Session 3aAA

Architectural Acoustics and Noise: Acoustics in Concert Halls II (Lecture/Poster Session)

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Chair's Introduction—8:55

Contributed Papers

9:00

3aAA1. Practice and cogitation on acoustics design of professional concert hall. Song Yongmin and Zhang Kuisheng (Zhang Kuisheng Acoustical Design and Research Studio, 11F, No. 268, Shimen Er Road, Shanghai 200041, China, asong1102@163.com)

Development overview on design and construction of professional concert hall since the 1990s in China is summarized in this paper. Acoustics design cases of professional concert hall completed by Zhang Kuisheng acoustical design and research studio over the past decade are described. Then four designs among those professional concert halls including the architectural characteristics and acoustical parameters are introduced. Those are Hunan musical hall, concert hall in China conservatory, Beijing, philharmonic hall in Xiamen international conference center and Yangzhou musical hall. Finally, the preferred reverberation time, plane shape, volume per seat, acoustical material and diffuser design in concert hall are discussed in detail. Those successful experience and considered suggest are put forwards for sharing.

9:20

3aAA2. The acoustical design of Xiamen University Concert Hall. Yuezhe Zhao and Shuoxian Wu (State Key Laboratory of Subtropical Building Science, South China Univ. of Tech., Guangzhou 510640, arzhyzh@scut.edu.cn)

Xiamen University is located in the Fujian Province, South East of China. Xiamen University Concert Hall is the essential musical education site for the college students, as well as for holding important meetings. The concert hall has 560 seats. It has a comparatively long reverberation time to offer a fullness and reverberant sound field for music performance. At the same time, rich early reflections from the ceiling and the side walls together with the enough signal to noise ratio guarantee speech intelligibility when using a loudspeaker system. With this conception in the acoustical design of the concert hall, the use of changeable absorptive components was avoided which may influence the brightness and liveness of the chamber music hall. After the completion of the building, acoustical measurements were taken and the measurement results are also given in this paper. Since autumn 2010 when the concert hall was finished, music performance and meeting events have been successfully held in the hall. It has become the main hall for the musical education and performance, as well as the meeting center for the college.

9:40

3aAA3. Prediction of acoustical parameters for open plan offices according to ISO 3382-3. Jens Holger Rindel (Odeon A/S, Scion-DTU, Diplomvej 381, DK-2800 Kgs. Lyngby, Denmark, jhr@odeon.dk)

In the new international standard ISO 3382-3 the measurement procedure for open plan offices is described and a number of new room acoustical parameters for the objective evaluation are defined. Among the new parameters are the privacy distance and the distraction distance, both derived from the STI (speech transmission index) as a function of distance from the sound source. The final evaluation is a balanced compromise between a number of parameters that depend on the amount of sound absorption, the application of screens between work stations and the level of background noise. With room acoustic simulation software these measurements can be simulated, thus providing a tool for the acoustical design of open plan offices. The paper presents an example office with a range of alternative acoustical solutions that include different amount of absorption, screens of different height, and different levels of background noise. Also the influence of dynamic background noise from people talking can be taken into account, leading to a shorter privacy distance. This provides a background for the discussion of the efficiency of various acoustical measures in open plan office design.

10:00

3aAA4. Using synthesised musical stimuli to measure room impulse responses in occupied spaces. Francis Li (University of Salford, M5 4WT, UK, f.f.li@salford.ac.uk)

Since Sabine instigated objective parameters a century ago, the advance of room acoustics has been centred around measurement findings. Room impulse responses are of particular importance: nowadays, measurements typically start from impulse responses, individual acoustic parameters are then derived. With existing methods, noisy signals intolerable to audience are employed as stimuli to obtain the impulse responses. Consequently, occupied measurements are rarely carried out. Unoccupied measurements are unreliable and problematic, because they do not accurately represent the acoustic profile under in-use conditions. This paper presents a method that utilises "presto-chirps", short chirps centred on musical notes in an equal temperament scale, to synthesise musical notes. The harmonics might be added by the Volterra kernel convolution, if richer tones are preferred. These musical notes are used to compose synthesised music as test stimuli. Room impulse responses are deconvolved from received signals in musical

note specified sub-bands. Following energy normalisation and superposition broadband impulse responses are obtained. The use of musical stimuli facilitates occupied measurements. The purpose-defined presto-chirp enables the measurement to be completed in a relatively short duration, mitigating time variance problems.

10:20

3aAA5. How the design of a balcony affects the acoustics in an auditorium? L.Y. Cheung and S.K. Tang (Department of Building Services Engineering, the Hong Kong Polytechnic University, Hong Kong, louisa.cheung@connect.polyu.hk)

A 3D-simulation for improving the acoustics in an auditorium was done using room acoustic software, Odeon. The software provides the sound field inside the hall and thus the sound propagation physics was studied. The 3D computer model was done based on an existing auditorium of over 1000 seats. Further simulations have been done by removing the balcony and changing it's the geometry. The effect of different balcony geometry on the sound quality inside the hall was estimated and compared. Apart from reverberant time, the effects on energy ratios and other parameters from simulation results were studied. [L. Y. Cheung is supported by the Hong Kong Polytechnic University.]

10:40–11:00 Break

11:00

3aAA6. Vocal intelligibility and clarity in amplification: challenges for concert hall acoustics. Damian Doria (75 Feather Lane, Guilford, CT 06437, DamianJDoria@gmail.com), Tom Clark (Acme Sound, 23 Park Lane, Norwalk, CT, 06854), Todd L. Brooks (Artec, 114 West 26th Street, New York, NY 10001), and Bob McCarthy (Alignment and Design Inc, 204 Falling Leaves Court, Creve Couer, Missouri 63141)

The modern concert hall presents a range of programming from soloists and small classical ensembles to large orchestras with choir. In many communities the same concert venue is also required to host a range of amplified events from politely-reinforced ensembles to overtly amplified popular music artists. Maintaining intelligibility of vocals and clarity at high amplification levels depends upon a number of factors both within the control of the acoustics and sound system designers and not. This paper will discuss the programming for a typical season at one 1600-seat concert hall, the elements within its design to allow flexibility of program use, and experiences during the process of adjustment, tuning, and optimizing the hall over its first season.

11:20

3aAA7. Acoustic re-radiation of structurally coupled instruments by stage floors and orchestra risers. Clemeth L. Abercrombie, Todd L. Brooks, Damian J. Doria, and Tateo Nakajima (Artec Consultants Inc, New York, cla@artecconsultants.com)

The role that structural vibration plays on concert hall stage floors is a point of continous discussion in several lines of research. It is often

discussed, if only briefly, in research relating to the perception of warmth in performance spaces, low-frequency sound propagation, and the musician's acoustic environment. Three effects have been researched: acoustic absorption, acoustic reradiation of structurally coupled instruments, and perceptible tactile stimulation. New measurements have been conducted to explore the role of reradiation by wood stage floor constructions and orchestra risers in two recently opened concert halls. Results of these measurements will be presented and reviewed in the context of previous research. Implications for design of musical environments will be discussed.

11:40

3aAA8. Effects of periodically arranged absorptive materials on acoustic potential energy in rectangular rooms. Hao Liu and Xiaodong Li (Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, Beijing, China, liuhao@mail.ioa.ac.cn)

A modal analysis method is applied to compute the acoustic potential energy of a three-dimensional rectangular room, where sound absorptive materials are periodically arranged on the boundaries of the rectangular room. This paper studies the influence of two parameters, including the frequency of the sound source and the number of absorptive material strips, on the acoustic potential energy in detail. This study reveals that both of the two parameters have notable effects on the coupling behavior of room modes. A main result of this paper is that using a periodic arrangement of absorptive materials can be more efficient than totally covering of absorptive materials on corresponding surface in reducing acoustic potential energy under certain conditions. The coupling behavior of room modes can well explain why excess potential energy reduction can be achieved by using periodically arranged absorptive materials.

12:00

3aAA9. Acoustical design of the National Theatre Company of China (NTCC). Chan Chun Huang, You Guo Qin, Xiang Yan, and Peng Wang (Tsinghua University, School of Architecture, Beijing, China, james601129@hotmail.com)

The National Theatre Company of China seats 886, volume 5,400 m3, and reverberation time is 1.2s without audience and orchestra. As part of the design process, measurements on CAD computer and acoustical simulation using Raynoise software and full-sized materials samples were conducted over two year period. The hall in plan is bell shape. The ceiling is a curved cloud, with its U-shape balcony above the main floor (stall), two side rails provide the useful early reflections to the central rear seating area. The unique wall architectural features around the auditorium was analyzed on the models that all interior surfaces combine to distribute sources on the stage uniformly over the seating areas and to yield optimum values for reverberation time–RT, early decay time–EDT, Lateral fraction–LF, and strength–G.

The following abstracts will be presented in poster format. The posters will be on display and the authors will be at their posters from 12:20 p.m. to 1:00 p.m.

3aAA10. Investigation of improved metrics for the characterization of musicians' room acoustical conditions in concert halls. Behzad Ranjbari (Chalmers Room Acoustics Group, Chalmers University of Technology, SE-41296 Gothenburg, Sweden, br@behzadranjbari.com)

A number of metrics for assessing the acoustical conditions for performers on concert hall stages have been proposed, notably by Anders Gade but also others. However, the subjective relevance of existing stage acoustic metrics for musicians, appears mainly to be associated with the communication with the audience rather than with the communication between musicians. No acoustic metrics have been identified to assess the balance between the hearing of others vs. the hearing of one's own instrument,

which appears paramount to orchestral musicians. Problems regarding presence of orchestra, directional characteristics of instruments, distances from instruments to ears of musicians, etc., also have been an issue for researchers, making the work difficult, expensive and imprecise. However, in this paper, due to the comparative approach used, some of these problems were removed, since they are basically the result of properties of orchestral arrangement rather than stage conditions and can be assumed similar from one stage to another. In this paper, a number of laboratory experiments as well as measurements on real stages have been studied and a pair of metrics, namely G_{Self} and G_{Others} are suggested to assess the balance between the hearing of self and that of hearing others.

3aAA11. Acoustical design of the new concert hall at Helsinki Music Centre, Helsinki, Finland. Keiji Oguchi (Nagata Acoustics, Hongo Segawa Bldg.3F, 2-35-10 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan, oguchi@nagata.co.jp), Motoo Komoda (Nagata Acoustics, 2130 Sawtelle Blvd., Suite 308, Los Angeles, CA 90025, U.S.A.), Ayako Hakozaki (Nagata Acoustics, Hongo Segawa Bldg. 3F, 2-35-10 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan), Marc Quiquerez (Nagata Acoustics, 75, avenue Parmentier, 75011 Paris, France), and Yasuhisa Toyota (Nagata Acoustics, 2130 Sawtelle Blvd., Suite 308, Los Angeles, CA 90025, U.S.A.)

The Helsinki Music Centre opened in Helsinki, Finland on August 31, 2011. The Music Centre is anchored by the 1,704-seat concert hall, and is supported by 6 small halls, each with a different program, and the Sibelius Academy, the premier conservatory in Finland. The concert hall is the new home for Finland's two major orchestras, the Finnish Radio Symphony Orchestra and the Helsinki Philharmonic Orchestra. The concert hall is configured in the vineyard style with terraced steps in the auditorium, and measures 35m wide, 48m long and 20m tall. To support the stage acoustics, a 12m diameter ensemble reflector is suspended at a height of approximately 15m above the stage. The stage acoustics are also enhanced by motorized orchestra risers. The acoustical design and characteristics of the Concert Hall are reported.

3aAA12. Acoustic design of the Philharmonic Hall in the Shanghai Oriental Art Center. Jingbo Wang and Kuisheng Zhang (Shanghai XianDai Architectural Design (Group) Co., Ltd., Shanghai, 200041, jbwang827@163.com)

The Shanghai Oriental Art Center opened officially on July. 2005 is one of the largest performance art centers in the domestic. It mainly consists of the 2000 seats philharmonic hall, the 1100 seats opera house and the 300 seats chamber music hall, and several rehearsal facilities. It has been become one of the most important landmark buildings in Shanghai as well in PuDong new district. In this paper it is mainly elucidated the features of the architectural acoustics design of the 2000-seat philharmonic hall, the largest specially designed for music performance venue. It is also covered the objective acoustical measurement results and the subjective acoustics evaluation from all circles after opening.

3aAA13. Spring isolators designed for the Melbourne Recital Centre, Melbourne, Australia. Michael Plumb (Embelton, m.plumb@embelton.com)

The subject matter deals with the performance of spring isolators designed to meet the specified isolation requirement for the 1000 seat Dame Elisabeth Murdoch Recital Hall located in Melbourne Australia. Predicted performance of isolators is evaluated, and measured vibration results are presented for isolated and non-isolated sections of the building. Results are presented in vibration reduction versus frequency with good agreement between predicted and achieved vibration reduction for the locations measured. Achieved background noise levels are also presented in order to provide comparison with anticipated outcomes.

3aAA14. Factor analysis of reverberation perception. Zihou Meng and Lu Dai (Communication Acoustics Laboratory, Communication University of China, Beijing 100024, P.R. China, mzh@cuc.edu.cn)

The reverberation perception in a concert hall is affected by many attributes although the reverberation time may be the most important. To study the contribution to the perceived reverberation from different attributes, a series of listening tests are carried out. The semantic meaning of the reverberation is studied with the questionary to audio engineers and architectural acoustician. The factors to be analyzed are selected based on this semantic study. The subjects are asked to judge the running reverberation impression caused by acoustic scenes simulated by measured or virtual room impulse responses. The reverberation time of the room impulses used in the tests to stimulate the sound field are from 0.5 to 6.0 seconds. Besides the reverberation time, the attributes taken into the consideration in the factor analysis include the clarity, the sound level, the energy ration of early to late reflection, the distance between the source and listener, the volume and shape of the room and also the content of the sound. Based on the result of the factor analysis, a functional expression is proposed to describe the relationship between the perceived reverberation and a group of attributes.

WEDNESDAY MORNING, 16 MAY 2012   S424, 8:20 A.M. TO 12:40 P.M.

