for decades, but the behavior has now become pervasive enough that it is starting to affect government estimates of the sustainable catch, motivating further studies of this behavior. In 2007 and 2009, 11 bioacoustic "BProbe" tags were attached to adult sperm whales off Southeast Alaska under both natural and depredation foraging conditions. Measurements of the animal's dive profiles, acoustic behavior, and angular velocities allowed two categories of depredation to be identified. The dive depths and durations of "deep depredating" whales are similar to those of natural dives, but acoustic parameters show significantly significant differences. By contrast, "shallow depredating" whales conduct dives that are much shorter, shallower, and are four times more acoustically active than during natural foraging dives. In 2010, both a satellite and bioacoustic tag were deployed on a sperm whale near a two-element vertical tracking array. The location and acoustic data from the tags were used to confirm the long-range tracking ability of the fixed array system to ranges of at least 5 kms. [Work conducted under the SEASWAP program, supported by the 2011 North Pacific Research Board graduate student research award]

4:20

**5pAB8. Adaptive prey tracking by echolocating porpoises studied with acoustic tags.** Danuta Maria Wisniewska (Aarhus University, Department of Bioscience, Zoophysiology, C. F. Moellers Alle 3, bygn. 1131, DK-8000 Aarhus C, Denmark, danuta.wisniewska@biology.au.dk), Mark Johnson (Sea Mammal Research Unit, Scottish Oceans Institute, East Sands, University of St Andrews, St Andrews, Fife, KY16 8LB, UK), Kristian Beedholm, and Peter Teglberg Madsen (Aarhus University, Department of Bioscience, Zoophysiology, C. F. Moellers Alle 3, bygn. 1131, DK-8000 Aarhus C, Denmark)

Studying the behavior of aquatic echolocators and their prey has proved to be challenging. However, recent studies using Dtags on several toothed whale species in the wild have identified sequences of echoes interpreted as stemming from ensonified prey, along with accelerometer signatures possibly indicative of feeding events. The present study aimed at verifying those findings in a controlled environment, and elucidating what echograms may tell us about echolocation behavior during prey capture. We applied DTAG-3 tags, sampling sound at 500 kHz, to trained harbor porpoises during captures of dead and live fish of different species and sizes. To look at details of the feeding events, we used tag-synchronized high-speed underwater cameras. The prey targets gave rise to echoes that could be traced back to ranges of up to five meters and often tracked in the high repetition rate buzzes initiated at short ranges. These buzzes were typically closely tied to distinct acceleration signatures of attempted prey captures. Results show that porpoises can carefully track their prey with adjusted click intervals both during approach and buzz phases and can dynamically accommodate prey movements to provide high spatial resolution without range ambiguities.

## Session 5pBA

## Biomedical Acoustics and Physical Acoustics: Acoustic Microscopy Imaging Methods for Biomedical Applications II (Lecture/Poster Session)

Jonathan Mamou, Cochair  
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Tadashi Yamaguchi, Cochair  
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## Contributed Papers

2:00

**5pBA1. Photoacoustic microscopy of tissue lesions induced by high-intensity focused-ultrasound.** Amaury Prost, Olivier Simandoux, Jean-Marie Chassot, Emmanuel Fort, and Emmanuel Bossy (Institut Langevin, ESPCI ParisTech, CNRS UMR 7587, Université Paris 7, INSERM ERL U979, 10 rue Vauquelin, 75231 Paris Cedex 05, France, amaury.prost@espci.fr)

Photoacoustic imaging is a recent and rapidly developing technique that can provide images of optical absorption at depth in soft tissue. In this work, photoacoustic imaging is applied to detect tissue lesion induced by high-intensity focused-ultrasound (HIFU). Tissue changes during HIFU therapy include changes in optical tissue properties that may be detected using photoacoustics. However, although it has been demonstrated that HIFU lesion could indeed be detected using photoacoustics (Chitnis et al., JBO 15(2), 2010, Cui et al., JBO 15(2), 2010), the exact origin of the observed contrast remains unclear. In this study, lesions induced in different types of biological tissue are imaged in vitro using a photoacoustic microscope. Lesions are induced in the tissue samples with therapeutic ultrasound in the MHz frequency range, and a photoacoustic microscope with imaging frequencies from the MHz to the tens of MHz range, are used to obtain acoustic-resolution photoacoustic images of lesions located at different depths in tissue. Several optical wavelengths, from 532 nm to the therapeutic window in the near-infrared are used to perform a spectroscopic study of the observed contrast.

2:20

**5pBA2. Acoustic characteristics measurement of rat liver by multi-frequency ultrasound microscopy.** Kenta Inoue (Faculty of Engineering, Chiba University, Chiba, Chiba 263-8522, Japan, z8t0804@students.chiba-u.jp), Yoshifumi Saijo (Graduate School of Biomedical Engineering, Tohoku University, Sendai, Miyagi 980-8579, Japan), Kazuto Kobayashi (Honda Electronics Co., Ltd, Toyohashi, Aichi 441-3193, Japan), Jonathan Mamou (F. L. Lizzi Center for Biomedical Engineering, Riverside Research, New York, NY 10038), and Tadashi Yamaguchi (Research Center for Frontier Medical Engineering, Chiba University, Chiba, Chiba 263-8522, Japan)

Hepatitis is a growing health concern and early disease detection is critical. Ultrasound is ideally suited for real-time imaging of liver, but typical ultrasound images do not display quantitative tissue information because it is first necessary to understand the complex interaction between ultrasound and tissue and scattering models based on tissue properties must be devised. Towards this aim, speed-of-sound (SOS) and attenuation from three types of rat livers (normal, fatty, and fibrosis) were measured with a scanning acoustic microscope using transducers with center frequencies from 1-MHz to over 100-MHz. Results indicated that SOS and attenuation measured with each transducer showed the following trend. Variability in SOS and attenuation values of normal liver was much smaller than other livers at any frequencies. In the fatty liver, SOS was 20 m/s slower and the attenuation was 1.0 dB/cm/MHz larger than in the normal liver. In fibrosis, SOS and attenuation had values between those of normal and fatty liver. Additionally, the

relation between the pathologic state of liver and SOS and attenuation was investigated. Correlation between the ultrasound wavelength and the distribution and size of fat or fiber deposits in the liver was investigated using the corresponding stained histology photomicrograph.

2:40

**5pBA3. Magnetoacoustic tomography with magnetic induction: a novel approach for electrical impedance imaging.** Qingyu Ma, Feng Zhang, Xiaodong Sun, and Xuanze Chen (Nanjing Normal University, maqingyu@njnu.edu.cn)

As a novel image approach, magnetoacoustic tomography with magnetic induction (MAT-MI) was proved to possess the potential merits of enhanced contrast and high spatial resolution. In this paper, based on the theoretical analysis of pulsed magnetic excitation, eddy current induction, acoustic vibration, acoustic transmission and acoustic waveform collection, the principle of MAT-MI was deduced in formulae for cylindrical measurement configuration. It was proved that the collected acoustic waveforms comprise the information of conductivity distribution of the object in various vibration amplitudes and opposite phases. A tomographic algorithm for diffraction acoustic source was employed to perform image reconstruction for a two-layer cylindrical phantom model and the conductivity configuration in terms of shape and size was reconstructed. The theoretical theory was also testified by the experimental results for a tissue-like sample phantom that the collected waveforms had good agreements with the simulation predictions and reconstructed image provided the conductivity distribution of the model in both the configuration and the dimension. The favorable results of the research suggested a potential feasibility of MAT-MI in electrical impedance imaging.

3:00

**5pBA4. Three-dimensional quantification of freshly-excised human lymph node properties using high-frequency ultrasound.** Jonathan Mamou (Riverside Research, New York, NY, jmamou@riversideresearch.org), Alain Coron (Laboratoire d'Imagerie Paramétrique, CNRS and UPMC Univ Paris 06, Paris, France), Emi Saegusa-Beecroft (Department of Surgery, Kuakini Medical Center and University of Hawaii, Honolulu, HI), Masaki Hata (Department of Surgery, Juntendo Medical Center, Tokyo, Japan), Michael L. Oelze (Bioacoustics Research Laboratory, University of Illinois, Urbana-Champaign, IL), Eugene Yanagihara (Department of Surgery, Kuakini Medical Center and University of Hawaii, Honolulu, HI), Tadashi Yamaguchi (Research Center for Frontier Medical Engineering, Chiba University, Chiba, Japan), Pascal Laugier (Laboratoire d'Imagerie Paramétrique, CNRS and UPMC Univ Paris 06, Paris, France), Junji Machi (Department of Surgery, Kuakini Medical Center and University of Hawaii, Honolulu, HI), and Ernest J. Feleppa (Riverside Research, New York, NY)

Human lymph nodes excised from cancer patients during lymphadenectomy can contain small clinically-important metastatic regions that can be missed because conventional histopathology methods do not allow nodes to

be examined over their entire volume. In this study, more than 250 lymph nodes were scanned in 3D using a 26-MHz ultrasound transducer before histology processing. Acquired radio-frequency data were processed using 3D regions-of-interest to yield thirteen quantitative ultrasound (QUS) estimates. The QUS estimates are related to tissue microstructure and are hypothesized to be different in normal nodal tissue and metastatic tissue. Four QUS estimates were obtained from backscattered spectra and the remaining nine were derived from envelope statistics. Following ultrasound scanning, serial-section histology was performed at 50- $\mu\text{m}$  intervals to depict cancer foci in 3D. Classification based on QUS estimates was performed using linear-discriminant analyses in a step-wise approach, and areas under ROC curves (AUCs) were computed. The AUC for the linear combination of four QUS estimates was 0.87 for a dataset of 95 breast-cancer nodes. Similarly, using only two QUS estimates, an AUC of 0.95 was obtained for a dataset of 160 gastrointestinal-cancer nodes. These results suggest that QUS may provide an effective tool for detecting metastatic foci in lymph nodes.