Session 3aAB

Animal Bioacoustics, Acoustical Oceanography, Underwater Acoustics, and Signal Processing in Acoustics: Biosonar I

James Simmons, Cochair
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Hiroshi Riquimaroux, Cochair
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Invited Papers

8:20

3aAB1. Estimating the biosonar detection range of mesopelagic patches by spinner dolphins. Whitlow Au, Marc Lammers (HIMB, P.O. Box 1106, Kailua, HI 96734, wau@hawaii.edu), and Jokob Jung (Bremen University of Applied Science, Berman, Germany)

Spinner dolphins (*Stenella longirostris*) in the near-shore waters of the Hawaiian islands forage on the mesopelagic boundary community (mbc) of organisms consisting of myctophids, mid-water shrimp and small squids. They forage at night and supposedly in a coordinated fashion and in groups between 16 and 24 animals that are divided into pairs. In the search phase of the foraging process, the dolphins are thought to be spaced in a V-shape formation with the tip of the "V" at the deepest depth, and swim parallel to shore hunting for patches of prey that they can encircle and herd into a tight three-dimensional patch. A profiler housing a broadband echo-ranger that

projected dolphin-like biosonar signals was used to measure the target strength of the mbc based on a dolphin's integration window of 264 μs. The bottlenose dolphin, *Tursiops truncatus*, was used as a proxy to estimate the biosonar detection ranges of *Stenella longirostris* searching for mbc patches because only limited acoustic research has been performed with spinner dolphins. Using the sonar equation, the biosonar threshold detection range of spinner dolphins was estimated to be approximately 50 to 64 m, more than sufficient range for the animals to formulate their prey herding behavior.

8:40

3aAB2. FM bats use transform-based biosonar imaging. James Simmons (Brown University, Providence, RI 02912, james_simmons@brown.edu), and Michaela Warnecke (Brown University, Providence, RI 02912)

Big brown bats (Eptesicus fuscus) perceive target range from echo delay using neuronal-delay lines that extract and display the time that elapses between successive occurrences of individual frequencies in each FM broadcast and its subsequent echoes. The bat's delay accuracy is very sharp for echoes containing all broadcast frequencies. Decreasing the bandwidth of echoes reduces the number of frequencies available for estimating delay, which degrades acuity. However, removal of frequencies triggers the operation of a second, parallel estimation process, loosely related to the cepstrum, whereby delay differences between two or three closely-spaced reflections are estimated from the pattern of modulations (peaks and notches) in the echo spectrum. When a wide span of frequencies is removed, as in lowpass filtering, multiple spectral-modulation solutions coexist, which the bat perceives as many different glints distributed across several hundred microseconds. This defocuses the bat's images for the echoes and renders them not capable of clutter masking. The effect of spectral blurring on delay images is opposite to that expected from time-domain blurring, as demonstrated in 3 different delay-discrimination experiments. [Work supported by ONR and NSF]

9:00

3aAB3. Overcompensation of echo attenuation and dual-component biosonar control in echolocation of an Atlantic bottlenose dolphin (*Tursiops truncatus*). Songhai Li, Paul E. Nachtigall, and Marlee Breese (Marine Mammal Research Program, Hawaii Institute of Marine Biology, University of Hawaii, P.O. Box 1106, Kailua, Hawaii 96734, songhai@hawaii.edu)

Transmitting biosonar clicks and auditory evoked potential (AEP) responses triggered by the clicks were synchronously recorded during echolocation in an Atlantic bottlenose dolphin (Tursiops truncatus) trained to wear suction-cup EEG electrodes and to detect targets by echolocation. Three targets with target strengths of –34, –28 and –22 dB were used at a target distance of 2 to 6.5 m for each target. The results demonstrated that the AEP appeared to both transmitting echolocation clicks and echoes during echolocation, with AEP complexes consisting of alternative positive and negative waves. The echo-related AEP amplitudes were obviously lower than the transmitting click-related AEP amplitudes for all the targets at the investigated target distances. However, for targets with target strengths of –22 and –28 dB, the echo-related AEP response amplitudes increased at further target distances, demonstrating an overcompensation of echo attenuation with target distance in the echo-perception system of the dolphin biosonar. Measurement and analysis of transmitting click intensities showed that the click levels increased with target distance (R). The results demonstrated that a dual-component biosonar control system formed by intensity compensation behavior in both the transmission and receiving phases of a biosonar cycle exists synchronously in the dolphin biosonar system.

9:20

3aAB4. Adaptive echolocation behavior in a complex sonar scene. Cynthia Moss (University of Maryland, College Park, MD 20742, cynthia.moss@gmail.com)

Adaptive sonar behavior in bats provides a window to echo information processing and perception of complex scenes. Echolocating bats produce ultrasonic vocalizations and receive a cascade of echoes from a single sonar call when the environment contains multiple reflecting sources. Some echoes may return from food and others from obstacles, and the bat must rapidly sort and identify the sources of echo returns to analyze the sonar scene and accurately control its flight. Big brown bats produce frequency modulated sonar signals that change in direction, duration, bandwidth and repetition rate as they inspect objects at different directions and distances. The work presented here will focus on adaptive sonar behavior in bats as they track a selected prey item in the presence of other objects, both obstacles and other prey. Data suggest that echo stream segregation of targets in clutter is supported by finely tuned adaptive sonar signal control.

9:40

3aAB5. Evolutionary convergence and divergence in bat and toothed whale biosonars. Peter Teglberg Madsen (Aarhus University, Build 1131, Peter.madsen@biology.au.dk), and Annemarie Surlykke (SDU, Nils Bohrs Alle)

Bats and toothed whales have independently evolved the capability to use echolocation to locate, track and capture prey in a 3-dimensional world of darkness in the night sky or at 1000 meters depth. Despite a very distant common ancestor and the vastly different acoustical properties of air and water, bats and toothed whales use a surprisingly similar ultrasonic frequency range from 15 to 200 kHz for echolocation. In this talk we use recent technical advances in field studies to address and compare the acoustic behavior of bats and toothed whales in the wild. We show that both bats and toothed whales switch to high repetition rate buzzing for prey capture, but that bats capture prey after and toothed whales during buzzing. Bats face a much higher absorption and lower impedance in air by which they have prey detection distances that are between 1 and 2 orders of magnitude shorter than those of toothed whales while moving forward at speeds that are 2-3 times higher. That implies that bats have little time and hence potential for prey discrimination in the wild whereas toothed whales have many seconds between detection/discrimination and the time of capture.

10:00

3aAB6. Shandong University—Virginia Tech Biosonar Research in China. Rolf Müller (ME Dept., Virginia Tech, 150 Slayton Ave., Danville, VA 25240 & School of Physics, Shandong Univ., Shanda Nanlu 27, Jinan 250100, China, rolf.mueller@vt.edu)

China is home to a diverse and in many places abundant bat fauna. Among the most diverse and prominent bat families in the country are the horseshoe bats (*Rhinolophidae*) which also have one of the most specialized and capable sonar systems found in nature. Biosonar research at the Shandong University - Virginia Tech International Laboratory seeks to understand the capabilities and the diverse adaptations in the sonar systems of Chinese bats. A common thread of this research is the analysis of the natural variability in biosonar solutions. For example, the International Laboratory has been compiling a digital database of the noseleaves and outer ear shapes of bats from China and neighboring regions. Current research explores biological adaptation pattern in these shapes and their acoustic properties. Other research explores sound production across different species of Chinese bats. The International Laboratory also conducts behavioral experiments, in particular with horseshoe bats. This research has characterized novel dynamic features on the emission as well as on the reception side of the horseshoe bats' biosonar system. The International Laboratory collaborates with a sister lab at Virginia Tech (GLOBES) on the engineering analysis of the biosonar properties it discovers as well as the development of bioinspired devices.

Contributed Papers

10:20

3aAB7. Effects of water levels on distribution patterns of the Yangtze finless porpoises in Poyang and Dongting Lakes, China. Kexiong Wang, Lijun Dong (Key Laboratory of Aquatic Biodiversity and Conservation of the Chinese Academy of Sciences; Institute of Hydrobiology of Chinese Academy of Sciences, Wuhan 430072, China, wangk@ihb.ac.cn), Tomonari Akamatsu (National Research Institute of Fisheries Engineering, Fisheries Research Agency, Kamisu, Hasaki, Kashima, Ibaraki 314-0408, Japan), Satoko Kimura (Graduate School of Informatics, Kyoto University, Kyoto 606-8501, Japan), Shiyong Wang, Zhigang Mei, Songhai Li, and Ding Wang (Key Laboratory of Aquatic Biodiversity and Conservation of the Chinese Academy of Sciences; Institute of Hydrobiology of Chinese Academy of Sciences, Wuhan 430072, China)

Two large freshwater lakes in China (Poyang and Dongting Lakes) are crucial habitats of the Yangtze finless porpoises. The lakes are confronted with threatens from low water levels. For evaluating possible impacts of low water levels on the porpoises in the lakes, the distribution patterns of the animals in the lakes were monitored in different seasons by using a boat-towing A-tag array from 2009 through 2011. The survey routes were almost same among different seasons. The acoustical detection number (i.e. encounter number) of porpoise in every 3-km section was calculated by counting the bearing angle traces of the sonar sources recorded by the array. The numbers in the same section were compared between high and low water level periods. Results indicated that porpoises appeared to congregate in deep water areas in low water level periods, while they tended to disperse toward the near shore waters in high water level periods. The results suggest concentration of individuals during low water level period. The variations of distribution patterns in different water level periods remind us that protection efforts should be focused on different areas according to the changes of water levels in different seasons.

10:40–11:00 Break

11:00

3aAB8. Large reconfigurable microphone array for transmit beam pattern measurements of echolocating bats. Jason E. Gaudette (Ctr. for Biomedical Eng., Brown U., 171 Meeting Street, Providence, RI 02912, jason_gaudette@brown.edu), Laura N. Kloepper (Dept. of Zoology, U. of Hawaii, Honolulu, HI 96822), and James A. Simmons (Dept. of Neuroscience, Brown U., 89 Waterman Street, Providence, RI 02912)

Measurements of the transmit beam patterns in bats have previously been limited to a single cross-sectional plane or averaged over multiple in-flight approaches with sparse microphone arrays. No high-resolution measurements have been published to date of individual transmitted beams jointly in azimuth and elevation. Toward this goal, a high density microphone array was designed and constructed using low-cost ultrasonic microphones and custom electronic circuitry. The planar array is 1.83 meters wide by 1.42 meters tall with sensors positioned on a 2.54 cm square grid.

The system can record up to 228 channels simultaneously at a 500 kHz sampling rate. Big brown bats (*Eptesicus fuscus*) were trained to echolocate pairs of virtual targets in a two-alternative forced choice discrimination task while their signals were being recorded by the array. Visualizations of the beam patterns during the task will be presented along with some advanced signal processing techniques used in the analysis. [funded by ONR and NUWC, Division Newport]

11:20

3aAB9. Detection on the presence and frequency use pattern of cetacean tonal sound. Tzu-Hao Lin (Institute of Ecology and Evolutionary Biology, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 10617, Taiwan, schonkopf@gmail.com), Hsiang-Chih Chan, Chi-Fang Chen (Department of Engineering Science and Ocean Engineering, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 10617, Taiwan), Tomonari Akamatsu (National Research Institute of Fisheries Engineering, Fisheries Research Agency, 7620-7 Hasaki, Kamisu, Ibaraki 314-0408, Japan), and Lien-Siang Chou (Institute of Ecology and Evolutionary Biology, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 10617, Taiwan)

Passive acoustic monitoring (PAM) had already been proved to assess the presence of many cetacean species successfully. However, the continuous recording makes the manual data analysis difficult. In the present study, an automatic detection algorithm was developed for tonal sounds produced by Indo-Pacific humpback dolphins. The algorithm included a tonal sound detector which found the local spectral peaks and sampled the dominant frequencies every 5.3 ms. A noise exclusion process was used to exclude the spectral peaks with wide -3 dB bandwidth. After filtering the isolated frequency points within specific duration and frequency range, the adopted frequencies of tonal sounds could be obtained. The result showed the algorithm had 70% correct detection and 2.8% false positive based on each 1 sec time bin in 10 field recordings. The first to third quartile of adopted frequencies showed significant difference with those extracted manually, but the differences were only 245-489 Hz in average. The current algorithm performed considerably faster than real time. In the future, it can be applied as a first step in a real-time monitoring.

11:40

3aAB10. Expression of the gap junction protein connexin-36 in the adult big brown bat cochlear nucleus may be involved in temporally precise biosonar processing. Alyssa Wheeler, Carolina Veltri (Brown University, Alyssa_Wheeler@brown.edu), Victoria Flores, Andrea Simmons, and James Simmons (Brown University)

The big brown bat uses biosonar to orient, navigate, and forage. Successful prey capture requires sonar emissions and returning echoes to be encoded and compared in the central auditory system with precision. Behavioral experiments show that E. fuscus can discriminate echo delay, relative timing of harmonics, and echo phase on the order of $3\mu s$ or less. The neurobiological specializations underlying this perceptual acuity remain elusive.

New evidence shows that principal cells in the bat's cochlear nucleus (CN) express the neuronal gap junction protein connexin-36. During early postnatal development, connexin-36 expression is seen throughout the AVCN and PVCN of both big brown bats and mice. In adult bats, but not mice, cx36 expression is restricted to a specific population of cells in the ventral AVCN. The retention of cx36 in a discrete population of cells in the adult bat CN suggests that electrical transmission could be involved in processing echolocation sounds with temporal accuracy. Support: NSF grant 0843522 and ONR grant N00014-09-1-0691 to James Simmons.

12:00

3aAB11. Dolphin echolocation—synthetic aperture or "raster scanning"? Matthias Hoffmann-Kuhnt, Mandar Chitre (National University of Singapore, 18 Kent Ridge Road, Singapore 119227, tmsmh@nus.edu.sg), Eszter Mátrai (Ocean Park Hong Kong, Aberdeen Hong Kong SAR, China), Kelvin Yeo (National University of Singapore, 18 Kent Ridge Road, Singapore 119227), and Jason Lee (Ocean Park Hong Kong, Aberdeen Hong Kong SAR, China)

A bottlenose dolphin performing a cross-modal matching-to-sample task was stationed on a biteplate while echolocating on a sample object concealed in an opaque box. This procedure prevented the animal from gaining different aspects of the stimulus. Despite these restrictions on his location the dolphin was still able to recognize the object and successfully perform a match. The echolocation signals emitted by the dolphin were recorded with a rectangular array of 16 hydrophones mounted on a frame and placed between the dolphin on the biteplate and the object inside the box. A custom high-frequency data acquisition system recorded the signals at 500 kS per second and also collected synchronized video from several locations around the animal. The collected data was filtered and processed. The results presented here show that the dolphin was scanning the object and steering his echolocation beam without moving his head thus avoiding the possible acoustic clutter from multiple reflections from the object. The acquired data was also analyzed for the backscattered echo from the object.