3:20

**5pBA5. Automatic segmentation of ultrasound contrast images of arteries for determining boundaries between arterial inner walls and blood flows: in vivo animal studies.** Ming Qian, Lili Niu, Ruibo Song, Guan Qi, and Hairong Zheng (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, 1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, P.R. China, ming.qian@siat.ac.cn)

Ultrasound contrast images could be used together with ultrasonic particle image velocimetry technology to obtain multi-component field of

The following abstract will be presented in poster format. The poster will be on display and the author will be at the poster from 3:40 p.m. to 4:00 p.m.

**5pBA6. Two-dimensional multi-layer of arterial elasticity measurement considering geometric transformations.** Lili Niu, Ming Qian, Ruibo Song, Long Meng, Guan Qi, Xin Liu, and Hairong Zheng (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, 1068 Xueyuan Ave., SZ University Town, Shenzhen 518055, China, ll.niu@siat.ac.cn)

Knowledge of the arterial elasticity can provide an important reference for understanding arterial wall changes that may occur before and during the early stages of atherosclerosis. In practice, the movements of arterial wall during the cardiac cycle are complex, which undergo not only translation but also rotation and deformation subjected to pulse pressure, transmural pressure and shear force. Conventional correlation based methods for arterial wall movement evaluation consider only the translational

arterial blood velocity and shear stress, which is helpful to understand atherogenic process and predict plaque rupture. Near-wall flow can hardly be measured accurately due to artery pulsation and tissue movement. Measuring accuracy for PIV analysis can be improved by detecting the boundaries between arteries and blood flow and determining region of interest in arterial ultrasound contrast images. A fully-automatic algorithm is proposed, which is named as time frame difference snake(TFDS). The ultrasound contrast images are subjected to median filter using a window frame difference method to de-speckle the lumen and highlight the arterial wall. The filtered image is subsequently subjected to an automatic initialization procedure to obtain the initial contour for the snake model. The TFDS model takes advantages of the standard deviation matrix of consecutive images, and is applied to obtain the final delineation of the boundary. Ultrasound contrast images of mouse carotid arteries are used for performance evaluation. The computer-generated segmentation is compared with the hand-outlined delineations. Statistical analysis shows that our algorithm's segmentations agree with that of trained operators for both the near-end and far-end carotid artery wall.

component and limit their accuracy. This study proposes a texture matching method based on ultrasonic B-mode image for accurately measurement the movement of the arterial wall with geometric transformations, improving the accuracy of elasticity measurement. Feasibility of the method was studied in an in vitro silicone tube phantom and in vivo carotid arteries of mice. The calculated elastic modulus for the in vitro silicone tube agrees well with the results obtained from mechanical testing, deviating only 6.2%. The mean elastic modulus of the carotid arteries of mice is  $122.4 \pm 29.2$  kPa. The results demonstrate that the texture matching method can measure elastic modulus of the arterial wall with geometric transformations accurately. It may be clinically useful for aiding early detection of atherosclerosis.

FRIDAY AFTERNOON, 18 MAY 2012

S221, 2:00 P.M. TO 4:40 P.M.

### Session 5pEA

## Engineering Acoustics, Underwater Acoustics, and Biomedical Acoustics: Acoustic Sensors and Actuators IV

Hairong Zheng, Chair  
*hr.zeng@sait.ac.cn*

### Contributed Papers

2:00

**5pEA1. Synchronization intercomparison method and sea trials of acoustic doppler current profiler (ADCP).** Jianbo Wu, Kai Deng, Chao Gao, Jun Li, and Changhong Wang (Institute of Acoustics, Chinese Academy of Sciences, wujianbo@mail.ioa.ac.cn)

The advantage and disadvantage of intercomparison methods adopted routinely for performance comparison of Acoustic Doppler Current Profiler (ADCP) were analyzed. A new ADCP intercomparison method was

introduced, by which ADCPs were synchronized to work alternately ping by ping in the same steady platform, and the requirements for achieving credible comparing measurements were also discussed. Several intercomparison tests of two ADCPs at mooring shelves and subsurface buoy were conducted in northern South China Sea. One ADCP is 150 kHz self-contained ADCP made by Institute of Acoustics, the other is RDI 150 kHz Quartermaster ADCP. A statistical method was used to process the measurement data obtained through the new intercomparison method, and criterions were adopted to evaluate the performance of ADCPs. Comparing with other

methods, the synchronization intercomparison method is more objective and credible.

2:20

**5pEA2. Humidity measurement using a ultrasonic probe based on sound attenuation.** Takahiro Motegi, Koichi Mizutani, and Naoto Wakatsuki (1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577, motegi@aclab.esys.tsukuba.ac.jp)

Measurement of spatial average humidity has been required for air conditioning management in facilities, to obtain a change tendency of environment. For example, spatial humidity management is important to prevent the damage of cultural assets. However, conventional sensors such as wet-dry hygrometers measure the local humidity at a measurement point and do not reflect the spatial humidity. In this paper, humidity measurement using a ultrasonic probe is proposed. A ultrasonic probe, which measures the sound attenuation coefficient in acoustical path, reflects the averaged humidity among the path and achieves non-contact measurement of the spatial average humidity between ultrasonic transducers. The performance of the proposed technique is evaluated in experiment, and it is found that if the probe knows the information of temperature, humidity can be successfully measured from sound attenuation coefficient.

2:40

**5pEA3. Controllable fuel cell humidification by ultrasonic atomization.** Chia-Chi Sung, Chang-Yuen Bai, Shao-Jui Chang, and Jau-Hong Chen (Department of Engineering Science and Ocean Engineering, National Taiwan University, ccsung@ntu.edu.tw)

Compared to the conventional bubble type used for PEMFC (proton exchange membrane fuel cell) humidification, ultrasonic atomization has the advantages of smaller size, it is easy to refill and change temperature, and, more importantly, humidity controllability. To improve the performance of the FC, this study developed a unique ultrasonic atomization system, including a gas heating pipe, ultrasonic driving circuit, ultrasonic atomizer, and humidity sensors. The reactant gases used are hydrogen and air. When the reactant gas obtains sufficient heat from the heating pipe and enters the ultrasonic atomizer, gas humidification is increased due to the ultrasonic micro water droplets blending into the gases. The humidity is controllable by adjusting either the heating temperature or driving voltage. The size of the micro water droplets can also be manipulated by adjusting the driving frequency. A higher driving frequency leads to smaller droplet mean diameter, which in turn increases the humidification efficiency. At least 90% relative humidity can be maintained under the condition that the flow rate of anode and cathode's reactant gas is restricted to between 1LPM and 25LPM. Under the same condition, the conventional bubble type can only achieve around 80%.

3:00

**5pEA4. A free-flooded flexensional transducer with tube-beam coupling structure.** Yaozong Pan, Xiping Mo, Yongping Liu, Yong Chai, and Yunqiang Zhang (Institute of Acoustics, Chinese Academy of Sciences, No. 21, Bei-Si-Huan-Xi Road, Beijing 100190, China, lapan@mail.ioa.ac.cn)

The transducer consists of two annulus steel end plates, a tube stacked by piezoelectric rings as the driving element and a dual slotted concave aluminum shell coupled one end plate to the other. The shell has two concave parts and an annulus ring between them; and each part is equally slotted into several beams with gaps between each other. The tube and the beams form the tube-beam coupling structure. A sealing boot is covered on both inner surface of the stack and outer surface of the shell so that the water could freely flood through the ring stack. Some vibrating modes of the transducer including a cavity resonance are used to broaden the band. A prototype is fabricated and measured. The cavity resonant frequency is about 1250Hz with the transmitting voltage response of 130dB and the TVR fluctuates less than 6dB from 1800Hz to 5700Hz. This work was supported by the National Natural Science Foundation of China (No. 11074276).