12:20

3aAB12. A numerical study of the role of the noseleaf in the Egyptian slit-faced bat. Qiao Zhuang (Shandong Jianzhu University, 250101, zhuangqiao@sdjzu.edu.cn), Xiaomin Wang, and Mingxuan Li (Institute of Acoustics, Chinese Academy of Sciences, 100190)

Around 300 bat species are known to emit their ultrasonic biosonar pulses through the nostrils. This nasal emission coincides with the presence of intricately shaped baffle structures surrounding the nostrils. Some prior experimental evidence indicates that these "noseleaves" have an effect on the shape of the animals' radiation patterns. Here, a numerical acoustical analysis of the noseleaf of a slit-faced bat species is presented to show that all three distinctive parts of its noseleaf ("pit", "upper leaf", "lower leaf") have an effect on the acoustic near field as well as on the directivity pattern. In their effects on the near field, the noseleaf parts showed a tendency toward spatial partitioning with the effects due to each part dominating a certain region. However, interactions between the acoustic effects of the parts were also evident, most notably, a synergism between the frequency-dependent effects of two parts of the noseleaf ("pit", "lower leaf") to produce an even stronger frequency selectivity. supported by the Natural Science Foundation of China (Project No. 10974222), and the China Postdoctoral Science Foundation funded project (No. 20090450599). Bat specimen provided by the School of Physics, Shandong University, China.

WEDNESDAY MORNING, 16 MAY 2012

S428, 9:00 A.M. TO 10:40 A.M.

Session 3aBAa

Biomedical Acoustics: Ultrasound Imaging and Therapy (Poster Session)

Alfred Yu, Cochair
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Contributed Papers

All posters will be on display from 9:00 a.m. to 10:40 a.m. To allow contributors an opportunity to see other posters, contributors of odd-numbered papers will be at their posters from 9:00 a.m. to 9:50 a.m. and contributors of even-numbered papers will be at their posters from 9:50 a.m. to 10:40 a.m.

3aBAa1. A preliminary study of ultrasound blood imaging in the common carotid artery of stroke patients. Tae-Hoon Bok, Qi Kong (Jeju National University, Jeju-si, Jeju Special Self-Governing Province, Rep. Korea, bth012@jejunu.ac.kr), Yun Hee Oh, Jang Jin Lee, Joong Goo Kim, Jay Chol Choi (Jeju National University Hospital, Jeju-si, Jeju Special Self-Governing Province, Rep. Korea), and Dong-Guk Paeng (Jeju National University, Jeju-si, Jeju Special Self-Governing Province, Rep. Korea)

Blood echogenicity is changed by red blood cell aggregation due to hemodynamic and hematological factors depending on a person. A stroke is known as a cerebrovascular accident due to lack of the blood flow. Hence, an ultrasound blood imaging could be the preliminary diagnosis for the stroke patient. In this paper, ultrasound images were acquired from the common carotid artery of stroke patients and the control group by the ultrasound imaging system (Voluson e, GE Healthcare, USA). The numbers of subject were 6 stroke patients and 5 healthy people for the control group, and their ages were 67 ± 17 and 68 ± 3 years old, respectively. The average of blood echogenicity of the stroke patients (54 ± 8) was lower than that of the control group (96 ± 8). The amplitudes of the cycle variation of blood echogenicity were similar for both of the stroke patient (18 ± 6) and the control group (23 ± 6). The preliminary experimental results showed the statistical difference of blood echogenicity between the stroke patients and the control group, and the data would be continuously collected from more volunteers (~20 people for each group) and discuss the data in the conference. [Work supported by NRF-2011-0017984.]

3362   J. Acoust. Soc. Am., Vol. 131, No. 4, Pt. 2, April 2012

Acoustics 2012 Hong Kong   3362

3aBAa2. Multi-dimensional real-time blood flow velocity field measurement in elastic vascular phantoms using ultrasonic particle image velocimetry technique. Ruibo Song, Ming Qian, Lili Niu, Qiaofeng Jin, and Hairong Zheng (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, 1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, P.R. China, rb.song@siat.ac.cn)

The experiment was implemented to measure the multi-component blood flow velocity in elastic vascular phantoms. Poly (vinyl alcohol) cryo-gel, PVA-C, is presented as a tissue-mimicking material, suitable for application in ultrasound imaging. The hardness of PVA-C changed with the number of freeze-thaw cycles. Two kinds of PVA phantoms with different shape were made in our experiment. Mechanical tests were performed on cylindrical samples with a pressure column, and Young's modulus were obtained varying from 50kPa to 320kPa depending on the number of freeze-thaw cycles (one to eight).The phantoms of tubular body with different elasticity were fixed in the fluid system. The information of flow field in the vascular phantom was obtained using the newly developed ultrasound velocimetry technique (echo particle image velocimetry). The flow rate and the pressure at the upstream of the vascular phantom are respectively measured by the Flow Meter and the Pressure Transmitter.

3aBAa3. Blood clot characterization by ultrasound Nakagami imaging. Po-Hsiang Tsui, Chieh-Ming Hung, and Chung-Hsin Hsu (Chang Gung University, tsuiph@mail.cgu.edu.tw)

Detection of blood clotting by ultrasound has been widely explored. Many ultrasonic quantitative parameters have been demonstrated to have the ability to characterize clot. This study proposes the ultrasound Nakagami image as a tool to visually characterize the properties of blood clot. Whole blood samples with a hematocrit of 40% were made. A 10-mL whole blood was placed in a tube and 1 mL of 0.2 mol/L CaCl2 solution was added to induce clotting. A 35-MHz focused transducer was used to scan the tube filled with blood before and after blood clot formation for Nakagami imaging. The results showed that whole blood and clot have similar textures in their B-scans, but the Nakagami image behaved well in distinguishing between blood and clot. The Nakagami image before clot formation is based on red-blue-interlaced shading, corresponding to Rayleigh distribution (the Nakagami parameter m approaches 1). However, the clot has more blue shadings in the Nakagami image, representing that the backscattered statistics of blood clot tends to be pre-Rayleigh distributed (m < 1). This study suggests that the Nakagami image may be used to characterize blood and clot for clinical studies and diagnosis.

3aBAa4. Observation of blood echogenicity variation in rat arteries using high-frequency ultrasound. Kweon-Ho Nam, Eunseop Yeom, Sang Joon Lee (Center for Biofluid and Biomimic Research, Department of Mechanical Engineering, Pohang University of Science and Technology, San 31, Hyoja-dong, Namgu, Pohang 790-784, Korea, kwonho@gmail.com), and Dong-Guk Paeng (Department of Ocean System Engineering, Jeju National University, Ara 1-dong, 102 Jejudaehakno, Jeju 690-756, Korea)

Previous studies have demonstrated that blood echogenicity is highly variable depending on blood flow velocity and pulsatility mainly due to the variation of red blood cell (RBC) aggregation. However, most of the studies were performed in a mock-flow loop using porcine blood and the results were not fully validated in vivo. Rat was rarely used for investigation of RBC aggregation due to its low aggregation tendency. But high-frequency ultrasound may detect the RBC aggregation from rat blood. The purpose of the present study is to investigate the cyclic and radial variation of blood echogenicty in rat arteries using a high-frequency ultrasound system with a 40-MHz scanner. B-mode images of blood were acquired from various arteries, including carotid artery and abdominal aorta. Blood echogenicity increased at systole and decreased at diastole. The cyclic variation was larger at the vessel center than near the vessel wall. The central hypoechoic zone ('black hole' phenomenon) was observed in carotid arteries. The experimental results from rat arteries in vivo corroborate the previous observations of cyclic and radial variations of blood echogenicity from porcine blood in mock-flow loops. Acknowledgments: This work was supported by the Korea Research Foundation Grant funded by the Korean Government (NRF-2011-0017984).

3aBAa5. Measurement of brain tissue motion using extended autocorrelation strain estimator. Redouane Ternifi, Melouka Elkateb Hachemi Amar, and Jean-pierre Remenieras (UMR INSERM CNRS U930, 10 Bd Tonnelle, 37032 Tours, France, redouane.ternifi@etu.univ-tours.fr)

Pulsatile motion of brain parenchyma results from cardiac and breathing cycles. In this study, transient motion of brain tissue was estimated using an Aixplorer\textregistered imaging system allowing an ultrafast 2D acquisition mode. The strain was computed directly from the ultrafast IQ complex data using the extended autocorrelation strain estimator (EASE), which provides great SNRs regardless of depth. The EASE first evaluates the autocorrelation function at each depth over a set of successive IQ pairs. This estimates the mean change in phase over time, which is proportional to the velocity. A second autocorrelation is evaluated on the results of the first autocorrelation. This estimates the mean change in phase over depth, which is proportional to the strain rate. The developed algorithm was first validated on "in vivo" data acquired at 7.5MHz from the carotid. Tissue velocity and strain rate were estimated on artery wall and adjacent regions. The estimated displacement velocity and displacement of the wall artery were 2.5 cm/s, and 150 μm respectively. The displacement velocity and displacement of the region near the surface were 1 cm/s and 30 μm respectively.

3aBAa6. Body surface scanner for the abdominal sound speed tomographic imaging. Akira Yamada, Kensuke Sasaki (Tokyo Univ. A&T, Koganei, Tokyo 184-8588, Japan, yamada@cc.tuat.ac.jp), and Toshihiko Yokoyama (Seiko Epson, Shiojiri, Nagano 399-0785, Japan)

The ultrasound tomography has been studied for the reconstruction of the abdominal sound speed image to measure the visceral fat area. The method is based on the travel time observations of the sound waves transmitted through the abdominal medium. In the present study, aiming to realize the method as a clinically available equipment, body surface scanner machinery was developed keeping good contact between a transducer and a human abdominal body surface. To-and-fro movement scanning equipment including the attachment of the elastic coupling gel hemisphere in front of the transducer surface was installed. The optimum pushing status was controlled by monitoring the variation of the received sound wave amplitude. They were in stable over the wide pushing distance region, regardless of the contact surface angle. It was shown that measured precision of the travel time were good enough to discriminate the difference of the sound speed between the fat and protein regions in the human abdominal region.

3aBAa7. Development of an ultrasound beamforming research platform based on SonixRP system. Xin Chen (School of Medicine, Shenzhen University, chenxin@szu.edu.cn), Ting Zhou, Siping Chen, and Tianfu Wang

The raw pre-beamforming data are necessary for the study of ultrasound imaging beamforming algorithm. However, the raw data are not accessible for most of the commercial ultrasound scanner. Therefore, most researches have to depend on software simulation. The purpose of this paper was to develop an open platform for the research of ultrasound beamforming. This platform utilized the SonixRP system to obtain the raw pre-beamforming data with great flexibility. The essential imaging parameters and scan sequence can be defined through a user-friendly GUI. Furthermore, a new adaptive beamforming algorithm was proposed and verified on the platform. The results showed that the algorithm can improve the image quality with better enhancement and lateral resolution while compared the conventional DAS algorithm. Acknowledgements: This work is supported by the National Natural Science Foundation of China (81000637, 61031003).

3aBAa8. Influence of temperature field produced by phase aberration in HIFU. Zhenbo Liu (Institute of Acoustics, Key Laboratory of Modern Acoustics (Ministry of Education), Nanjing University, Nanjing 210093; Nanjing Normal University, 210097, liuzb@njnu.edu.cn), Tingbo Fan, Xiasheng Guo, and Dong Zhang (Institute of Acoustics, Key Laboratory of Modern Acoustics (Ministry of Education), Nanjing University, Nanjing 210093)

High Intensity Focused Ultrasound (HIFU) is a noninvasive treatment in the field of cancer therapy. The principle of this technique is to raise the tissue temperature to relatively high values and cause thermal coagulation and

ablation of cells by using tissue penetrable, strong directional and easily focused ultrasound. The phase aberration introduced by tissue inhomogeneity affects the tissue temperature evidently on the focus. This article studies the influence of temperature field debased by phase aberration theoretically using the 3D KZK (Khokhlov-Zabolotaskaya- Kuznetsov) combined phase aberration screen models and simulates the temperature field by solving Pennes equation. The peak and the size of the temperature with various phase aberration will be compare to homogeneity. In order to prove the theoretical results a series of in vitro experiments will be execute.

3aBAa9. The temperature dependent thermal properties of ex vivo porcine liver tissue heated from 20°C to 90°C.

Min Joo Choi, Sitaramanjaneya Reddy Guntur (Jeju National University, mjchoi@jejunu.ac.kr), Kang IL Lee (Kangwon National University), Dong Guk Paeng (Jeju National University), and Andrew Coleman (Guy's & St Thomas'Hospital)

Thermotherapy uses a heat source which raises temperatures in a target tissue, and the temperature rise depends on the thermal properties of a tissue. Little is known about the temperature dependent thermal properties of a tissue, which prevents an accurate prediction of the temperature distribution of a target tissue that is undergoing thermotherapy. The present study reports the key thermal parameters (specific heat capacity, thermal conductivity and heat diffusivity) that was measured on ex-vivo porcine liver while being heated from $20°$ C to $90°$ C. The results show that all the thermal parameters resulted in the plots with asymmetrical quasi-parabolic curves with temperature, being convex downward with their minima at the turning temperature of $35-40°$ C. The largest change was observed for a thermal conductivity, which decreased by 9.6% from its initial value (at $20°$ C) at the turning temperature ($35°$ C) and rose by 45% at $90°$ C from its minimum (at $35°$ C). The minima were 3.567 mJ/(m3.K) regarding the specific heat capacity, 0.520 W/(m.K) regarding the thermal conductivity, and 0.141 mm^2/s regarding the thermal diffusivity. The minimum at the turning temperature was unique and is suggested to be taken as a characteristic value of the thermal parameter of the tissue. The study indicates that the key thermal parameters varied largely with temperature, which resulted in having a substantial influence on the temperature distribution of the tissue undergoing thermotherapy. Keywords: thermal properties, ex-vivo porcine liver, temperature, specific heat capacity, thermal conductivity, thermal diffusivity, thermotherapy

3aBAa10. An optically transparent tissue mimicking phantom for monitoring the thermal lesion produced by high intensity focused ultrasound.

Min Joo Choi, Sitaramanjaneya Reddy Guntur (Jeju National University, mjchoi@jejunu.ac.kr), Kang IL Lee (Kangwon National University), Dong Guk Paeng (Jeju National University), and Andrew Coleman (Guy's & St Thomas'Hospital)

An optically transparent tissue mimicking (TM) phantom whose acoustic properties are close to those of tissue was constructed for visualizing therapeutic effects by high intensity focused ultrasound (HIFU). The TM phantom was designed to improve a prevalent polyacrylamide hydrogel (PAG) which attenuates ultrasound far less than a tissue and does not scatter ultrasound unlike any other tissue. A modified recipe has been proposed in the study by adding scattering glass beads with diameters of 40 ~ 80 μm (0.002 % in w/v) and by raising the concentration of acrylamide (30% in v/v). The constructed TM PAG has an acoustic impedance of 1.66 Mrayls, a speed of sound of 1,573±5 m/s, an attenuation coefficient of 0.53±0.04 dB cm-1MHz-1, a backscattering coefficient of 0.23×10-3 cm-1sr-1 MHz-1 and a nonlinear parameter (B/A) of 5.5±0.2. These parameters are close to those of liver. The thermal and optical properties are almost the same as the prevalent PAG. The TM PAG was tested to visualize the thermal lesions by HIFU and the characteristic features were contrasted with those of the prevalent PAG. In conclusion, the proposed TM PAG acoustically mimics tissue far better than the prevalent PAG and would be expected to be used in assuring if a clinical HIFU device could produce the thermal lesion as planned. Keywords: tissue mimicking phantom, high intensity focused ultrasound (HIFU), ultrasound, polyacrylamide hydrogel (PAG), monitoring, thermal lesion

3aBAa11. Ultrasonic standing wave patterns in a petri-dish.

Min Joo Choi, Gwansuk Kang (Jeju National University, mjchoi@jejunu.ac.kr), Tetsuya Kodama (Tohoku University), and Andrew J Coleman (Guy's & St Thomas'Hospital)

A standing wave is well developed in a petri-dish used for cell culture, which is subject to the height of the culture fluid. A simple acoustic theory states that the pressure at the bottom of the petri-dish varies from 0 to its maximum while the height varies over a half wave length of the driving ultrasound. This suggests that the standing wave pattern should be taken into account when the cell line in a petri-dish is exposed to ultrasound. The present study has experimentally verified the theoretical prediction using the pressure sensitive film attached to the bottom of the petri-dish, when water, instead of the culture fluid, was contained in the dish. The driving field was made of 1 MHz transducer (V316, Panametrics, USA). Gradual destructuring of the standing wave patterns was observed as the driving power increased and, thus, the surface of water was becoming more fluctuating. Keywords, standing wave, petri-dish, cell, culture fluid, monitoring

3aBAa12. High-intensity focused ultrasound heating of large tissue region enhanced by cavitation bubbles at multiple focal spots.

Shin Yoshizawa, Kotaro Nakamura, Ayumu Asai, Jun Yasuda, and Shin-ichiro Umemura (Tohoku University, 6-6-05 Aoba, Aramaki, Aoba-ku, Sendai 980-8579, Japan, syoshi@ecei.tohoku.ac.jp)

High-intensity focused ultrasound (HIFU) causes selective tissue necrosis through heating and is used for a noninvasive treatment of cancer therapy. However, it has a problem of a long treatment time for a large tumor. To improve the throughput of the treatment, the development of a highly efficient method is needed. It is known that cavitation bubbles enhance the heating effect of ultrasound during ultrasonic irradiation because the increase in the energy dissipation is caused by the volumetric oscillation of cavitation bubbles. In this study, cavitation bubbles were generated at multiple spots by changing focal position of high-intensity ultrasound. Immediately after generating the bubbles, the bubbles were exposed to a wide-focused ultrasound which covers all the cavitation sites for the cavitation-enhanced heating in a large region. The behavior of the cavitation bubbles at multiple spots in a tissue-mimicking gel was observed by high-speed photography, and the coagulation performance of the developed sequence was confirmed with an experiment using excised tissue. The results showed high efficacy of the proposed method for to coagulate a large tissue region.

3aBAa13. Efficient large-scale ultrasound simulation using the k-space pseudospectral method.

Bradley E. Treeby (Research School of Engineering, College of Engineering and Computer Science, The Australian National University, Canberra ACT 0200, Australia, bradley.treeby@anu.edu.au), Jiri Jaros (Research School of Computer Science, College of Engineering and Computer Science, The Australian National University, Canberra ACT 0200, Australia), Ben T. Cox (Department of Medical Physics and Bioengineering, University College London, Gower Street, London WC1E 6BT, UK), and Alistair P. Rendell (Research School of Computer Science, College of Engineering and Computer Science, The Australian National University, Canberra ACT 0200, Australia)

Computational acoustics offers a powerful tool for investigating the interaction between ultrasound waves and the human body. However, in many common ultrasound settings, performing realistic simulations is computationally difficult due to the large size of the tissue volume compared to the size of the acoustic wavelength. This is particularly true in the case of high-intensity focused ultrasound where large diameter transducers are used to tightly focus ultrasound waves, often deep within the tissue. Here, an efficient model for large-scale ultrasound simulation is presented. The model is based on coupled first-order acoustic equations valid for nonlinear wave propagation in heterogeneous media with power law absorption. The equations are discretized using the k-space pseudospectral method and encoded using advanced programming techniques for parallel computer architectures. This allows the efficient simulation of nonlinear ultrasound propagation in three-dimensions over hundreds of wavelengths. Applications to both diagnostic and therapeutic ultrasound are discussed, and the results from several simulation examples are presented.

3aBAa14. Optically transparent gel for experimentally mimicking cavitation enhanced ultrasonic heating of tissue. Ayumu Asai, Tatsuya Moriyama, Shin Yoshizawa, and Shin-ichiro Umemura (Tohoku University, 6-6-05, Aramaki Aoba-ku Sendai, Miyagi, a.asai@ecei.tohoku.ac.jp)

High intensity focused ultrasound (HIFU) is a noninvasive method for cancer treatment. However, there is a problem of a long treatment time for treating a large volume. It is known that cavitation bubbles, generated by extremely high intensity ultrasound pulses, enhance the heating effect of HIFU. In order to investigate a cavitation-enhanced highly-efficient method of HIFU, an optically transparent gel with both ultrasonic absorption and cavitation threshold similar to biological tissue is being developed. Such a polyacrylamide (PAA) gel was successfully produced by controlling the concentrations of both acrylamide and albumin. The effect of cavitation bubbles enhancing the ultrasonic heating was measured using the gel by exposing it to HIFU. The effect was considered in the bio-heat transfer equation (BHTE) by increasing the ultrasonic absorption coefficient in the region of the cavitation, whose volume was determined by high-speed-camera observation. The absorption coefficient was calculated by fitting between the temperature rise curves at the focal point in the experiment and numerical simulation. The simulation using the obtained absorption coefficients of the gel with and without cavitation showed overall agreement with the experiment using the gel. The developed gel and method will be useful for further development of this HIFU method.

3aBAa15. Microbubble-enhanced high intensity focused ultrasound therapy: effect of exposure parameters on thermal lesion volume and temperature. Sonal Bhadane, Raffi Karshafian, and Jahan Tavakkoli (Department of Physics, Ryerson University, Toronto, ON M5B 2K3, Canada, sbhadance@ryerson.ca)

Microbubble agents have been shown to increase therapeutic effect of HIFU (high intensity focused ultrasound). Here, the effects of treatment parameters on lesion volume and temperature are investigated. Ex vivo tissue was treated with a 2 MHz HIFU beam in absence and presence of the Artenga™ microbubbles at varying HIFU focal intensities (649-2316 W/cm^2), microbubble concentrations, and exposure durations (3-10 s). The temperature was measured at 1 mm from focus using a K-type thermocouple. Thermal lesion volume was measured based on an ellipsoid model. Microbubbles increased the lesion volume and peak temperature achieved with HIFU. At the intensity of 2316 W/cm^2, the lesion volume increased by 2-folds, and the peak temperature increased by 16° C with microbubbles. This effect depended on microbubble concentration, ultrasound intensity and exposure duration. Lower intensities and shorter time durations were required at higher microbubble concentrations to ablate the tissue. It was concluded that the efficacy of the HIFU therapy in combination with microbubbles can be controlled through ultrasound/microbubble exposure parameters

3aBAa16. Measurement of high intensity focused ultrasound fields using a combined measurement and SBE modeling approach. Tao Chen (Key Laboratory of Modern Acoustics (MoE), Institute of Acoustics, Nanjing University, Nanjing 210093, China; Jiangsu Province Medical Instrument Testing Institute, Nanjing 210012, China, 13584004956@139.com), Tingbo Fan (Key Laboratory of Modern Acoustics (MoE), Institute of Acoustics, Nanjing University, Nanjing 210093, China), Liyang Xia, Jimin Hu, Ru Liu (Jiangsu Province Medical Instrument Testing Institute, Nanjing 210012, China), and Dong Zhang (Key Laboratory of Modern Acoustics (MoE), Institute of Acoustics, Nanjing University, Nanjing 210093, China)

Acoustic characterization of high Intensity focused ultrasound (HIFU) is essential for its development in clinical treatment. In the present study, a combined measurement and modeling approach is proposed. At relative low amplitude excitation, acoustic measurement in water is performed to calibrate the transmitter parameters; then the acoustic fields of HIFU transmitter can be predicted based on the SBE model. To verify the validity of this approach, a 1 MHz HIFU transmitter with large aperture is utilized in the study, and the HIFU field is measured by a HFO-660 fiber optic hydrophone. This study is helpful for the accurate characterization of HIFU fields.

3aBAa17. Activities of the cavitation bubbles in the wake of a shock pressure pulse recorded by an optical fiber hydrophone. Min Joo Choi, Sung Chan Cho, Gwansuk Kang (Jeju National University, mjchoi@jejunu.ac.kr), and Andrew J. Coleman (Guy's & St Thomas' Hospital)

The shock pulse used in an extracorporeal shock wave treatment (ESWT or ESWL) has a large negative pressure (< -5MPa) which can always produce acoustic cavitation. The resulting cavitation bubbles are known to play an important role in therapeutic effects, however, the bubble activities are not readily measurable yet. The present study considered a weird tail after the negative peak in the time history of pressure sensed by an optical fiber hydrophone which was usually abandoned in typical pressure field measurements. A shock pressure pulse in water causes change of mass density which modulates the optical refractive index. The change of the refractive index can be measured by the light reflection at the tip of the glass fiber submerged in water. The loss of water contact by cavitation bubbles at the fiber tip leads to an abnormal increase of high reflection which is clearly identified. This suggests that the weird tail of the hydrophone signal beyond the negative cycle of a shock pulse is closely related to the extent of the cavitation bubbles. This was experimentally validated in the shock wave field which was produced in water by a clinical ESWT system (ShineWave, HnT Medical, Republic of Korea) with an optical hydrophone (FOPH2000, RP Acoustics, Germany). Keywords: shock pressure pulse, ESWT, ESWL, cavitation, bubbles, optical fiber hydrophone

3365   J. Acoust. Soc. Am., Vol. 131, No. 4, Pt. 2, April 2012

Acoustics 2012 Hong Kong   3365

Session 3aBAb

Biomedical Acoustics: Ultrasound Enhanced Drug Delivery and Bone Quantification (Poster Session)

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Contributed Papers

All posters will be on display from 11:00 a.m. to 12:40 p.m. To allow contributors an opportunity to see other posters, contributors of odd-numbered papers will be at their posters from 11:00 a.m. to 11:50 a.m. and contributors of even-numbered papers will be at their posters from 11:50 a.m. to 12:40 p.m.

3aBAb1. A novel formulation of lipid microbubbles coated with stearic acid modified polyethylenimine to enhance ultrasound-mediated gene delivery in vitro. Qiaofeng Jin, Zhiyong Wang, Fei Yan, Zhiting Deng, Lu Li, and Hairong Zheng (Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, 1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, P.R. China, qf.jin@siat.ac.cn)

The aim of this study was to assess the properties of a new designed cationic microbubbles as gene carriers and the relative gene transfection efficacy with ultrasound triggered microbubble destruction. Polyethylenimine as a high efficient gene transfection agent has higher cell toxicity with molecular weight increasing. Stearic acid was used to modify branched polyethylenimine to change its hydrophilic properties so that it can be assembled onto the lipid shell of the microbubbles and simultaneously decrease its cell toxicity. Cationic microbubbles was prepared by encapsulating perfluoropropane into phospholipids and stearic acid modified polyethylenimine hybrid shell using mechanical vibration method. The mean, median size and zeta potential of the microbubbles were measured 1.84 ± 1.62um, 1.60um and 54mv respectively. Hoechst 33258 was used to stain the green fluorescent protein reporter plasmid which was charge-coupled to cationic microbubbles, and microbubbles was observed emitting blue light under a fluorescence microscope. About 4ug plasmid loaded by 10^8 microbubles that contain 5% mole ratio stearic acid modified polyethylenimine was measured by gel electrophoresis. A 1.25MHz single element transducer was used to mediate the gene transfection to MCF-7 cell by using the cationic microbubbles and enhancement of green fluorescent protein expression was observed.

3aBAb2. Paclitaxel-liposome loaded microbubbles for ultrasound-triggered drug delivery in vitro and in vivo. Fei Yan, Lu Li, Zhiting Deng, Qiaofeng Jin, and Hairong Zheng (Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, 1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, P.R. China, fei.yan@siat.ac.cn)

The aim of this work was to develop paclitaxel-liposome loaded microbubbles (PTX-loaded MBs) and to investigate the efficacy of chemotherapy through ultrasound-triggered drug delivery in vitro and in vivo. PTX-loaded liposomes were prepared by a minor modification of thin film hydration method and further conjugated to the surface of microbubbles through biotin-avidin linkage. The resulting payload-loaded MBs were characterized and applied to ultrasound assisted chemotherapy in breast cancer. Our results showed the MBs were able to achieve satisfactory drug encapsulation efficiency. Under ultrasound exposure, about 9.54-fold higher drug release and a significant improvement of cell uptake than that of loaded liposomes were observed. In addition, PTX-loaded MBs showed significantly greater tumor growth inhibition both in vitro and in vivo xenograft growth of breast tumor cells, compared with PTX-loaded liposomes and unloaded MBs. Drug distributions assay in various organs (heart, liver, spleen, lung, kidney and tumor) indicated about 3-fold higher PTX enriched in tumor. Histological examinations further demonstrated the tumor growth inhibition might contribute to increased apoptosis and reduced angiogenesis in tumor xenografts. In conclusion, the study indicated the PTX-loaded MBs significantly increased the anti-tumor efficacy and can be used as a potential chemotherapy approach for ultrasound assisted breast cancer treatment.

3aBAb3. Cytotoxicity enhancement of DOX-liposome-containing microbubbles combined with ultrasound to the multi-drug resistant cell. Zhiting Deng, Fei Yan, Lu Li, Qiaofeng Jin, Fei Li, and Hairong Zheng (Paul Lauterbur Center for Biomedical imaging, Institute of Biomedical and Health Engineering, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, 518055, zt.deng@siat.ac.cn)

Multidrug resistance (MDR) in cancer cells is a significant obstacle to successful cancer therapy. Doxorubicin (DOX) is very active chemotherapeutic agent for the treatment of breast cancer and the efficacy of DOX is also restricted by multidrug resistance.Ultrasound (US) targeted destruction of drug loaded microbubbles (MBs) is gaining more and more attention as a promising strategy for locally drug delivery. In this article, through avidin–biotin binding of DOX-containing liposomes to the microbubbles, we developed DOX-liposome-containing microbubbles in order to investigate its effect of enhancing cellular uptake and cytotoxicity of DOX against drug-resistant cancer cells. The results demonstrated that treatment of cells with ultrasound and DOX-liposome-containing microbubbles caused a significant higher drug uptake in DOX-resistant MCF-7 cells, compared with control (DOX-liposome). More importantly, a significant enhancement of tumor growth inhibition against DOX-resistant MCF-7 cells was found when using the drug-liposome-containing microbubbles combined with ultrasound.-Compared with DOX-liposome treatment, the cytotoxicity effect was greatly enhanced from 21% to 60%. By further mechanism study, DOX-loaded microbubbles plus ultrasound induced significant apoptosis in MDR line of MCF-7 cells.