3:20

**5pEA5. A new type of wide band and wide beam longitudinal transducer.** Yong Chai, Xiping Mo, Yongping Liu, Yaozong Pan, and Yunqiang Zhang (Institute of Acoustics, Chinese Academy of Sciences, No. 21, Bei-Si-Huan-Xi Road, Beijing 100190, China, chaiyong@mail.ioa.ac.cn)

A new type of wide band and wide beam longitudinal transducer is introduced in this paper. The beam width could be expanded significantly by union of the special design about the shape of the head mass and a bucket tail mass which could both enhance radiating ability and reduce the longitudinal size. And the working bandwidth could also be expanded efficiently by using mode coupling between the flex mode of the head mass and the longitudinal mode. Using the finite element analysis, some major electro-acoustic parameters of a prototype transducer with a size of 74mm in maximum outside diameter and 76mm in total length are computed. It is shown that the projector has good performance. The resonance frequency is about 14kHz with a transmitting voltage response of 141dB. The Q factor for -3dB bandwidth is 1.3 and the beam width for -6dB bandwidth would be over 200 degrees.

3:40

**5pEA6. A binaural hearing assistance system with front-back discrimination capability.** Tsuyoshi Usagawa, Atsuya Saho, and Yoshifumi Chisaki (Kumamoto University, 2-39-1 Kurokami, Kumamoto 860-8555, Japan, tuie@cs.kumamoto-u.ac.jp)

Binaural hearing assistance systems have a well known ambiguity in front-back discrimination which is called as "front-back confusion" or "cone of confusion" in psychoacoustics. It is known that spectral cue of sound provides keys to solve this confusion in binaural listening condition and the peaks and notches of spectral components play main role to estimate the vertical angle in sagittal coordinate. In this paper, a binaural hearing assistance system with new front-back discrimination method is proposed. The discrimination method is implemented on an artificial neural network using interaural level and phase differences as input in selected frequency bins. The performance of the proposed system is examined for simulated conditions as well as experiments.

4:00

**5pEA7. On direct optimization in mode space for robust supergain beamforming of circular array mounted on a finite cylinder.** Yong Wang, Yixin Yang, and Yuanliang Ma (Institute of Acoustic Engineering, Northwestern Polytechnical University, yxyang@nwpu.edu.cn)

A direct optimization method in mode space for robust supergain beamforming of circular array mounted on a finite rigid cylinder is presented. According to the concept of eigen-decomposition, the beam pattern is decomposed into a series of eigen-beams weighted by modal coefficients. The modal cross spectral matrix in isotropic noise field is calculated from sound scattering theory based on boundary element method (BEM). This beamforming method gives the most suitable modal coefficient vector directly under the related constraint conditions via second-order cone programming, so that there is no need to transform indirectly from the weighting vector in sensor space which is essential in the modal robust supergain beamforming method proposed before. The results of simulation show that the direct modal beamforming method in this paper can not only improve robustness using the white noise gain constraint, but also change the mode orders to provide trade-off between array gain and robustness in low frequencies. Beam performance measures such as sidelobe level can be optimized in addition to array gain, and in this way more effective schemes for designing practical robust supergain beamformers can be developed.

4:20

**5pEA8. Electromagnetic tomographic ultrasonic sensor.** Pol Grasland-Mongrain, Jean-Martial Mari, Bruno Gilles, Jean-Yves Chapelon, and Cyril Lafon (LabTAU INSERM u1032, 151 Cours Albers Thomas, 69424 Lyon Cedex, pol.grasland-mongrain@inserm.fr)

A tomographic method based on the Lorentz force for the measurement of the pressure of an ultrasound transducer is presented. When a metal wire is vibrating under the influence of a pressure field created by an ultrasound

transducer while submitted to a magnetic field, the Lorentz force induces an electrical current. This current is considered proportional to the integral of pressure along the wire. By moving the wire perpendicular to the ultrasound axis, and rotating it around the same axis, a sinogram of the pressure field can be elaborated. Then an inverse Radon transform of the signal gives the pressure field spatial distribution. An experiment was conducted where a 1 MHz transducer generated an ultrasound wave with a focal point at 4 cm. A

100  $\mu\text{m}$  in diameter shielded copper wire was placed perpendicular to the ultrasound propagation axis, and inside a 300 mT magnetic field created by a permanent magnet. The main advantages of the hydrophone created by the wire-magnet system are the large frequency bandwidth and the resistance to high pressure, parameters still under investigation. Possible disadvantages are the sensibility to electromagnetic noise and the possible distortion of the pressure field when using a too thick wire.

FRIDAY AFTERNOON, 18 MAY 2012

S421, 2:00 P.M. TO 4:00 P.M.

## Session 5pNSa

### Noise and ASA Committee on Standards: Environmental Noise and Regulations II

Robert Hellweg, Cochair  
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Paul Schomer, Cochair  
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Maurice Yeung, Cochair  
*mklyeung@yahoo.com*

Jiping Zhang, Cochair  
*jpzhang@email.hz.zj.cn*

### Contributed Papers

2:00

**5pNSa1. Noise control for 24-hour rock drilling in urban area.** Wilson HO, Isaac CHU (Wilson Acoustics Limited, Unit 616, Technology Park, 18 On Lai Street, Shatin, Hong Kong, China, who@wal.hk), Etienne Baranger (Dragages – Maeda – BSG Joint Venture, Mui Fong Street, Sai Ying Pun, Hong Kong), and Richard Kwan (MTR Corporation, MTR Headquarters Building, Telford Plaza, Kowloon Bay, Hong Kong)

Dill and blast is often utilized for construction of vertical shaft in hard rock geology for various tunneling projects in Hong Kong. Such excavation work is usually restricted during 1900-0700 hours due to noise concern, especially in urban area. For MTR West Island Line Contract No. 703 SHW to SYP tunnels, extensive noise mitigation measures have been employed at the Tunnel Boring Machine (TBM) launching shaft where located less than 10m from the nearest noise sensitive receiver (NSR). A well designed shaft cover is the most prominent feature of noise mitigation measures and the insertion loss of the shaft cover was found to be minimum 49dB(A) on site. Groundborne noise impact from rock drilling was predicted within the statutory criteria and verified on site. Construction noise permit for 24-hour rock drilling by 2-boom jumbo drill was obtained.

2:20

**5pNSa2. Controlling environment noise—a hong kong experience.** Hom Au, Kin Wui Cheng, and Flora Kit Mei Lin (Environmental Protection Department, Hong Kong SAR, 26th Floor Southorn Centre, Hong Kong, frhau@epd.gov.hk)

Controlling environmental noise in a metropolitan city, like Hong Kong, has always been a challenge to both the Authority and the industries. This is partly attributable to the past neglect in environmental planning during the early 80s', and partly to the compacted urban settings in Hong Kong. Strategically, the Environmental Protection Department has attempted to pre-empt noise problems through early inventions in projects' planning stage, while in parallel effort was made to address existing noise problems through abatement programs and enforcement of the noise control legislation. This paper briefly outlines the overall framework being implemented in Hong Kong, both

legislatively and administratively, to control different kinds of environmental noise sources. Some of the crucial thoughts in the framework and the experience gained through enforcing the relevant legislative provisions will be discussed.

2:40

**5pNSa3. "Background" noise levels in mining towns—a case study.** Chris McNeillie (SLR Consulting Australia Pty Ltd, Level 1, 514 Sturt Street, Townsville, 4810 QLD, Australia, cmcneillie@slrconsulting.com)

Legislation and planning policy often stipulate "background plus" criteria for assessing the noise impact of industry and validating noise related complaints. However, these criteria generally do not take into account the fact that industrial noise may be an established and accepted part of the noise environment of an area. This paper presents a case study of an assessment of a large-scale mining operation in central Queensland, Australia where mine noise contributed significantly to the background noise level in an adjacent Township. The paper explains why a true background plus approach was not appropriate and describes how, instead, 3D noise modelling was used to "benchmark" existing mine noise emissions for the purposes of controlling future increases.

3:00

**5pNSa4. A deterrent to repeated noise offences.** Louis P.L. Chan, C. L. Wong, K.W. Cheng, and T.W. So (Environmental Protection Department, Government of the Hong Kong Special Administrative Region, lplc@epd.gov.hk)

Since the Noise Control Ordinance (NCO) was implemented in 1989, various environmental noise sources and activities have been regulated through different control mechanisms. Nevertheless, the penalty in terms of fines imposed for breaches of the NCO seemed not sufficient to deter the recurrence of offences, in particular during the 90s, when Hong Kong was actively enhancing its infrastructure to accommodate the growth of its thriving economy. Although the maximum fines under the NCO had been doubled in 1994, repeated violations were still serious at that time, with one reason being the

continued disregard of those legal requirements by the corporate management. Despite the court had in some offence cases actually imposed the maximum fines, the corporate management simply treated the fines as part of project expenses as they were not held personally liable for the actions of their companies. That malpractice was also disturbing a level playing field in the industry, creating unfairness to other law-abiding persons. A legislative amendment was successfully introduced in 2002 to hold the top management of bodies corporate personally liable for repeated noise offences. This paper will describe the framework of this provision with reference to similar legislation in other countries. The corresponding deterrent effect over the past years would be analysed. Moreover, a code of practice providing practical guidance to prevent violation would also be discussed in the paper.

3:20

**5pNSa5. Environmental noise from wind farms, prediction and measurements.** Alice Elizabeth González (IMFIA - Facultad de Ingeniería, elizabet@fing.edu.uy)

Although mechanical noises of wind turbines have been eliminated with the development in their design, aerodynamic noise generation during operation is inherent to them in nature. Their major acoustic emission occurs in low frequencies. To predict noise levels in the environment associated with the operation of stationary sources-wind turbines included-, the methodology of ISO 9613-2 is usually recommended. It is not only a standard method of calculation but it is also the recommended methodology in the European Union. However, under some conditions (such as a stable atmosphere) the predictions of this method may significantly underestimate the expected environmental noise levels. Lately, other methodologies of prediction that take in account atmospheric stability have been developed. Nevertheless, predictions from different calculation methods do not always result on the same sound

pressure levels. Different prediction methods are compared in this article. Their accuracy is then evaluated by checking environmental sound pressure levels with the predicted ones. Some issues that should not be neglected at the moment of working with noise emission sources of great height are remarked.

3:40

**5pNSa6. Systematic approach for wind noise analysis of buildings for engineering applications in Hong Kong.** C. W. Ng, K.W. Lo, and Sam P.S. Tsoi (Ove Arup & Partners Hong Kong Limited Level 5 Festival Walk, 80 Tat Chee Avenue, Kowloon Tong, Hong Kong, william.ng@arup.com)

Wind noise for tall buildings can be a concern for densely populated area. It is needed to develop a systematic approach of wind noise analysis for building design in engineering applications. This paper presents an innovative approach based on a three-tier analysis framework for wind noise assessment of external features in urban environment. The framework is divided into screening review of external locations susceptible of impact; broad assessment of areas susceptible to impact; and focused model assessment. In Tier 1, review of facade design is conducted to identify susceptible impacted areas. Screening criteria related to wind speed, shapes, dimension of facade elements are derived for evaluation of facade/architectural forms. Fundamental principles are applied to different turbulent flows to estimate relative significance based on Lighthill's Theory of aerodynamic noise. Statistical analysis of meteorological data is conducted from weather, wind tunnel/AVA study data to form representative wind conditions. In Tier 2, broad assessment of categorised areas is conducted by simplified calculations using scaling laws/regeneration prediction technique to estimate wind noise significance. In Tier 3, focused assessment of potential areas is conducted for specific evaluations. CFD is applied to flow fields for computation of aeroacoustic characteristics of vortex sources using Lighthill-Curle equation.

FRIDAY AFTERNOON, 18 MAY 2012

HALL C, 2:00 P.M. TO 4:00 P.M.

## Session 5pNSb

### Noise: Ship Noise and Vibration II (Lecture/Poster Session)

Lin He, Cochair  
*helin202@public.wh.hb.cn*

Changgeng Shuai, Cochair  
*chgshuai@163.com*

#### Contributed Papers

2:00

**5pNSb1. Analysis on transmission of sound and vibration of underwater double cylindrical shells connected with noncontinuous slab ribs.** Zhen-guo Bai (Dept 5, Mailbox 116#, WuXi City, JiangSu Province 214082, China, xiaobzg@126.com)

To analyze the sound and vibration transmission characteristics of double finite cylindrical shells, modal superposition method is adopted to establish the analytical mode, in which interaction induced by water between shells and slab ribs connecting the shells is taken into account. The in-face and out-face motion of slab ribs bring forth the interaction of shells, and the former factor features in the vibration transmission of the double shells below the ring frequency of the shell. The circumferential discrete slab ribs is mathematically described as algebraic sum of some step functions, which is then expanded in sine function series to fit in with the control equation of double shells. The results show that: whether the slab ribs are discrete or continuous as an annular rib, the level of sound radiation of double shell

doesn't alter a lot, instead of which, only the peak points move a bit. Keywords: Sound radiation, Step function, Double cylindrical shells

2:20

**5pNSb2. An active vibration control method based on nonlinear reverse model and Fx-LMS algorithm.** Li Yan, He Lin, and Shuai Changgeng (Institute of Noise & Vibration, Naval University of Engineering, Wuhan 430033, P.R. China; Science and Technology on Ship Vibration and Noise Laboratory, 430033, P.R. China, liyan312a@yeah.net)

The Filtered-X algorithm based on linear adaptive filters had been widely used in the active vibration control, but its effectiveness was limited by the nonlinearity of the active actuators. In this paper, the nonlinear reverse model of actuator was built using polynomial method and neural network algorithm, and an improved Fx-LMS algorithm based on reverse model linearization was put forward to address the nonlinearity of the actuators in active vibration isolation system. Simulation and experiment showed

that the improved Fx-LMS algorithm had better effect on periodic vibration control with nonlinearity compared with the traditional Fx-LMS feedforward control method.

2:40

**5pNSb3. Low creep isolator design and research for Ship propulsion engine.** Shu Lihong, He Lin, and Yang Xue (Institute of Noise & Vibration, Naval University of Engineering, Wuhan 430033, P.R. China; Science and Technology on Ship Vibration and Noise Laboratory, 430033, P.R. China, shulihong313@yeah.net)

A mechanical model based on Zener component was presented, which can perfectly describe and predict the creep characteristics of materials as parameters can be extracted with genetic algorithm not only from the step loading process, but also from the no-ideal loading process. This model can be applied to numerical calculation and prediction of vibration isolator's creep characteristics. The creep characteristic of the isolator has relationship with the creep characteristics of materials and the structure of the isolator. We can get the best creep characteristic and appropriate static and dynamic properties of the isolator by right design. A type of low creep vibration isolator made in polyurethane was designed for ship propulsion engine. Experimental results accorded with the numerical calculation result well.

3:00

**5pNSb4. Study on the dynamic model of magnetorheological elastomer vibration isolator.** Yang Xue, He Lin, and Shuai Changgeng (Institute of Noise & Vibration, Naval University of Engineering, Wuhan 430033, P.R. China; Science and Technology on Ship Vibration and Noise Laboratory, 430033, P.R. China, yangxue312@yeah.net)

Magnetorheological elastomers vibration isolator is a new controllable device, which shows a widely application in active or semi-active control.

The following abstract will be presented in poster format. The poster will be on display and the author will be at the poster from 3:40 p.m. to 4:00 p.m.

3:40

**5pNSb6. A study on the transfer matrix and dynamical characteristics of flexible pipe bend.** Shuai Changgeng and Lv Zhiqiang (Institute of Noise & Vibration, Naval University of Engineering, Wuhan 430033, P.R. China; Science and Technology on Ship Vibration and Noise Laboratory, 430033, P.R. China, shuaichanggeng411@yeah.net)

Much of the noise originates from pressure and flow fluctuations generated by pump. These pressure fluctuations are transmitted along the hydraulic lines and cause unbalanced forces at pipe bends and changes of section. The flexible pipe bend, a recently developed flexible component of pipe, can usually reduce thermal expanding reaction and endure large and complex stress and strain arising from different movements and also due to

In fact, it is very important to constitute a precise dynamic model of the MR elastomer isolator, which gives help for design the control strategy and control method, and achieve good control effectiveness. At present the models is convenient to analyze and calculate the change of MR elastomer's properties, but it can not put up the saturation of the stiffness and the parameter of model is magnetic field strength which adding the complexity of engineering application. In this paper, a phenomenon model was constituted to describe the dynamic performance of the MR elastomer vibration isolator. Using the test results of the isolator, parameters of the model were achieved. By comparing the simulation results with the test results, we can find that they tally well with each other, which validates the dynamic model.

3:20

**5pNSb5. A study of designing and computational method of single convoluted air spring.** Zhao Yinglong, Lv Zhiqiang, and He Lin (Institute of Noise & Vibration, Naval University of Engineering, Wuhan 430033, P.R. China; Science and Technology on Ship Vibration and Noise Laboratory, 430033, P.R. China, zhaoyinglong409@yeah.net)

The method of design and calculation of single convoluted air spring is studied in this paper. And the method is used to design an air spring which is meet the demand. The load, static stiffness, dynamic stiffness, and normal frequency of the air spring are calculated and tested. The aramid cord filament framework layer of the air bag and the air inside are modeled by the Rebar Element and Cavity Element of the MSC.Marc software respectively. And the nonlinear Finite Element Analysis (FEA) model is obtained. The characteristics of the air spring are calculated by FEA. Lastly, the characteristics of the air spring are tested by the MTS test machine. The design and simulation results are accord with the experiment results. The theoretical analysis and experimental results indicate that the design method is simple and exact, the nonlinear FEA model simulate exactly the air spring, and the design and simulation method can be used to design the single convoluted air spring.

complex geometry. The rubber hose wall can conduct oscillating longitudinal forces that may interact with fluid waves inside. Up to now, little attention has been paid to study its performances of vibration damping and noise attenuation in pipeline. The transfer matrix, an effective numerical method, is applied to analyze and evaluate the transfer performance of flexible pipe bend. However, because of its geometrical complexity, it is difficult to directly calculate the transfer matrix of the flexible pipe bend. In this paper, the flexible pipe bend is divided into several parts, each of which can be considered as a short straight pipe. Through the conversion between the global coordinate system and local coordinate system, a transfer matrix of the flexible pipe bend is derived and applied, which provide a practical method to analyze the frequency, modal and response of the flexible pipe bend.