3aBAb4. The estimation of bone microstructure using characteristic refraction of fast wave. Katsunori Mizuno, Keisuke Yamashita, Bunri Fujita, and Mami Matsukawa (Doshisha University, 1-3 Tatara Miyakodani Kyotanabe City Kyoto, kmizuno0417@gmail.com)

Two-wave phenomenon, known as the wave propagation of fast and slow waves, has been observed in the cancellous bones when the ultrasonic wave propagates along the trabecular alignment. It is also reported that the acoustical parameters of the fast and slow waves related to not only bone

mass but also bone microstructure. In this study, the characteristic refraction of the fast wave was focused, and a method was proposed to estimate the bone microstructure. Cylindrical specimens of cancellous bone were obtained from a bovine femur. Using a conventional ultrasound pulse technique, the receiver was moved to investigate the ultrasonic fields after the propagation in the specimen. In addition, the structure of the specimen was estimated by using the X-ray micro CT. The fast wave showed the "apparent refraction" following the trabecular alignment in the specimen, which was not observed from the slow wave behavior. The ultrasonic field after the sample propagation changed reflecting the trabecular alignment, which gives us the information of microstructure of cancellous bone. Especially, the evaluation of fast wave propagation can be useful for the estimation of bone microstructure and will support the ultrasound bone assessment in the in vivo situation.

3aBAb5. Ultrasound propagation in trabecular bone: a numerical study of the influence of micro-cracks. Samuel Callé, Hélène Moreschi, and Marielle Defontaine (Université François-Rabelais - INSERM U930 - 10 bd Tonnellé - 37032 Tours cedex - France, samuel.calle@univ-tours.fr)

The accumulation of microdamage in trabecular bone tissue is suspected of being a predictive indicator of osteoporosis diagnosis. To quantify this microdamage, the Dynamic AcoustoElastic Testing (DAET) method measures the time of flight (TOF) and amplitude variations of transmitted ultrasound (US) pulses, while the bone sample is submitted to a low frequency pressure (opening/closing of microcracks). However, DAET is both sensitive to viscoelastic properties changes and microcracks density. To estimate the microcraks density contribution, a numerical approach is proposed, allowing simulations of different levels of microdamaged media. A 2D pseudo-spectral time domain numerical model was then developed to simulate linear wave propagation in heterogeneous solids including thermo-viscous attenuation. The influence of the microcracks number, size and orientation on the US TOF and amplitude was particularly investigated. Results are discussed and compared with experimental data extracted from DAET measurements in trabecular bone samples.

3aBAb6. Application of dual frequency ultrasound method in through transmission measurements. Janne Petri Karjalainen (University of Eastern Finland, P.O. Box 1627, FI-70211 Kuopio, Finland, janne.p.karjalainen@iki.fi), Michal Pakula (Institute of Environmental Mechanics and Applied Computer Science, Kazimierz Wielki University in Bydgoszcz, ul. Chodkiewicza 30 85064 Bydgoszcz Poland), Quentin Grimal (Universite Paris 6 - CNRS, 15 rue de l'Ecole de Medecine 75006 Paris, France), Juha Töyräs (Department of Clinical Neurophysiology, Kuopio University Hospital, and Department of Applied Physics, University of Eastern Finland, P.O. Box 1627, FI-70211 Kuopio, Finland), Jukka Sakari Jurvelin (University of Eastern Finland, P.O. Box 1627, FI-70211 Kuopio, Finland), and Pascal Laugier (Universite Paris 6 - CNRS, 15 rue de l'Ecole de Medecine 75006 Paris, France)

Soft tissue layers overlying bones, with unknown thickness, can produce significant errors to bone quantitative ultrasound measurements. In this study dual frequency ultrasound (DFUS) technique, developed originally for pulse-echo measurements, is applied and evaluated in a configuration typical to clinical through-transmission measurement. A mathematical algorithm is presented for determination of soft tissue composition, i.e. amount of lean and fat tissue, and correction of typical clinical parameters such as broadband ultrasound attenuation (BUA) and speed of sound (SOS). Ultrasound soft tissue phantoms mimicking lean and fat tissues, were tested in five different configurations by varying the composition (0-100% of fat). Different configurations were built using 10mm of fat or lean and 30mm of fat or lean, and total thickness of soft tissue constructs varied from 20mm to 40mm. Using through-transmission measurements at 0.5 MHz center frequency the thickness of soft tissue layers could be determined using DFUS technique (low and high frequency band 0.4-0.45 and 0.55-0.6 MHz, respectively). The average absolute error of fat/muscle layer thickness was 2.2mm (SD=1.3mm). The results suggest that DFUS technique may be used in through-transmission to assess the soft tissue content over/underlying the bone, and subsequently to reduce soft tissue induced errors in quantitative ultrasound measurements.

3aBAb7. Age-dependence and variation of elastic properties and cortical porosity in human femoral neck and shaft. Markus Kalle Henrik Malo (Department of Applied Physics, University of Eastern Finland, Kuopio, Finland, markus.malo@uef.fi), Daniel Rohrbach (Julius Wolff Institut & Berlin-Brandenburg School for Regenerative Therapies, Charité - Universitätsmedizin Berlin Augustenburger Platz 1, 13353 Berlin, Germany), Hanna Isaksson (Division of Solid Mechanics, Lund University, Lund, Sweden), Juha Töyräs (Department of Applied Physics, University of Eastern Finland, Kuopio, Finland), Jukka Sakari Jurvelin (Department of Applied Physics, University of Eastern Finland, Kuopio, Finland), and Kay Raum (Julius Wolff Institut & Berlin-Brandenburg School for Regenerative Therapies, Charité - Universitätsmedizin Berlin Augustenburger Platz 1, 13353 Berlin, Germany)

Tissue level structure and mechanical properties are important determinants of macroscopic bone strength. Scanning acoustic microscopy (SAM) provides maps of local elasticity in bone. The present aims were to evaluate spatial variations of elastic and structural properties in human femoral neck and shaft, and their variations with age. A total of 48 transverse cross-sectional bone samples were obtained from femoral neck (Fn) and proximal shaft (Ps) of 24 cadavers (21 men, 4 women; age 49.2 ± 16.3 years). Samples were measured with a custom SAM using a 50-MHz ultrasound transducer. Distributions of the elastic coefficient c_{33} of cortical (Ct) and trabecular (Tr) tissues and microstructure of cortex (cortical thickness Ct.Th and porosity Ct.Po) were investigated (ANOVA). Significant variations in c_{33} were observed with respect to tissue type (trabecular < cortical), location (Ct.Ps=32.3GPa > Ct.Fn=29.9GPa > Tr.Ps=28.9GPa > Tr.Fn=26.9GPa, and cadaver age. Regional variations in Ct.Po were found in the neck (inferior 6.7%; superior 13.2%; anterior 11.3%; posterior 9.1%) and in the shaft (medial 9.3%; lateral 8.0%; anterior 8.3%; posterior 12.9%). This study provides a comprehensive database of age-dependent spatial distributions of microstructural and microelastic properties in the femoral neck and shaft.

3aBAb8. Numerical investigation of ultrasound reflection properties in cancellous bone. Atsushi Hosokawa (Akashi National College of Technology, hosokawa@akashi.ac.jp)

Bone is composed of two components of cancellous and cortical bones, and cancellous bone is generally surrounded by cortical bone. Therefore, ultrasound waves propagating in bone can reflect at the boundary between cancellous and cortical bones. In this study, the ultrasound reflection properties in cancellous bone were numerically simulated using a finite-difference time-domain (FDTD) method with microcomputed tomographic (μCT) models of the bone. From the simulated results, it was investigated how the ultrasound waves propagating in cancellous bone could reflect at the boundary. The reflected waveform at normal incidence to the boundary was calculated using the numerical model comprised of two layers of cancellous and cortical bones, and only the reflection properties were derived by subtracting the waveform calculated using the model adopting the absorbing boundary condition instead of the cortical bone layer. In the case of the strong trabecular orientation parallel to the ultrasound propagation, the reflections of both fast and slow longitudinal waves could be observed.

3aBAb9. Analytical model of Dynamic AcoustoElastic Testing measurements in trabecular bone tissue: a rheological approach. Hélène Moreschi, Samuel Callé, Chloé Trarieux, and Marielle Defontaine (Université François-Rabelais INSERM U930 - 10 bd Tonnellé - 37032 Tours - France, helenemoreschi@gmail.com)

A dynamic acoustoelastic testing (DAET) method based on the interaction of two acoustical waves was developed to measure viscoelastic properties of trabecular bone tissue. While a sinusoidal low-frequency (LF) acoustic wave successively compresses and expands the medium, ultrasonic (US) pulses are generated to probe the uniformly stressed medium (quasistatic pressure, pLF). The US pulses velocity and amplitude (c, A) vary with respect to the medium stress level. These modulations (c(pLF)-c(0); A(pLF)-A(0)) are plotted as a function of the instantaneous LF pressure. From these rheograms, nonlinear elastic and viscous (dissipative) parameters, β' and β'' respectively, are extracted. Since the US velocity is directly related to the medium viscoelastic modulus (M*), considering either the celerity variations or the modulus variations as a function of LF pressure is equivalent. In this perspective, we developed an analytical model of the variations of M*, derived from the Kelvin-Voigt approach (M* as a function of

pLF), introducing linear (M', M") and nonlinear (β', β") viscoelastic moduli. This model was first validated in water and Newtonian oils. In this paper we present preliminary results derived from measurements in the calcaneum, a highly inhomogeneous and porous trabecular bone tissue exhibiting hysteretic loops and asymmetry in rheograms.

3aBAb10. Influence of healing time on the echographic response of the bone-implant interface. Vincent Mathieu, Romain Vayron (CNRS, Université Paris-Est, Laboratoire Modélisation et Simulation Multi Echelle, UMR 8208 CNRS, 61 avenue du Général de Gaulle, 94010 Créteil, France, vincent.mathieu@u-pec.fr), Emmanuel Soffer, Fani Anagnostou (CNRS, Université Paris-Diderot, Laboratoire Bioingénierie et Biomécanique Ostéo Articulaire, UMR 7052 CNRS, 10 avenue de Verdun, 75010 Paris, France), and Guillaume Haiat (CNRS, Université Paris-Est, Laboratoire Modélisation et Simulation Multi Echelle, UMR 8208 CNRS, 61 avenue du Général de Gaulle, 94010 Créteil, France)

The study aims at investigating the effect of bone healing on the ultrasonic response of coin-shaped titanium implants. Sixteen implants were inserted on the tibiae of rabbits. Two groups of eight samples were considered, each group corresponding to a healing duration (7 or 13 weeks). After the sacrifice, the ultrasonic response of the bone-implant interface was measured in vitro at 15 MHz with a 2-D scanning device. The average value of the ratio r between the amplitudes of the echo of the bone-implant interface and of the water-implant interface was determined. The fraction of implant surface in contact with bone was measured by histomorphometry. The ultrasonic quantitative indicator r decreases significantly with healing time ($p = 2.10^{-4}$, from $r = 0.53$ to $r = 0.49$). Two phenomena are responsible for the decrease of the gap of acoustical impedance at the bone-implant interface: i) the increase of mineralization of newly formed bone tissue and ii) the increase of the bone-implant contact fraction (from 27 % to 69 %).

3aBAb11. Experimental investigation of a bone-conducted ultrasonic hearing system based on a DSP platform. Ziying Yu (Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, No. 21, North 4th Ring Road West, Haidian District, Beijing 100190, P.R. China, yuziying@mail.ioa.ac.cn), Junxian Shen (State Key Laboratory of Brain and Cognitive Science, Institute of Biophysics, Chinese Academy of Sciences, Beijing, China), and Jun Yang (Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, No. 21, North 4th Ring Road West, Haidian District, Beijing 100190, P.R. China)

Ultrasonic signals can be conducted and perceived by bones when a certain part of human skull is pressed. Experiments show that hearing-impaired people may be able to perceive ultrasound, distinguish different frequencies, or even recognize words after training. This finding is very promising for hearing-aid studies. In this paper, a novel bone-conducted ultrasonic (BCU) hearing system is developed. Both the software simulations and experiments on human subjects are carried out. The BCU hearing system is implemented on a DSP platform to achieve an appropriate modulation strategy. An ultrasonic vibrator is attached to the system, allowing the audible sound signals to be demodulated from the ultrasonic region via bone conduction. Different carrier frequencies and modulation algorithms are examined and validated in this platform. To evaluate system performance, perception tests are also conducted on the deaf and normal-hearing subjects. Experimental results show that the proposed system can operate as a flexible experimental platform suitable for BCU hearing studies.

3aBAb12. Estimation of the radiation force on implanted medical devices: a theoretical study. Samuel Callé (Université François-Rabelais INSERM U930 - 10 bd Tonnellé - 37032 Tours - France, samuel.calle@univ-tours.fr), Guillaume Ferin (Vermon - 180 rue du général Renault - BP 93813 - 37038 Tours cedex 1 - France), and Jean-Pierre Remenieras (Université François-Rabelais INSERM U930 - 10 bd Tonnellé - 37032 Tours - France)

Implantable medical devices, such as pacemaker or insulin pump, are more and more used to extend or improve the quality of life. The radiation force could actually be a solution to remotely control these devices in different applications (energy supply, drug delivery control...). The aim of this work is to quantify the amplitude and spatial repartition of the ultrasound radiation force which could be applied on such a system. Reflection of the incident acoustic beam at the interface (surface force) and attenuation of the US beam along the wave path (body force) both contribute to this force. In this study, these force contributions have been calculated in the case of a device implanted one centimeter under the skin. First, a heterogeneous axisymetric pseudo-spectral time domain method is used to estimate the ultrasound particle velocity and acoustic pressure (amplitude, spatial repartition) inside the device and at the interface. These parameters are then inserted in analytical expressions to precisely calculate the force applied on the implantable device. Surface and body forces contributions have been analyzed and the global force estimated for two configurations of 5 MHz transducers (plane and focused) and two types of device mechanical characteristics (semi-rigid and rigid).