## Session 5pNSc

## Noise and Architectural Acoustics: Noise Effects On Occupant Comfort and Performance in Buildings II

Lily Wang, Cochair  
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C. M. Mak, Cochair  
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## Contributed Papers

1:40

**5pNSc1. The acoustics approach to new towns and buildings planning.**  
James Wing Ho Wong (Allied Environmental Consultants Ltd. 19/F, Kwan Chart Tower, 6 Tonnochy Road, Wanchai, Hong Kong, gk@aechk.com)

Sound have been known to affect the physical, emotional, mental and spiritual states. Sound affects pulse rate, skin temperature, blood pressure, muscle tension, and brain wave activity. It helps release biochemicals, such as endorphins. It relaxes, excites, releases emotions, and helps to travel to altered states of consciousness. Sound has been applied in architectural design in ancient times and recent years, it helps in healing all those disease in which stress plays a role. This study develop advanced acoustic design concepts in use of sound healing in new towns and buildings planning. Harmonic building design and town planning is an exciting and emerging field that links the ancient sciences and arts with sound and vibration to heal the spirit, mind and body. The goal is to assist the individual and community at large in establishing healthier patterns for living in wholeness. It draws fundamentally on a unified view of the cosmos in which all things are inextricably bound and in relationship to one another whether it be an organ system, a family or an ecosystem. When our bodies experience an illness or disharmony, this will initially develop within the organizational energy matrices. The energy matrix of the body's cellular makeup is made up of a highly complex multitude of frequency interactions. When the body is subject to sound stimulation, it sets up a series of harmonic oscillations that influence a change in phase and frequency in the energy field or matrix on the cellular level. The result will be to reorganize the energetic matrix back to a more balanced state. This paper investigate how does sound and harmonic healing work. What is a typical resonance based building look like? What is the underlying concept about resonance healthy communities and how can Harmonic Town Planning design techniques be applied to create healthy communities.

2:00

**5pNSc2. A study on acoustical protection effects of plenum windows.**  
Y.G. Tong (Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, Johore, Malaysia, ygtong@uthm.edu.my), and S. K. Tang (Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, China)

Urban noise is likely to continue as a major issue in densely populated cities. The use of natural ventilation for energy saving and sustainable reasons become difficult to implement for the buildings in noisy urban environments. A staggered inlet and outlet openings design of plenum window was investigated in the present study. Two-dimensional model simulation was used to examine the effect of acoustic benefits of this window system relative to the different sound incidence of angle by solving numerical Helmholtz equation. Fully opened window is used as reference case. The results show that the insertion loss of plenum window is affecting by its staggered design and orientation of the window. There is peak of insertion loss observed at lower frequency which becomes sharper when the opening size of the window becomes smaller. [Y.G. Tong sponsored by Ministry of Higher Education, Malaysia.]

2:20

**5pNSc3. Innovative approach of acoustic design of high performance facade with auralization at Arup SoundLab.** C. W. Ng (Ove Arup & Partners Hong Kong Limited Level 5 Festival Walk, 80 Tat Chee Avenue, Kowloon Tong, Hong Kong, william.ng@arup.com), Henry C.K. Chan, and Sam P.S. Tsoi

This paper presents an innovative approach of acoustic design of high performance facade for buildings in the vicinity of an airport. The sound insulation performance of the facade system is established by an aircraft noise auralization of the aural environment in the built environment such as a Star hotel at Arup SoundLab for determining an acoustically suitable glazing system. Arup SoundLab uses a 3D loudspeaker reproduction system called Ambisonics to reproduce the sound phenomena in a dedicated room that allows people to listen to simulated sound in virtual spaces before actual construction. The audio samples can be generated to mimic the dynamic indoor acoustic environment for the takeoff noise profile of B747 aircraft. After listening to the audio samples for different glazing configurations and ambient conditions, subjective responses from a group of representative individuals to the audio sound track that simulates a possible future situation are collected for evaluation analysis. The engineering development of high performance acoustic facade is presented including laboratory testing to reach a confidence level for achieving the end results. An opportunity for identifying potential cost saving is also discussed as a result of this aircraft noise auralisation. Examples will be presented to illustrate the approach.

2:40

**5pNSc4. Innovative arc screen development for adaptive traffic noise mitigation of housing development using full scale prototype testing.** Sam P. S. Tsoi, C. C. Lai, C. K. Lau (Ove Arup & Partners Hong Kong Limited Level 5 Festival Walk, 80 Tat Chee Avenue, Kowloon Tong, Hong Kong, sam.tsoi@arup.com), and Kenneth H. K. Wong (Housing Department, Hong Kong)

The Housing Authority is responsible for public housing development in Hong Kong. With increasing demand for sites of challenging environmental conditions, the authority has been continuously diverting efforts on innovative design to tackle site environmental issues. One of the frontline development is an innovative arc-screen structure, which was devised to become one of the new generations of adaptive traffic noise mitigation. Its inception was initiated from the need to reduce traffic noise impact of a major highway parallel to the public housing development in Sai Chuen Road. As scale model evaluation of traffic noise reduction is somewhat limited, the project commissioned a full scale testing of an arc-screen prototype built into a 3-storey full size stacking up housing flat model for evaluation. This is believed to be the first time of a full scale experimental evaluation of traffic noise mitigation for housing development. The arc-screen structure has achieved 5 dB(A) nominal noise attenuation performance. Results are encouraging for public housing development applications and will form new generations of adaptive architectural forms of arc-screen uses to suit different needs. The first application is already planned at the Sai Chuen Road development and in-situ performance evaluation will be assessed in second phase.

### Session 5pNSd

#### Noise, ASA Committee on Standards, Psychological and Physiological Acoustics, and Animal Bioacoustics: Impulsive Noise Exposure Metrics: Development and Validation

Richard Mckinley, Cochair  
*richard.mckinley@wp.afb.af.mil*

#### *Invited Papers*

3:00

**5pNSd1. Comparative study of military impulse noise criteria currently in use and identification of research needs.** Steve Goley (Mechanical Engineering, University of Cincinnati, Cincinnati, OH 45221-0072, *steve.goley@gmail.com*), and Jay Kim (Mechanical Engineering, University of Cincinnati, OH 45221-0072)

Impulse noise criteria currently being in use, such as MIL-STD 1474D, Pfander, Smoorenburg and LAeq8hr, employ respectively a different noise metric to estimate the exposure risk to military noises. In these criteria, the risk is assessed based on the characteristics of the noise such as the peak level or equivalent energy. Recently a new approach that utilizes a simulation program of the auditory system called AHAH is advocated as an alternative, which considers characteristics of not only the noise but the auditory system response in assessing the risk. In this work, underlying assumptions and analytical structures of widely used impulse noise criteria and AHAH are examined to understand their relative strengths and shortcomings. Then, performances of the criteria are compared by utilizing an existing animal data obtained by exposing chinchillas to various impulse noises. Linear correlations of the noise metric with the PTS at 0.5, 1, 2, 4 K-Hz inflicted in chinchillas are used as the basis of the comparison which indicates that LAeq8hr and AHAH show better performance. Research needs to enable improvement of existing criteria and development of a new improved criterion are discussed. Acknowledgment: Travel for this invited presentation was supported by the Air Force Research Laboratory

3:20

**5pNSd2. Changes in distortion product oto-acoustic emissions after exposure to continuous and impulsive noise.** Miguel Angel Aranda de Toro (GN ReSound; Lautrupbjerg 7, DK-2750 Ballerup, Denmark, *maadtoro@gnresound.dk*), Rodrigo Ordoñez, and Dorte Hammershøi (Acoustics, Department of Electronic Systems, Aalborg University; Fredrik Bajers Vej 7-B5, DK-9220 Aalborg Ø, Denmark)

Temporary changes in the hearing of human subjects were monitored with distortion product otoacoustic emissions (DPOAEs) after control sound exposures in a laboratory. The objectives of the experiment were to investigate whether the +5-dB penalty for impulsiveness used in international standards and legislation correlates to a higher risk of hearing damage. Subjects were exposed to two types of binaural recordings consisting of a continuous broad-band noise-exposure normalized to  $L_{EX,8h} = 80$ -dB and the interaction of the previous stimulus with a noise of impulsive character normalized to  $L_{EX,8h} = 75 + 5$ -dB penalty = 80-dB. The results show that the effects on DPOAE levels from the two stimuli could be compared in terms of their total acoustic energy.