Session 3aEAa

Engineering Acoustics: Acoustic Well Logging and Borehole Acoustics II

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Hailan Zhang, Cochair
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Invited Papers

8:20

3aEAa1. Low frequency broadband monopole transducer based on trilaminar bender bar structures. Dai Yuyu, Wang Xiuming, Xin Penglai, and Cong Jiansheng (Institute of Acoustics, Chinese Academy of Sciences, daiyuyu001@126.com)

A transducer which is produced by a skeleton and four Trilaminar bender bar vibration elements is presented in the paper. Four vibration elements formed a square array are excited by the same signal to realize monopole radiation. The influence of the skeleton is taken into account: flexural mode of vibration of the skeleton is used to extend the bandwidth. The transmitting voltage response of a modeling result shows that there are two peaks existed close to 1.8 kHz, which correspond to the 2nd order flexural mode of the Trilaminar bender bar and the 1st order flexural mode of the skeleton. The -3dB operational frequency range from 16.6kHz to 20.2kHz. The directivity patterns reflect that transducer can realize a monopole radiation in the horizontal plane before 13kHz.

8:40

3aEAa2. Design of multi-functional ultrasonic imaging logging tool. Zhifeng Sun (COSL, P.O. Box 232, Bejing, China, sunzf@cosl.com.cn), Ao Qiu, Wenliang Wang, Aihua Tao, Honghai Chen, and Xien Liu

By analyzing the measurement principle of the ultrasonic impulse method, a kind of Multi-functional ultrasonic imaging logging tool was designed and the implementation of its measurement technique was given. mainly contains the components of the tool, the realization of electronic sections and the measurement specifications. It can conduct borehole surface imaging in high resolution in the opened-hole. It can also conduct casing inspection and cement bonding evaluation in the cased-hole. The proposed tool was tested in the field of opened-hole and cased-hole. It shows that this tool can evaluate the geologic feature's informations, such as fracture, vug and bedding structure in the opened-hole. The casing thickness imaging, inner and outer diameter imaging and cement impedance imaging also can be measured in the cased-hole.

Contributed Papers

9:00

3aEAa3. Study on the discrimination of the second interface bonding conditions using characteristics of the first arrivals in cased boreholes. Xiumei Zhang (State Key Laboratory of Acoustics, Institute of Acoustics, Chinese Academy of Sciences, No. 21, 4th Northwestern Ring RD, Haidian District, Beijing 100190, P.R. China, zhangxiumei@mail.ioa.ac.cn), Xien Liu, Honghai Chen (Well-Tech R&D Institutes, COSL, Hebei 101149, P.R. China), and Weijun Lin (State Key Laboratory of Acoustics, Institute of Acoustics, Chinese Academy of Sciences, No. 21, 4th Northwestern Ring RD, Haidian District, Beijing 100190, P.R. China)

The evaluation of cementing bonding conditions influence the production of oil or gas in cased boreholes. Many researchers have focused their studies on identifying the cementing quality of the first and second interface, and provide lots of methods in evaluating the bonding conditions of the first interface, while for the second interface, remain a difficult problem till now. In this paper, the propagation velocity and amplitude of the first arrivals with different cement qualities, together with different channeling for the same cased hole are studied. The results show that for poor first interface bonding conditions, the velocity of the first arrival almost doesn't change with different channeling, while for poor second interface bonding

conditions, the velocity varies greatly with different channeling. Specially, Time-Frequency Analysis on different cementing conditions are conducted, the analysis indicate that there is a relative large energy peak of the first arrivals for all poor first interface, while for poor second interface, which is not the case. As a result, the propagation velocity and the time frequency distributions rather than the amplitude of the first arrivals can evaluate the second interface bonding conditions.

9:20

3aEAa4. Radial detection depths of borehole Stoneley modes. Xiao He and Xiuming Wang (State Key Laboratory of Acoustics, Institute of Acoustics, Chinese Academy of Sciences, No. 21, 4th Northwestern Ring Rd, Beijing 100190, China, hex@mail.ioa.ac.cn)

Propagation features of Stoneley modes are widely used for measurements of reservoir permeability and rock anisotropy in acoustic logging. Through the finite difference algorithm, the radial detection depth of the Stoneley wave along a fluid-filled borehole is investigated. The radial variations of the displacement components U_r for Stoneley wavefronts are presented as the particle motions in that direction are controlled by the permeability and transverse shear modulus of the medium surrounding the

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wellbore. It is shown that the Stoneley-wave energy reaches a peak value at the borehole wall and attenuates exponentially with the increasing radial depth in the formation. By comparison of reflected Stoneley-wave amplitudes from reflectors with various distances to the borehole wall, the prospecting depths of Stoneley modes can be confirmed. It is generally no more than 0.2 meters with the frequency range of acoustic logging. This result reveals that only a very shallow region around the wellbore can be detected from the Stoneley-wave responses.

3aEAa5. Processing dipole acoustic logging data to image fracture network in shale gas reservoirs. Zhuang Chunxi, Su Yuanda, and Tang Xiaoming (China University of Petroleum, Qingdao, Shandong 266555, zhuangchunxi@sina.com)

A recent advance in borehole remote acoustic reflection imaging is the utilization of a dipole acoustic system in a borehole to emit and receive elastic waves to and from a remote geologic reflector in formation. An important application of this new technique is the delineation of fracture network in shale gas reservoirs, as interest and activities in shale gas exploration increase in China. We develop a data processing procedure and implement it to handle routine processing of dipole acoustic logging data. The procedure takes into account the characteristics of the dipole data, such as frequency, dispersion, attenuation, recording length, and dipole source orientation, etc., to obtain an image of reflectors within 20~30 meters around the borehole. We have applied the technique to process dipole acoustic data from several wells drilled into gas reservoirs in China. The obtained images clearly identify major fracture network in the gas producing intervals of the reservoir, demonstrating the effectiveness of the imaging technique.

3aEAa6. Acoustic wave propagation in cracked porous rocks and application to interpreting acoustic log data in tight formations. Xiaoming Tang and Xuelian Chen (China University of Petroleum, Qingdao, Shandong 266555, tangxiam@yahoo.cn)

Rocks in earth's crust usually contain both pores and cracks. Typical examples include tight sandstone and shale rocks that have low porosity but contain abundant microcracks. By extending the classic Biot's poroelastic wave theory to include the effects of cracks, we obtain a unified elastic wave theory for porous rocks containing cracks, adding crack density and aspect ratio as two important parameters to the original theory. The new theory is applied to interpret acoustic velocity log data from tight sand and shale gas formation, whereas the classic Biot theory has difficulty in explaining such data. Because the flat- or narrow-shaped cracks can easily deform under acoustic wave excitation, the acoustic property of a cracked porous rock is quite different for different saturation conditions. This allows the new theory to correctly predict the trend of velocity variation with gas saturation in low-porosity rocks, providing a useful interpretation tool for acoustic logging in tight formations.

3aEAa7. Effects of eccentric acoustic source on the amplitude and arriving time of the first arrival in cased boreholes. Dehua Chen, Xiuming Wang, Hailan Zhang, and Weijun Lin (State Key Laboratory of Acoustics, Institute of Acoustics, Chinese Academy of Sciences, No. 21, Bei-Si-Huan-Xi Rd., Haidian District, Beijing 100190, China, chendh@mail.ioa.ac.cn)

The acoustic fields excited by eccentric acoustic source in cased boreholes bonded by cements with different densities are simulated numerically using 2.5-dimension (2.5D) finite-difference method (FDM). The effects of the source eccentricity on the amplitude and arriving time of the first arrival (FA) in the full waveform are investigated. The numerical results show that the amplitude of the FA will decrease quickly and its arriving time will go ahead as the source eccentricity increases. The change of the arriving time can be estimated approximatively using geometrical acoustics theory. As the eccentric distance of the acoustic source reaches 1/4 of the borehole radius, the amplitude of the FA will reduce to below 20% of the centered

case. The quantitative varying trends of the amplitude and arriving time of the FA are the same both in the free pipe and in boned pipe. Therefore, during the cementing evaluation, the tool's eccentricity should be estimated through the arriving time of the first arrival, and then its amplitude should be corrected according to the eccentricity. Otherwise, when the interface between the steel pipe and the cement is not boned well, the over-optimistic cementing evaluation could be led to because of the large reduction of the FA's amplitude aroused by eccentric acoustic source.

3aEAa8. Phase spectrum correlation method to extracting anisotropic parameters from four-component dipole waveforms. Xiao-Hua Che, Rui-Jia Wang, and Wen-Xiao Qiao (State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing 102249, China, aclab@cup.edu.cn)

The anisotropy parameters extracted from 4-component dipole waveforms are always affected by dispersion of mode waves, the distribution of stress, the invasion zone and so on. It is impossible to extract the real anisotropy parameters in time domain process. In this paper, we develop a phase spectrum correlation method (PCM) to extract the anisotropic parameters in frequency domain. The PCM searches the real slowness difference of fast and slow flexural waves by comparing the coherence of phase spectra of the fast wave and slow wave. Contrast to the traditional time domain method, this method offers not only the normal shear anisotropy parameters but also an anisotropic map, an anisotropic monitor curve and so on, which can make the interpretation conclusion more reliable. The PCM is verified by both synthesized multi-pole array waveforms and experiment data. The results show that this method is fast and stable for anisotropy analysis.

3aEAa9. Dispersion measurement of acoustic field excited by dipole sources in fluid-filled borehole. Rui-Jia Wang, Wen-Xiao Qiao, and Xiao-Hua Che (State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing 102249, China, wruijia@foxmail.com)

The flexural wave in fluid-filled borehole excited by dipole sources is dispersive wave. To obtain the phase slowness of dispersive waves, firstly we made several small-scaled model wells, and then measured the acoustical field excited by dipole sources. We researched three kinds of formation, including hard formation (aluminum well models), soft formation (nylon well models) and anisotropy formation (bakelite well models). For hard formation, the flexural mode is the main propagation wave mode in the measured waveforms, and the extracted dispersion curves are well agreed with theory curves. For soft formation, the measured dispersion curves do not well agree with theory curves due to the existence of stoneley wave mode. We drilled seven holes in the anisotropic media with different dip angles. This paper only studied the 7th borehole, whose axis is perpendicular to the symmetry's in this media, which is also called HTI formation model. For the HTI formation model, we observed that the dispersion curve of the slow flexural wave is obviously higher than that of fast flexural wave at the frequency plotted, which is consistent with the theory that the dispersion curves of slow and fast flexural wave arrays for intrinsic anisotropy formation are uncrossed.

3aEAa10. Decreasing casing deformation by using cross-dipole acoustic logging data. Baohua Huang, Hao Chen, and Jianqiang Han (Institute of Acoustics, Chinese Academy of Science, huangbh@mail.ioa.ac.cn)

For increasing oil production, it is necessary to inject water into formations continuously during the oil field development. If the injection pressures are not controlled in a proper range according to in-situ stresses, it can lead to a serious imbalance of horizontal geostresses around the borehole and a higher reservoir pressure. And this will therefore cause casing deformations after a long-term exploitation. The paper presents an approach to acquire anisotropy parameters of the formation and evaluate the distribution

and magnitude of in-situ stresses by using cross-dipole acoustic logging data (XMAC). Together with electronic imaging results, we can conclude an appropriate design of injection wells and thus decrease casing deformation. This approach conducted on Daqing Oilfield shows efficiency and greatly increases the economic profit.

12:00

3aEAa11. Research on sensitivity of dipole receiving transducers.
Chengxuan Che, Xiuming Wang, Dehua Chen, and Jiansheng Cong (Institute of Acoustics, Chinese Academy of Sciences, chechengxuan@mail.ioa.ac.cn)

The dipole receiving transducers play an important part in Cross-dipole array acoustic well logging tools. It is necessary to study the properties of the dipole receiving transducer, especially the sensitivity of it. In this paper, transducers in two ways of wiring, including parallel connection and series connection, were considered numerically and experimentally. The sensitivities obtained by numerical and experimental method respectively were contrasted. The results show that as a receiving transducer, the receiving sensitivity in series connection is higher, which can guide us in the dipole receiving transducer design. Keywords: dipole, receiving sensitivity, receiving transducer

12:20

3aEAa12. Numerical study on the acoustic field in noncircular elastic pipes filled with fluid. Hailan Zhang, Chengxuan Che, Xiao He, and Xiuming Wang (Institute of Acoustics, Chinese Academy of Sciences, State Key Laboratory of Acoustics, 21 Beisihuanxilu, Beijing 100190, China, zhanghl@mail.ioa.ac.cn)

Due to the high cost of real field test, the testing and calibration of acoustical logging tools are usually conducted in a steel pipe filled with fluid. The information provided by the calibration in a circular pipe is not proper for nonaxisymmetric dipole tools. So the possibility of using a noncircular pipe filled with fluid for the testing and calibration of acoustic dipole logging tools is considered. In our previous report the acoustic fields generated by a dipole source in the noncircular fluid waveguide with the rigid wall were numerically studied using the finite-element software package of Comsol Multiphysics. So called 2.5D method has been used. The transformed acoustic field in a frequency wave-number domain is calculated first and from which the acoustic field in the time space domain was obtained by a 2D Fourier transformation. In this report the method is extended to include an elastic wall instead of the rigid boundary of the fluid waveguide. The results show that the contribution of the elastic wall is significant to the whole acoustic field and the propagating modes in the waveguide are coupling of the modes in the fluid part with that in the elastic wall.

WEDNESDAY MORNING, 16 MAY 2012   S221, 8:20 A.M. TO 12:00 NOON

Session 3aEAb

Engineering Acoustics and Physical Acoustics: Acoustic Metamaterials III (Lecture/Poster Session)

Michael Haberman, Chair
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Contributed Papers

8:20

3aEAb1. Numerical simulation of noise induced by contact between two rough surfaces. Dang Viet Hung and Le Bot Alain (Laboratoire de Tribologie et Dynamique des Systèmes, 69134 Ecully Cedex, France, viet-hung.dang2@ec-lyon.fr)

The roughness noise generated during the sliding of two rough surfaces under light load is a complex phenomenon which is relevant to mechanics of multi contact interfaces. The objective of this study is to estimate the statistical properties of the local dynamic inaccessible to measurement (shock rate, shock duration, probability density function of local forces). A numerical approach based on a modal development has been proposed with two algorithms, penalty or Lagrange multipliers, to compute the contact force and six time integration schemas. The validity and the efficiency of this approach is discussed. In terms of CPU time, the comparisons show that the proposed approach is better than the classical finite element method. The analysis also shows that the source mechanism of roughness noise is the presence of shocks occurring between antagonist asperities transforming a part of kinetic energy into acoustical energy. It is also shown that roughness noise level is simultaneously an increasing function of the logarithm of the surface roughness and the sliding speed. Microscopically, the shock rate, the

shock duration, the power being injected by individual shocks are correlated with these two macroscopic parameters.

8:40

3aEAb2. Complex-modulus measurement by longitudinal vibration testing using pulse wave. Hong Hou, Liang Sun, and Jianhua Yang (Northwestern Polytechnical University, houhong@nwpu.edu.cn)

Paper presents a method to measure the complex modulus of rigid viscoelastic materials by the longitudinal vibration testing. In the measurement, one end of a rod of the material is driven by a transducer using a pulse wave and the other end is allowed to move freely. The Complex-modulus is calculated from the displacement ratio between the driven end and the free end. The displacement of the rod end is measured by an accelerometer whose mass load should be considered since the accelerometer is attached to the rod. The displacement ratio can be obtained over a wide frequency range because the driven signal of the pulse wave is a broadband signal. The Complex-modulus can then be determined at resonant frequencies. Some rigid viscoelastic rods are measured and the measured results agree well with that of commercial viscoelastic instrument.

9:00

3aEAb3. Effective mass density for periodic solid-fluid composties. Jun Mei (South China University of Technology, phjunmei@scut.edu.cn), Ying Wu (King Abdullah University of Science and Technology), Zhengyou Liu (Wuhan University), and Ping Sheng (Hong Kong University of Science and Technology)

Effective mass density is one of the basic parameters in the study of acoustic wave propagating in fluid-solid composites. Based on the multiple-scattering theory, an analytic solution of the dynamic effective mass density for composites with solid inclusions immersed in fluids periodically in two dimensions is obtained in the low frequency limit. When the concentration of solid is small, the dynamic mass density can be described by an angle-dependent dipole solution and the angle-dependence vanishes if the structure has a four- or six-fold symmetry. When the solid concentration is getting large, the dynamic mass density differs from the dipole solution and also becomes structure-dependent even for square and hexagonal lattices. The Wood's formula is accurately valid, independent of the structures, at any solid concentrations. Numerical evaluations from the analytic solution are shown to be in excellent agreement with finite-element simulations. In the vicinity of the tight-packing limit, the dynamic mass density exhibits a universal behavior independent of the lattice symmetry. Support of this work comes from KAUST Start-up Package, National Natural Science Foundation of China (Grant No. 10804086), the Ph.D. Programs Foundation of Ministry of Education of China (Grant No. 200804861018) and Hong Kong RGC grant HKUST 604207.

9:20

3aEAb4. Experimental investigation of elastic modes localized within a defect in a phononic slab. Bernard Bonello, Olga Boyko, Mathieu Rénier, and Rémi Marchal (INSP - University Paris 6; 4 place Jussieu 75252 Paris cedex 05, bernard.bonello@insp.jussieu.fr)

Heterostructures with periodic variations of both their optical refractive index and their elastic properties may induce band gaps for both electromagnetic and acoustic waves. As a consequence of the expected enhancement of the acousto-optic interactions, these artificial materials, called "PhoXonic crystals", are of primary interest for new sensing applications. In this context, we have experimentally studied the localization of elastic energy within a defect. The heterostructures consist in arrays of voids periodically drilled throughout silicon plates (graphite symmetry) and featuring a vacancy, or a line of vacancies. An all-optical experimental technique allows for both the generation and the detection of the elastic guided waves. The non-contact probing allows one to monitor the displacements field inside the defects. First, we have measured the dispersion of broad band elastic waves guided in between the free surfaces of the sample. Then narrow band elastic guided waves, whose central frequency corresponds to resonance modes of the cavity are generated. The optical probe allows for the measurement of the out-of-plane displacements associated to the elastic modes localized within the cavity or transmitted through the phononic structure. The spatial distribution of elastic energy inside the cavity is measured and compared with numerical predictions. This work is supported by the European Community through the FET-Open project "TAILPHOX" (Grant No. 233883).

9:40

3aEAb5. Elastic metamaterials with negative bands. Ying Wu (King Abdullah University of Science and Technology, ying.wu@kaust.edu.sa), Yun Lai (Soochow University), Ping Sheng, and Zhaoqing Zhang (Hong Kong University of Science and Technology)

The unusual properties of a metamaterial come from special resonances supported by its resonating structure units. Guided by a previously developed effective medium theory, which links the resonances of the microstructures and the unusual properties, two types of elastic metamaterials in two dimensions were designed with different resonant structures in their building blocks that exhibit multiple negative dispersion bands with special characteristics. The first type possesses negative mass density and negative shear modulus simultaneously over a large frequency regime, which leads to a negative band for shear waves only. Mode conversion takes place at the interface of the metamaterial and the common solids. The second type is able to produce negative effective moduli in different frequency regimes within a large frequency regime of negative effective mass density. This results in a super anisotropic negative band and a negative band that only compressional is allowed. All of these unusual properties are demonstrated by simulations. This work was supported by Hong Kong RGC Grant No. 605008, HKUST604207 and KAUST start-up package.

10:00

3aEAb6. Negative stiffness metamaterials and periodic composites. Michael R. Haberman, Timothy D. Klatt, Preston S. Wilson (Applied Research Laboratories & The Department of Mechanical Engineering, The University of Texas at Austin, Austin, TX, haberman@arlut.utexas.edu), and Carolyn Seepersad (The Department of Mechanical Engineering, The University of Texas at Austin, Austin, TX)

The creation of negative stiffness (NS) metamaterials is of interest for damping treatments, vibration isolation, and even more exotic applications such as acoustic lenses displaying negative refraction. This work will present ongoing efforts to produce NS metamaterial elements that rely on a bistable microscale geometry that leads to NS under quasistatic loading conditions. A candidate bistable microstructure employing thermal mismatch will be introduced along with finite element simulations predicting its full stiffness tensor. Effective medium modeling will show the broadband utility of these elements to enhance acoustic absorption for low volume fraction bi-material composites. The special case of a bi-material periodic composite containing NS inclusions will then be explored. It will be shown that a periodic composite containing NS inclusions permits the simultaneous elimination of the acoustic branch and reduction of the lower frequency of the optical branch passband to arbitrarily low frequencies. Physical interpretations of these results and potential applications will be discussed. *This material is based upon work supported by the U. S. Army Research Office under grant number W911NF-11-1-0032.*

10:20

3aEAb7. Vibroacoustic characteristic of membrane-type acoustic metamaterials. Yuguang Zhang and Jihong Wen (Key Laboratory of Photonic and Phononic Crystals of Ministry of Educationand Institute of Mechatronical Engineering, National University of Defense Technology, Changsha 410073, China, zyg00192@163.com)

Acoustic barriers with effective sound insulation performance can find many useful applications in the area of aerospace, automotive vehicles and environmental noise control. However, traditional acoustic barriers are always not effective at low frequencies due to the mass law. Membrane-type acoustic metamaterials have been shown to exhibit unique sound insulating performance at low frequencies (100-1000Hz). The structure of membrane-type acoustic metamaterials can be simplified as a stretched, rim fixed membrane carrying a distributed mass. There are publications on beams, rods and plate with uniformly distributed mass, but the vibration equation of membrane is different from the plate, and the presence of air around the membrane needs to be properly included. In this paper, we present an analytical model of this type acoustic metamaterials. The transmission loss and vibration characteristic are then described using the coupled structural-acoustic model. The validity of the model is confirmed by comparing our analytical results with the FEA calculations and experimental measurements in existing publications.

10:40–11:00 Break

The following abstracts will be presented in poster format. The posters will be on display and the authors will be at their posters from 11:00 a.m. to 12:00 noon

3aEAb8. An investigation on polymer modulus test using laser-based finite element method. Yao Yin, Bi-Long Liu, Guo-Feng Bai, Cheng-Guang Zhou, and Ke Liu (Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, No. 21, North 4th Ring Road West, Haidian District, Beijing 100190, P.R. China, yinyao@mail.ioa.ac.cn)

A laser-based finite element(FEM) method for determination of the complex modulus of visco-elastic material is re-examined in this paper. The parametric sensitivity on FEM inverse algorithm and the applicable scope on material damping are investigated. Measurement of time-temperature superposition (TTS) has been achieved at the developed test systems. The discrepancy is within 10% in comparison with the measured date from a commercial Dynamic Mechanical Analysis (DMA), and this validates the accuracy of the developed test system.

3aEAb9. An effective medium approach and elastic metamaterials. Pai Peng and Ying Wu (King Abdullah University of Science and Technology, pai.peng@kause.edu.sa)

Metamaterials are artificial materials that are designed to manipulate waves as desired. The unusual properties of a metamaterial are derived from its complex building blocks which make the development of effective medium theory challenging. In this work, effective medium parameters, such as anisotropic mass density and moment of inertia, are obtained for metamaterials based on mechanical models consisting of masses and springs. The effective moment of inertia is capable of providing a clear understanding of the mechanism of rotational modes which are widely observed in both two- and three-dimensional phononic crystals and metamaterials. The effective medium descriptions are served as guidance in the engineering of the building block to achieve rich resonances that lead to intriguing properties of the metamaterial. (Support of this work comes from KAUST Start-up Package)

3aEAb10. Elastic wave scattering by periodic axisymmetric cavities in viscoelastic materials : theory and experiment. Guofeng Bai (Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, No. 21, North 4th Ring Road West, Haidian District, Beijing 100190, P.R. China, bgf@mail.ioa.ac.cn), Bilong Liu, Ke Liu, and Fusheng Sui

The reflection, transmission and absorption performance of periodic axisymmetric cavity in viscoelastic materials are analyzed by multiple

scattering(MS) method. Based on MS method of elastic wave, the transition matrix between the incident wave and scattered wave is obtained by the numerical integrals for cavity surface. Meanwhile, the complex modulus of viscoelastic materials is measured by dynamic mechanical thermal analysis and time-temerature equivalent theory. With transfer function method in water tube, the absorption coefficient curves of different specimens of rubber materials containing cylindrical cavities are obtained. The measuring results are compared with that of MS method and also verified experimentally. The results indicate energy attenuation in viscoelastic materials depends on cavity scattering properties.

3aEAb11. A micro-machined high-Q film bulk acoustic resonator for chip-scale atomic clock. Liang Tang, Quan Sun, Min Qi, and Donghai Qiao (Institute of Acoustics, Chinese Academy of Sciences, Beijing, P.R. China, tangliang@mail.ioa.ac.cn)

Taking advantage of its low power consumption and small volume, Chip-Scale Atomic Clock (CSAC) will play a critical role in portable applications, underwater communication systems, unmanned aerial vehicles, underwater sensor systems and geophysical equipments. It has aroused great research interest in these years. Traditionally, the 3.4GHz Voltage Controlled Oscillator (VCO) applied to 87Rb atomic clock is based on the frequency multiplier method of a high stable crystal oscillator. It's power hungry and can not satisfy the requirement of CSAC. Based on the fact that SiO2 film can both compensate the Temperature Coefficient of Frequency (TCF) of Film Bulk Acoustic Resonator (FBAR) and improve the Q-factor of FBAR's high-order resonance, a film bulk acoustic resonator with resonant frequency 3.4GHz, Q-factor better than 500 and TCF better than 20ppm per K was designed and fabricated with a micro-machined method, which satisfied the requirement of CSAC. The authors would thank National Natural Science Foundation of China for the support under contract number 11104313.

Session 3aHT

Hot Topics: Noise Around Airport

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Chair's Introduction—8:15

Invited Papers

8:20

3aHT1. Noise improvement measures of Hong Kong International Airport. Tim Wan Choi Hung and Chee Kwan Lee (Environmental Protection Department, Hong Kong SAR, 26th Floor Southorn Centre, Hong Kong, timhung@epd.gov.hk)

Hong Kong International Airport (HKIA) at Chek Lap Kok was designed in the early 90s and commenced operation in 1998 to meet Noise Exposure Contour (NEF) 25 standard under the Hong Kong Planning Standards and Guidelines. No new noise sensitive receiver is to be located within the NEF 25 contour. The NEF 25 contour of the airport covers largely sea areas. Only a small number of acoustically insulated village houses close to the airport marginally lie within the NEF25 contour. Despite all these planning efforts, aircraft noise from the airport operation still triggered considerable complaints from public about aircraft noise nuisance upon the airport came into operation in 1998. To address the nuisance, the Civil Aviation Department and the Environmental Protection Department of the Government of The Hong Kong Special Administrative Region implemented a number of improvement measures to reduce noise disturbance caused by these aircrafts on areas near the flight paths. This paper gives a retrospective view of aircraft noise problem in Hong Kong and experience gained after its operation.

8:40

3aHT2. Community response to aircraft noise around three airports in Vietnam. Thu Lan Nguyen, Huy Quang Nguyen, Khanh Tuyen Nguyen, Hiroaki Hukushima, Keiji Kawai, Takashi Yano (Kumamoto University, Kurokami 2-39-1, Kumamoto 860-8555, Japan, linh2lan@gmail.com), Tsuyoshi Nishimura (Sojo University, Ikeda 4-22-1, Kumamoto 860-0086, Japan), and Tetsumi Sato (Hokkai Gakuen University, Chuo Minami 26 Nishi 11-1-1, Sapporo 064-0926, Japan)

To assess the effect of aircraft noise on people in Vietnam, socio-acoustic surveys on community response to aircraft noise were conducted in residential areas around three airports in Ho Chi Minh City, Hanoi, and Da Nang. The community response was obtained by face-to-face interviews during the daytime on weekends. The aircraft noise was measured for seven successive days. Aircraft noise exposures ranged from 53 to 71 dB, from 48 to 61 dB, and from 52 to 64 dB Lden in Ho Chi Minh, Hanoi, and Danang, respectively. A representative dose-response relationship for aircraft annoyance in Vietnam has been proposed based on 3487 responses and noise data obtained by field measurements at 25 sites. It has been found that the curve for Vietnam is slightly higher than but rather almost consistent to the EU's curve. The respondents in each surveyed city have different levels of annoyance for the same aircraft noise exposure.

9:00

3aHT3. Noise around Suvarnabhumi Airport. Krittika Lertsawat (Project on the Development on Draft Law of Environmental Judicial Process, Thailand, krittikanonoise@gmail.com), Lalin Kovudhikulrungsri (International Institute of Air and Space Law, Leiden University, the Netherlands), Surocha Phoolsawat (Air Quality and Noise Management Bureau, Pollution Control Department, Thailand), and Tanaphan Suksaard (Environmental Research and Training Center, Thailand)

The noise levels in the vicinity of the Suvarnabhumi Airport (NBIA) were reported by the relevant authorities, including the noise levels before and after the opening of it since 2006. The overview of noise around NBIA will be illustrated in this paper. Meanwhile, the new guidelines on the airport noise management are under the consideration and development by the Pollution Control Department in corporation with other relevant agencies in compatible with the international recommendations on ISO 20906:2009, ISO 1996-1:2003, and ISO1996-2:2007. It should be into active within the next two years for applying to the airport projects in Thailand.