3:40

**5pNSd3. Scientific basis and shortcomings of EU impulse noise standards.** Karl Buck, Véronique Zimpfer, and Pascal Hamery (French-German Research Institute, 5 rue du Général Cassagnou, BP 70034, 68301 Saint-Louis, France, *karl.buck@isl.eu*)

In 2003 the Directive 2003/10/EC has been published by the European Union. It defines the maximum noise exposure levels for workers and the related necessities for hearing protection and for conservation programs. The limits for continuous noise are based on A weighted exposure levels as defined by ISO 1999:1990. For impulse noise the Directive limits the maximum peak pressure level to 140 dB including hearing protection. This single value limit which does not take into account any frequency or duration information is not adequate to evaluate the hazard of an impulse noise and lacks any scientific validation. Although it may not present many problems in industry, for the armed forces it has become a major problem, as it limits training and bans the use of some weapon. Therefore Germany has not implemented this Directive for its forces but uses the Damage Risk Criteria (DRC) designed by Pfander. In other countries which have implemented the Directive "As-is", other criteria based on A-weighted energy (LAex,8h) proposed by Dancer or the AHAH proposed by Price are taken into consideration for being used. The presentation will discuss scientific basis of the different DRCs for impulse noise in use or being candidate in Europe.

4:00

**5pNSd4. A case for using A-weighted equivalent energy as a damage risk criterion for impulse noise exposure.** William J. Murphy (National Institute for Occupational Safety and Health, Hearing Loss Prevention Team, 4676 Columbia Parkway, Mailstop C-27, Cincinnati, OH 45226-1998, wjm4@cdc.gov), and Richard L. McKinley (Air Force Research Laboratory, 2610 Seventh Street, Wright-Patterson Air Force Base, OH 45433-7901)

Damage risk criteria (DRCs) for continuous noise rely upon epidemiologic analyses of populations of persons exposed over several years to noise in occupational environments. In 2006, the U.S. Army proposed to update the MIL-STD 1474D to use the Auditory Hazard Assessment Algorithm for Humans (AHAHAH) and discontinue using the peak sound pressure level, envelope duration and number of impulses. The National Institute for Occupational Safety and Health has conducted two separate evaluations of the data used to justify the AHAHAH methodology and found that the use of the A-weighted equivalent energy  $L_{Aeq8}$  was more suitable for the purposes of predicting the effects of temporary threshold shifts (TTS) both in humans and in chinchillas. The  $L_{Aeq8}$  method provided best fit for the TTS outcomes and demonstrated the greatest discrimination (ability to predict TTS) when compared to AHAHAH, MIL-STD 1474D and two other proposed DRCs. Similarly,  $L_{Aeq8}$  was found to give the best-fit and greatest discrimination for the chinchilla impulse noise exposures. The  $L_{Aeq8}$  affords the best sensitivity and specificity for discrimination of potential hazards and has the greatest level of integration with present occupational exposure standards and prospective hearing protection labeling regulations.

4:20

**5pNSd5. Using impulsive peak insertion loss of hearing protectors with impulsive damage risk criteria.** Richard McKinley (Air Force Research Laboratory, 2610 Seventh St., AFRL/11HPW/RHCB, WPAFB, OH, 45433-7901, richard.mckinley@wpafb.af.mil), Hilary Gallagher (Air Force Research Laboratory, 2610 Seventh St., AFRL/11HPW/RHCB, WPAFB, OH 45433-7901), and William Murphy (National Institute for Occupational Safety and Health, 4676 Columbia Parkway, MS C-27, Cincinnati, OH 45226-1998)

Impulsive noise presents special challenges for hearing conservation. The scientific community continues to search for an impulsive noise exposure criterion which accurately assesses the hearing damage risk for both short and long duration impulses. Other factors, such as the use of hearing protectors, earmuffs and earplugs, also affect the hearing damage risk but the current criteria do not address methods for using the attenuation of hearing protectors in impulsive noise. The relatively new ANSIS12.42-2010 "Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures" describes methods for measuring the peak insertion loss of a hearing protector in impulsive noise. This paper will describe a method to apply the peak insertion loss data to impulsive noise damage risk criteria for an estimate of allowable impulsive noise exposure when using hearing protection.

### *Contributed Paper*

4:40

**5pNSd6. A hybrid model for predicting the sound level of shooting noise from recoilless rifles.** Byunghak Kong (School of Mechanical and Aerospace Engineering, Seoul National University 301-1214, 1 Gwanak-ro, Gwanak-gu, Seoul 151-742, Korea, bhgong03@snu.ac.kr), Kyuho Lee (School of Mechanical and Aerospace Engineering, Seoul National University 311-105, 1 Gwanak-ro, Gwanak-gu, Seoul 151-742, Korea), and Soogab Lee (Institute of Advanced Aerospace Technology and School of Mechanical and Aerospace Engineering, Seoul National University 311-105, 1 Gwanak-ro, Gwanak-gu, Seoul 151-742, Korea)

In the present study, acoustic signals from M40A1 recoilless rifle were measured according to recommendations of International Organization of

Standardization (ISO) using B&K 2250 sound analyzers. Contrary to expectations from previous studies about shooting noise, the signal recorded at each point shows different waveform in comparison with the others. This means that an additional acoustic source was present, and there was no doubt that it was located at a tail nozzle of the weapon through temporal and geometric relations between the microphone arrays. Spectral analysis and frequency band filter were used to find out what kind of acoustic source there was, and it was concluded that acoustic properties of the additional source was much close to those of jet noise rather than blast noise. Based on these results, consequently, a hybrid model has been developed to predict the sound pressure level of shooting noise from recoilless rifles using predicting algorithms applicable to acoustic sources, blast noise and jet noise, relatively.

## Session 5pPA

## Physical Acoustics: Negative Radiation Forces Exerted by Acoustical and Optical Beams

Phil Marston, Cochair  
*marston@wsu.edu*

Jack Ng, Cochair  
*jack@ust.hk*

*Invited Papers*

1:40

**5pPA1. Single beam acoustic tweezer.** K. Kirk Shung (Department of Biomedical Engineering, University of Southern California, Los Angeles, CA 90089, *kkshung@usc.edu*)

Single beam acoustic tweezer, a distant cousin of optical tweezer, has been recently experimentally validated. A prerequisite of acoustic tweezer as in optical tweezer is a sharply focused beam with a steep intensity variation within the dimension of a particle. As the frequency of an acoustic beam reaches 100 MHz or higher, the beam diameter may approach cellular level allowing acoustic tweezing or trapping of a cell. Recent experimental results have shown that it is possible to trap lipid spheres of 100  $\mu\text{m}$  diameter at 30 MHz and 15  $\mu\text{m}$  diameter leukemia cells at 200 MHz. These results along with the experimental arrangement and potential biomedical applications of acoustic tweezer will be discussed in detail in this paper.

2:00

**5pPA2. Pulling particles backward using a forward propagating beam.** Jack Ng (The Hong Kong University of Science and Technology, *jack@ust.hk*), Jun Chen, Zhifang Lin (Fudan University), and C. T. Chan (The Hong Kong University of Science and Technology)

Can the scattering force of a forward propagating beam pull a particle backward? A photon carries a momentum of  $\hbar k$ , so one may expect light will push against any object standing in its path. However, light can indeed “attract” in some cases. For example, a focused light beam can attract particles, due to the gradient force. But it is probably more appropriate to say that the gradient force “grabs” rather than “pulls”, as the particle will remain stable in the trap after being drawn to the focus. Here, we discuss another possibility — a backward scattering force which is always opposite to the propagation direction of the beam so that the beam keeps on pulling an object towards the source without an equilibrium point. In the absence of intensity gradient, using a light beam to pull a particle backwards is counter intuitive. The underlining physics is the maximization of forward scattering via interference of the radiation multipoles. We show explicitly that the necessary condition to realize a pulling force is the simultaneous excitation of multipoles in the particle and if the projection of the total photon momentum along the propagation direction is small, attractive optical force is possible.

2:20

**5pPA3. Negative acoustic radiation forces produced by Bessel beams: acoustic tractor beams and scattering.** Philip L. Marston (Physics and Astronomy Dept. Washington State University, Pullman, WA 99164-2814, *marston@wsu.edu*), Likun Zhang, and David B. Thiessen (Physics and Astronomy Dept. Washington State University, Pullman, WA 99164-2814)

The theory for negative acoustic radiation forces on objects in various Bessel beams is reviewed [P. L. Marston, J. Acoust. Soc. Am. 120, 3518–3524 (2006); L. K. Zhang and P. L. Marston, Phys. Rev. E 84, 035601 (2011)] together with geometric insight provided by researchers in optics. When examining conditions favorable for negative radiation forces it can be helpful to consider the far field scattering for axisymmetric objects of interest because the axial radiation force can be directly related to the asymmetry in the scattering and the conic angle of the beam. The analysis also serves to clarify the way in which absorption by the object contributes to positive forces and to clarify the influence of helicity. Considering the symmetry properties of the scattering provides additional insight as does the evaluation of radiation forces and wave fields using the computational method of finite elements. In the non-absorbing case it can also be helpful to express the partial-wave amplitudes in terms of phase shifts since in acoustics there is only one phase shift for each partial-wave. [Marston and Thiessen were supported by ONR and Zhang was supported by NASA.]

2:40

**5pPA4. Use optical beams to push and pull: an old paradigm with new features.** Cheng-Wei Qiu (National University of Singapore, 4 Engineering Drive 3, Singapore 117576, *chengwei.qiu@nus.edu.sg*)

We present a fundamentally distinguished schematic for a novel micromanipulation which realizes stable trapping and continuous optical traction/pulling of molecules at one go, opening up its widely appealing potentials in physics and biomedical engineering. We theoretically investigate the origin of pulling force by modeling tractor beams and its explicit correlations on the laser types, particle's

parameters, and beam polarization modulation. The novel technology of tractor beam is developed and proposed via a systematic analysis from electromagnetic scattering theory, condition of pulling force, and experimental investigation by using binary-lens optics. Instead of treating the object as a “blackbox” and interfering multiple beams, our technique exploits a single beam with phase modulation, and more importantly we study the fundamentals of the energy exchange, force direction switching, and the far-field radiation flipping. The major criterion is to manipulate the beam-particle interference to maximize the transfer of momentum along the forward direction, so that the reaction force will be dragging the particle all the way towards light source continuously, i.e., the fantasy of tractor beam.

3:00

**5pPA5. Attraction by sound—examples on the negative acoustic radiation forces of Bessel “tractor” beams on a sphere.** Glauber Silva (Universidade Federal de Alagoas, Maceio AL, Brasil, glauber@pq.cnpq.br), and Farid Mitri (Los Alamos National Laboratory, Los Alamos, NM)

Expressions for the axial (i.e. acting along the axis of wave propagation) and transverse (lateral) acoustic radiation forces on a suspended object in an ideal fluid are derived for arbitrary shaped beams. These expressions are obtained from the integration of the radiation stress tensor in the far-field. Numerical examples on non-vortex and vortex Bessel beams on a spherical target are presented. It is demonstrated the existence of both “pushing” and “tractor” behaviors for which the axial force can be oriented, respectively, along the direction of wave propagation or opposite to it. This can be adjusted by choosing specific values of the beam cone angle and the sphere size factor  $ka$  (where  $k$  is the wavenumber and  $a$  is the sphere’s radius). Furthermore, by changing the topological charge  $m$  of the beam and the position of the sphere, the transverse force may be oriented radially (outward or inward) for  $m=0$  or may exhibit a vortex pattern for  $m \geq 1$ .

3:20

**5pPA6. Acoustic trapping of particle by a periodically structured stiff plate.** Feiyan Cai, Fei Li, Long Meng, and Hairong Zheng (1068 Xueyuan Avenue, Shenzhen University Town, fy.cai@siat.ac.cn)

Acoustic tweezers have found potential applications in both the physical and life sciences in the past two decades due to their abilities of contactless, controllable and noninvasive trapping and manipulating micro-scale objects regardless of material transparency. Approaches to acoustic trapping of micro-objects required large field intensities. They are usually generated directly by acoustic transducer, cannot be redesigned easily, nor can the corresponding acoustic radiation forces be modulated efficiently. Recently, the artificial structures, such as phononic crystal or metamaterials, can provide a facile way of controlling the field distribution of acoustic wave. These artificial fields may have potential application in acoustic manipulation. In this work, we demonstrate that a geometrical modulated trapping force can exert on an object as it is near the surface of structured artificial brass plate at resonance frequency. The mechanism and condition of this trapping effect are discussed via the field and force analyzing, respectively.

3:40

**5pPA7. Parameter space for scattering and radiation forces for symmetric objects based on unimodular partial-wave s-functions.** Philip L. Marston (Physics and Astronomy Dept., Washington State University, Pullman, WA 99164-2814, marston@wsu.edu), and Likun Zhang (Physics and Astronomy Dept., Washington State University, Pullman, WA 99164-2814)

For situations in which dissipation is negligible it can be helpful to parameterize the scattering and radiation forces on axisymmetric objects using partial-wave  $s$ -functions [L. K. Zhang and P. L. Marston, Phys. Rev. E 84, 035601 (2011)]. The reason is that without dissipation, for axisymmetric objects illuminated by axisymmetric beams along the axis of the object, for each partial wave the scattering becomes characterized by a single parameter: the partial-wave phase shift. As a consequence of the finite diameter of the object, only a limited number of partial waves need to be included in the analysis of the radiation force and the scattering. In the case of a sphere illuminated by an electromagnetic beam, there are separate electric and magnetic partial waves. In the simpler acoustic case, the phase shifts and the cone angle of a Bessel beam may be used to characterize regions of negative radiation force and large scattering asymmetry. Fabrication of the associate object becomes a separate issue. It is not difficult to select the partial-wave phase shifts such that reduced backscattering with negative radiation forces occur with a cone angle of the beam as small as 22 degrees. [Supported by ONR and NASA.]

### *Contributed Papers*

4:00

**5pPA8. An experimental study of acoustically induced rocking motion of simple asymmetric geometries.** Gwendolyn V. Rodgers, Peter H. Rogers, and James S. Martin (George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA 30332, grodgers3@gatech.edu)

A series of experiments were done to test theoretical predictions that an acoustically small, rigid (aluminum) hemisphere and semicircular cylinder excited by a plane acoustic wave in water would each produce a rocking motion perpendicular to the incident wave direction about the axis parallel to the incident wave. A plane standing wave was generated in a short open-ended thick-walled cylindrical waveguide with the waveguide’s axis perpendicular to the symmetry axis of the hemisphere. Measurements were taken along the hemisphere from top to bottom to determine if any rocking motion occurred. The expected vibrational motion in the incident direction

and symmetry-forbidden perpendicular vibrational motion were also measured. The transverse displacement of the hemisphere at each point was determined by using an ultrasonic vibrometer. The incident wave direction motion was measured using a hydrophone, an accelerometer, and a Laser Doppler Vibrometer (LDV). The motion in the incident wave direction was found to be more than 10 times greater than the maximum rocking displacement for each case.

4:20

**5pPA9. Negative optical torque.** Jack Ng (HKUST, jack@ust.hk), Jun Chen, Zhifang Lin, and C. T. Chan

While it is now clear that optical scattering force can be negative (opposite to the propagating direction of the beam), less attention is being paid to the optical torque. Here, we show that the optical torque exerted on a structure by an electromagnetic wave can be in an opposite direction to the

angular momentum of the incident beam. This negative torque is closely related to the symmetry of the structure, and by playing around with the rotational symmetry and density of the structure, one can control the magnitude of the negative as well as the positive torque.

4:40

**5pPA10. Optical micro-manipulation of absorbing particles with tractor and bottle beams.** W. Krolkowski, V. Shvedov, C. Hnatovsky, N. Eckerskorn, and A. Rode

This paper presents an innovative approach of acoustic design of high performance facade for buildings in the vicinity of an airport. The sound insulation performance of the facade system is established by an aircraft noise auralization of the aural environment in the built environment such as

a Star hotel at Arup SoundLab for determining an acoustically suitable glazing system. Arup SoundLab uses a 3D loudspeaker reproduction system called Ambisonics to reproduce the sound phenomena in a dedicated room that allows people to listen to simulated sound in virtual spaces before actual construction. The audio samples can be generated to mimic the dynamic indoor acoustic environment for the takeoff noise profile of B747 aircraft. After listening to the audio samples for different glazing configurations and ambient conditions, subjective responses from a group of representative individuals to the audio sound track that simulates a possible future situation are collected for evaluation analysis. The engineering development of high performance acoustic facade is presented including laboratory testing to reach a confidence level for achieving the end results. An opportunity for identifying potential cost saving is also discussed as a result of this aircraft noise auralisation. Examples will be presented to illustrate the approach.

FRIDAY AFTERNOON, 18 MAY 2012

S428, 2:00 P.M. TO 4:40 P.M.

## Session 5pPP

### Psychological and Physiological Acoustics: Subjective Evaluation and Auditory Perception

Dongxing Mao, Cochair  
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Junji Yoshida, Cochair  
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#### Invited Paper

2:00

**5pPP1. Overall loudness perception properties under dichotic listening condition.** Zhiyue Shao (Institute of Acoustics, Tongji University, No. 1239, Siping Road, Shanghai 200092, China, *zshao921@gmail.com*), and Dongxing Mao (Institute of Acoustics, Tongji University, No. 1239, Siping Road, Shanghai 200092, China)

Dichotic listening conditions under which sound levels differ at the two ears are typical listening conditions, and there are yet no widely accepted results of binaural loudness summation. Researches show, the relationship between global loudness and interaural level difference (ILD) differs greatly for broadband noise and pure tone signals. Overall perceived loudness with interaural level difference (ILD) under different signal bandwidths was investigated through subjective listening experiment. In the subjective experiment, with the arithmetic mean of sound levels in both ears kept constant, the ILDs of dichotic signals ranged from 2dB to 12dB with 2dB step. Subjects were asked to match the overall loudness of dichotic test signals with that of diotic ones at the same center frequency and bandwidth. Signal of four bandwidths, which are 1/12, 1/6, 1/3 and 1/1 octave were taken for the experiments. Results showed that the overall loudness of dichotic signals increases nonlinearly with ILD, and the narrower the signal bandwidth was, the faster the speed of the increase was. Comparison of subjective results with Moore's loudness model showed, deviation from Moore's model became larger as signal bandwidth narrowed.

#### Contributed Papers

2:20

**5pPP2. Influence of SPL distribution on loudness impression for environmental noise.** Yuta Chaki and Junji Yoshida (Osaka Institute of Technology, *m1m11419@st.oit.ac.jp*)

To realize comfortable living environment, it is necessary to reduce the environmental noise according to the suitable environmental noise evaluation index. For considering the environmental noise evaluation index, it is important to know characteristics of loudness evaluation toward long-term noise because the environmental noise was evaluated for long-term. In this study, to investigate the evaluation characteristics, we focused on the distribution of sound pressure level in duration of environmental noise and performed loudness evaluation test using long-term noise by changing the distribution. In the test, four traffic noises in duration of 10 min which loudness was adjusted equality by pre-processing were employed as base sounds. In addition, modified four noises in which the deviation of sound pressure

level were increased (the mean value was same as the base sounds) were used as target sounds. Fourteen subjects evaluated the loudness of eight traffic noises immediately after hearing each sound. As a result, it was found that loudness impression toward the target sound was evaluated to be softer than the base sound. Consequently the long-term sound having large deviation of sound pressure level was clarified to be evaluated softer than the sound having small deviation.

2:40

**5pPP3. Interaction between vehicle exterior design and perceived loudness of vehicle acceleration sound.** Takumi Igata and Junji Yoshida (Osaka Institute of Technology, *m1m11403@st.oit.ac.jp*)

To increase cabin comfort, not only decreasing sound pressure level but also improving the sound quality is essential. In addition, when the sound quality of the vehicle matches with the exterior design, the sound is

considered to be perceived more attractive. In this study, to investigate the relationship between the perceptions of the sound and the exterior design, the loudness of acceleration sounds were evaluated with vehicle exterior images. In the loudness evaluation test, 10 acceleration sounds and 10 exterior images were prepared and half of the images were luxury vehicle images and the others were sporty vehicle images. The experimental subject evaluated the loudness of presented sound with the luxury or sporty vehicle exterior image. Twenty one male subjects participated in the test. Eleven of them drove vehicles frequently and the others were infrequently. As a result, frequently driving subjects felt the acceleration sound louder by having luxury vehicle impression. In contrast, infrequently driving subjects felt the sound softer by having the same vehicle impression. Consequently, it was clarified that perceived loudness was influenced by vehicle exterior design, and the tendency was changed depending on the driving frequency.

3:00

**5pPP4. Annoyance perception of environmental noises by hearing impaired listeners.** Srikanth Vishnubhotla, Jinjun Xiao, Buye Xu, Martin McKinney, and Tao Zhang (Starkey Labs, Inc., 6600 Washington Ave. S., Eden Prairie, MN 55344, Srikanth\_Vishnubhotla@starkey.com)

Annoyance perception of environmental noises is an important topic in many fields, including transportation, environmental studies and hearing aid design. While annoyance perception of normal hearing (NH) listeners has been studied extensively (e.g. Fastl & Zwicker 2006, Versfeld & Vos 1997, Alayrac et al 2010, Palmer et al 2006), data on annoyance perception of hearing impaired (HI) listeners is scant. In this study, we investigate the annoyance perception of typical environmental noises by both NH and HI listeners, using listeners with unilateral hearing loss. We use the magnitude estimation procedure to obtain the annoyance ratings and a paired-comparison method to obtain the annoyance preference for different environmental noises. The experimental data are analyzed to reveal the underlying dimensions of annoyance perception and differences between NH and HI listeners. A functional model for annoyance perception is developed for both HI and NH listeners. Finally, potential applications of our results are discussed in the context of hearing aid design.

3:20

**5pPP5. Relative contributions of on- and off-frequency spectral cues in increment detection.** Harisadhan Patra (Bloomsburg University of PA, 226 CEH, 400 E 2nd Street, Bloomsburg, PA 17815, hpatra@bloomu.edu), Petula Vaz (Bloomsburg University of PA, 223 CEH, 400 E 2nd Street, Bloomsburg, PA 17815), Abhijeet Patra, Joseph Motzko, and Adam Burkland (Bloomsburg University of PA, 338 CEH, 400 E 2nd Street, Bloomsburg, PA 17815)

Increment detection is often used as a measure of intensity resolution, where a listener detects a brief increment in intensity in a longer duration stimulus. Recent findings suggest that listeners rely on multiple cues rather than on-frequency energy cues. The relative contributions of on- and off-frequency cues are evaluated in five normal-hearing young adults. Detection thresholds for a 50-ms increment added in the middle of a 450-ms, 1000-Hz pedestal were obtained in quiet, telegraph noise (TN), and notched-noise (NN) conditions. The pedestal level was 60 dB SPL. NN stimuli were generated by filtering TN while keeping the notch geometrically centered at 1000 Hz. The NN-notches were also varied by increasing the notch-width unevenly on either side of the center frequency. The low-frequency cutoffs of the NN-notches were 125, 250, 500, and 750 Hz while the high-frequency cutoffs were 1500, 2000, and 4000 Hz. Although the NN-notches were centered at 1000 Hz, increment detection thresholds were poorer in NN conditions than in quiet. Detection thresholds were similar in TN and NN with the narrowest notch conditions. Results suggest that listeners may rely on a decision process based on multichannel on- and off-frequency cues. [Supported by BU research and scholarship grant]

3:40

**5pPP6. Temporal order judgment characteristics at the offset of auditory-visual stimuli.** Junji Yoshida, Kouhei Ueda (Osaka Institute of Technology, yoshida@med.oit.ac.jp), and Hiroshi Hasegawa (Utsunomiya University)

In this study, we investigated the influence of auditory-visual stimuli presentation timing at the onset on the perception of the offset asynchrony. To investigate the characteristic, we performed temporal order judgment test using auditory-visual stimuli. Pure tone and white rectangular were used as auditory and visual stimuli. In the test sequence, we prepared five presentation timings ( $0, \pm 128, \pm 256$  ms) and nine disappearance timing ( $0, \pm 32, \pm 64, \pm 96, \pm 128$  ms), and asked the experimental subject which stimulus disappeared first. From the obtained experimental result, we calculated the point of subjective simultaneity (PSS) at each presentation timing in each subject to obtain the PSS dependency on the onset presentation timing. As a result, the averaged offset PSS among the subjects was almost zero when the auditory-visual stimuli were presented simultaneously but the PSS varied widely among subjects. On the other side, with respect to the offset PSS dependency on the onset presentation timing, all subjects' result indicated the same tendency. The later the auditory stimulus was presented at the onset, the auditory stimulus was perceived to disappear earlier. Consequently, the temporal order judgment at the offset was found to depend on the presentation timing at the onset.

4:00

**5pPP7. Ménière's disease impaired hearing character and improving strategy.** Yan-Ping Zhang (Huazhong University of Science and Technology, Wuhan 430074, pzzyy0102@163.com), Xian-Ming Long (Hanchuan City Hospital), and Chang-Cai Long (Huazhong University of Science and Technology)

Hearing ability of Ménière's disease victim is usually impaired. They have a higher hearing threshold and a lower discriminating ability of speech, especially in noise environment. We demonstrate in psychoacoustics experiment that accompanying the usually observed hearing loss phenomena, the tuning shape of the disease victim is also changed into shallower. This phenomena can be explained by our physics theory about nonlinear cochlea signal processing and a improving strategy is also provided.

4:20

**5pPP8. How do driving sounds influence the subjective evaluation of longitudinal acceleration?** Sabrina Skoda, Jochen Steffens, and Joerg Becker-Schweitzer (Institute of Sound and Vibration Engineering, Duesseldorf University of Applied Sciences, Josef-Gockeln-Str. 9, 40474 Duesseldorf, sabrina.skoda@fh-duesseldorf.de)

The evaluation of vehicle interior sounds in a listening study is always based on multiple sensory interactions. In a driving simulator several visual and somatosensory stimuli are presented to the test subjects in addition to the pure driving sounds. These multisensory stimuli are processed consciously and unconsciously by the human brain. Thus attention processes and also the evaluation behavior change in comparison to monosensory acoustical experiments. In the automotive industry electric powered vehicles currently are a hot topic. These vehicles have a very quiet noise behavior compared to vehicles with combustion engines. So the question arises how driving sounds comprise to the subjective evaluation of a vehicle's acceleration. Do we associate loud driving sounds with strong acceleration? Which part takes the spectral structure of a sound? In a comparative listening study different vehicle interior sounds and different accelerations were evaluated in two different driving simulators. Based on the results from the study the influence of driving sounds on the subjective evaluation of longitudinal acceleration is discussed.