9:20

3aHT4. Treatment of auxiliary power unit as a ground noise source in airport noise modeling. Naoaki Shinohara (Narita International Airport Promotion Foundation, shino@napf.or.jp), Katsuji Iwasawa (Narita International Airport Corporation), and Ichiro Yamada (Airport Environment Improvement Foundation)

In Japan, noise index for evaluating airport noise was changed from WECPNL to Lden, which will be enforced from April, 2013. It was also decided to take aircraft ground noise within the airport when necessary. As a part of these ground noise components, it is necessary to take account of noise contributions due to APU operation on the apron before take-off, after landing, or maintenance during the midnight. This presentation explains a brief summary of an investigation of sound source characteristics of APU noise and compares noise calculations using the result with measurements observed by unattended noise monitoring devices.

9:40

3aHT5. Change of noise index and guideline values for airport noise in Japan. Ichiro Yamada (Airport Environment Improvement Foundation, K5 Bldg., 1-6-5, Haneda Kuhkou, Ohta-ku, Tokyo 144-0041, Japan, i-yamada@center.aeif.or.jp)

In Japan, mitigation of noise impact around airport has been promoted within the frame work of environmental noise measures, based on a noise guideline for aircraft noise enacted in 1974. Prompted by a subtle contradiction on noise index, the guideline was revised in 2007 and is planned to be enforced from April, 2013. The new guideline uses Lden as the cumulative noise evaluation index, instead of the conventional WECPNL. This paper explains details of revision of the guideline and the way to have specified new standard values. It also discusses the relationship of Lden with WECPNL at various airports in Japan.

Contributed Paper

10:00

3aHT6. Discussion on measurement method and standard of airport environment noise in China. Guang Yang, Jianghua Wang, Dandan Guo, Xiangdong Zhu, and Xiang Yan (School of Architecture, Tsinghua University, Beijing, China, yg@abcd.edu.cn)

With the blooming of economy, aircraft industry is growing rapidly in China. As result, the problem of disturbance from airport noise becomes more and more serious. However, airport noise control in China is still in the beginning stage. Noise testing is an essential part to hand the problem and collecting exact data can show what extent that the noise has impacted on the sensitive areas around the airport. But the Chinese standard GB 9661-88 Measurement of Aircraft noise around airport was promulgated in 1988. It has been over twenty years up to now. So there are some problems, such as, long measuring time, complicated data progressing and other noise interference including construction noise and so on in the actual measurements, which not only make the testing hard, but also difficult to evaluate the real effects accurately. This study will introduce approaches of testing points setting, data collection, filtration and progressing, and point out the practical deficiencies based on site measurements and obtained data. So the paper will be an important reference to revise measurement standard of aircraft noise.

3375   J. Acoust. Soc. Am., Vol. 131, No. 4, Pt. 2, April 2012

Acoustics 2012 Hong Kong   3375

Session 3aMU

Musical Acoustics and Speech Communication: Singing Voice in Asian Cultures

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Invited Papers

8:20

3aMU1. The tuning and vocal formant features of Chinese folk song singing: a case study of Hua'er music. Yang Yang (Institute of Education, UoL 20 Bedford Way London, WC1H 0AL, UK, yangyang.ioe@gmail.com), Johan Sundberg (KTH - Royal Institute of Technology, Drottning Kristinas v. 31 SE-100 44 Stockholm, Sweden), Graham Welch, and Evangelos Himonides (Institute of Education, UoL 20 Bedford Way, London, WC1H 0AL, UK)

Hua'er music is one of the representative folk music traditions in China today, designated as part of the world intangible cultural heritage by UNESCO in 2009. Whilst folk music traditions like Hua'er have been promoted in the education of young musicians due to their musical and cultural significance, no in-depth research has analyzed the acoustic characteristics of this vocal style. In this study, studio recordings were made of eighteen folk song examples sung by four four traditional and one formally educated singers. Analyses showed that both the traditional and the formally trained singers used a tuning pattern containing four main anchor-pitches approximating a Pythagorean tuning. The voice source in two different vocal styles ('Zhensheng' and 'Jiasheng'), reportedly used by these singers in performances, were examined by inverse filtering. LTAS of songs performed by the traditional singers were similar and showed a 'Speaker's formant' cluster near 3.5kHz. Implications are drawn for the education of folk music singers in higher education.

8:40

3aMU2. Acoustical study of classical Peking opera singing. Johan Sundberg (KTH, TMH/KTH, SE 10044 Stockholm, pjohan@speech.kth.se), Lide Gu, Qiang Huang, and Ping Huang (Voice Research Institute of China Conservatory, Peking, China)

Acoustic characteristics of classical opera singing differ considerably between the Western and the Chinese cultures. Singers in the classical Peking opera tradition are specializing on one out of a limited number of standard roles. Audio and electroglottograph signals were recorded of four performers of the Old Man roel and four performers of the Colorful Face role. Recordings were made of the singers' speech and when they sang recitatives and songs from their repertoires. Sound pressure level, fundamental frequency and spectrum characteristics were analyzed. Histograms showing the distribution of fundamental frequency showed marked peaks for the songs, suggesting a scale tone structure. Some of the intervals between these peaks were similar to those used in Western music. Vibrato rate was about 3.5 Hz, i.e., considerably slower than in Western classical singing. Spectra of vibrato-free tones contained unbroken series of harmonic partials sometimes reaching up to 17000 Hz. LTAS curves showed no trace of a singer's formant cluster. However, the Colourful Face role singers' LTAS showed a marked peak near 3300 Hz, somewhat similar to that found in Western pop music singers. The mean LTAS slope between 700 and 6000 Hz decreased by about 3 dB/octave per dB of equivalent sound level.

9:00

3aMU3. Vocal fold vibratory and acoustic features in fatigued Karaoke singers. Gaowu Wang, Andy Lo, Karen Chan (the University of Hong Kong, gwwang@hku.hk), Jiangping Kong (Peking University), and Edwin Yiu (the University of Hong Kong)

Karaoke is a popular singing entertainment particularly in Asia and is gaining more popularity in the rest of world. In Karaoke, an amateur singer sings with the background music and video (usually guided by the lyric captions on the video screen) played by Karaoke machine, using a microphone and an amplification system. As the Karaoke singers usually have no formal training, they may be more vulnerable to vocal fatigue as they may overuse and/or misuse their voices in the intensive and extensive singing activities. It is unclear whether vocal fatigue is accompanied by any vibration pattern or physiological changes of vocal folds. In this study, 20 participants aged from 18 to 23 years with normal voice were recruited to participate in an prolonged singing task, which induced vocal fatigue. High speed laryngscopic imaging and acoustic signals were recorded before and after the singing task. Images of /i/ phonation were quantitatively analyzed using the High Speed Video Processing (HSVP) program (Yiu, et al. 2010). It was found that the glottis became relatively narrower following fatigue, while the acoustic signals were not sensitive to measure change following fatigue. [Supported in part by HKRGC-GRF#757811]

3aMU4. Abrupt register changing technique "Atari" in traditional Japanese singing. Takeshi Saitou (Kanazawa University, Kakuma, Kanazawa 920-1192, Japan, t-saitou@ec.t.kanazawa-u.ac.jp), and Ken-Ichi Sakakibara (Health Sciences University of Hokkaido, 2-5, Ainosato, Kita-ku, Sapporo 002-8072, Japan)

A rapid modal-falsetto-modal register changing technique "Atari" is widely found in various Japanese traditional singing styles, such as Nagauta, Okinawan traditional singing, and Japanese traditional folk singing "Min-Yo". In other Asian singing styles, such as Urtin doo in Mongolia and similar styles in Tyva, and Sakha, consecutive rapid modal-falsetto register change is also widely used. In this study, a vocal fold vibratory pattern of "Atari" was observed by high-speed digital imaging. In "Atari", the vocal fold vibration did not break and was very smoothly carried out modal-falsetto and falsetto-modal register changing. Acoustical characteristics along with modal-falsetto-modal register changing were also analyzed. In "Atari", rapid changings of F0 and spectral tilt were observed. Based on these results, synthesis methods of "Atari" using STRAIGHT were proposed. By a listening test, it was clarified that "Atari" was effectively synthesized by changing only F0 without changing any spectral parameters.

9:40

3aMU5. Excitation source structural analysis of Japanese traditional singing voices. Hideki Kawahara (Faculty of Systems Engineering, Wakayama University, 930 Sakaedani, Wakayama 640-8510, Japan, kawahara@sys.wakayama-u.ac.jp)

New set of voice excitation source analysis methods are applied to study Japanese traditional singing voices, especially Noh. The first method, XSX (excitation Structure extractor) is capable of visualize detailed structure of subharmonic periodicity, by using multiple dedicated periodicity detectors. The second one analyzes symmetry of the fundamental component waveform, cycle by cycle. It enables to discriminate voice onset and offset details.

Contributed Papers

10:00

3aMU6. Timbral and melodic characteristics of Persian and Kurdish singing. Hama Jino Biglari and Johan Sundberg (Royal Institute of Technology, Department of Speech, Music and Hearing, TMH&KTH, SE/10044 Stockholm, Sweden, biglari@kth.se)

The floridly ornamented vocal technique in the courtly heritage of the Persian singing style called Avaz was studied along with excerpts from the flamboyant variety of the vivid Kurdish tradition. Audio and EGG signals were recorded from professional male tenor singers singing stylistically typical song excerpts from each tradition. Voice source parameters and formant settings (F1 & F2) were measured from inverse filtering of the audio signal, using the custom made DeCap (Svante Granqvist) and the commercial Soundswell softwares. Fundamental frequency F0 was measured from the EGG signal using the Soundswell CORR tool. In all melismatic embellishments, melody tones were preceded by short falsetto episodes whereby F0 quickly jumped up to a peak. For example, rapid tone repetitions as well as drill-like alternations between two neighbouring scale tones were interleaved with short falsetto segments. Moreover, for most vowels, the singers tuned F1 and sometimes also F2 to a spectrum harmonic in the higher part of their voice range, i.e. above about Bb4 (235 Hz, approximately). These findings will be discussed in relation to other singing styles, such as western operatic singing.

10:20

3aMU7. Easy confusion issues for non-Chinese scholar studying China traditional singing voices (CTSVs). Lide Gu (GU, Voice And Medical Institute, Sweden, gulide_sweden@hotmail.com)

In recent years, more and more non-Chinese scientists interested in investigation China Traditional Singing Voices (CTSVs). Misunderstandings then emerged out owing to cultural background differences. In order to make research more effective and to be carried out smoothly, some of the easy confusion issues are mentioned as reference. **A. Clearly indicates background of investigating voice sample** It is important to give clear indications of your investigating object(s) rather than using a general substantive expression, e.g. "China Native Folk Singing Voice", "Peking Opera Singing Voice", etc. because China traditional Singing Voice is varied. **B. Avoid misleading by accustomed terms** With Peking Opera example, she obviously missing some important elements of western opera must have. Her exact name is "Jing Ju", which means "Drama of Capital". **C. Concerned about the different aesthetic standards** Chinese native folk singers and local dramas performers usually have their own aesthetic standards,

which is quite different from the western vocal music. **D. Try to know habitual used words of singing voices and techniques** For example, big voice or big natural voice vs chest voice, small voice vs falsetto, position of the larynx, opening of the mouth, support of the breath, etc. **E. Others**

10:40–11:00 Break

11:00

3aMU8. Analysis of Chinese singing voices and its application to singing voice synthesis. Kenko Ota (Tokyo University of Science, Suwa, 5000-1 Toyohira, Chino, Nagano 391-0292, Japan, otakenko@rs.suwa.tus.ac.jp), and Terumasa Ehara (Yamanashi Eiwa College, 888 Yokone-cho, Kofu, Yamanashi 400-8555, Japan)

Currently, many researchers work on singing voice synthesis in Japanese or English etc. However, there are few researches on singing voice synthesis in Chinese. Thus, this research tackles development of a fundamental frequency (F0) controlling method for realizing a natural vocal conversion system from a Chinese speaking voice to a singing voice. Firstly, Chinese singing voices are analyzed in order to clarify the characteristics of F0 contour. From the analysis result of Chinese singing voices, it has been clarified that the F0 of Chinese singing voices is varied in accordance with not only the acoustic characteristics affecting the singing voice perception, e.g. overshoot, but also the four tones. Then, vocal conversion system is developed based on findings. In order to confirm the validity of the developed F0 controlling model, the following synthesized singing voices are subjectively evaluated by native Chinese evaluators. One is synthesized by controlling F0 contour according to the musical note, the second is synthesized by considering the acoustic characteristics affecting the singing voice perception and the third is synthesized by the proposed F0 controlling method. As the result, the singing voices synthesized by the proposed method realize high naturalness.

11:20

3aMU9. A system for developing a series of interactive tests of vocal production requiring on-line audiovisual recording. Bing-Yi Pan (Department of Psychology, University of Prince Edward Island, bpan@upei.ca), Ding Liu (Department of Information Engineering, Hubei University for Nationalities), and Annabel J. Cohen (Department of Psychology, University of Prince Edward Island)

AIRS-TEST, an online system supporting a major collaborative research initiative, Advancing Interdisciplinary Research in Singing (AIRS), was developed. AIRS-TEST administers a sequence of interactive tests and

organizes the results for analysis. The tests can present text and audiovisual information to prompt the participant's response (e.g., key presses, mouse clicks, touch-screen or audiovideo input). Researchers can design and create a sequence of related tests with auditory and/or visual stimuli via a management interface delivered by a web browser. Audiovideo recording modules can be embedded into the tests in many flexible ways. Participants need an invitation code to access a test collection. Experimental results can be explored online or downloaded for further analysis. An authority module is associated with collected data to control user's right of retrieval, considering both confidentiality and collaborative sharing. The software technologies supporting the various modules of AIRS-TEST are MySQL, Java EE, Flex and Red5. Whereas AIRS-TEST will be used worldwide to promote the AIRS study of cultural, universal, and individual influences on the acquisition of singing (Cohen *et al*, 2009, *Annals NYAS, 1169*, 112-115), AIRS-TEST can potentially support other experiments requiring on-line audio or audiovisual recording, as will be demonstrated. [Work supported by SSHRC MCRI]

11:40

3aMU10. Body radiation patterns of singing voices. Orie Takada and Rolf Bader (University of Hamburg, Institut of Musicology, Neue Rabenstr. 13, 20354, Hamburg, Germany, orie_deutschland@hotmail.com)

Most musical instruments exhibit complex patterns of sound radiation, which change with direction, played pitch, and many other factors. The same holds true for the body of a singer, regarded as an instrument, singing with her or his voice but activating also parts of the chest, neck, face, etc. The study examines differences in sound radiation of different body parts between various techniques and singing styles. Radiation patterns of the classical singing voice as well as non-classical singing styles, the Musical style, overtone singing, and Pop music, all produced by professional singers, were investigated using a microphone array comprising 128 microphones. The results are visualized displaying the strength of voice radiations and marking areas of radiation of the singer's upper body. The experiment shows that radiation patterns of the singing voice depend on vocal techniques, the vowel employed, and pitch. Additionally accelerometer measurements at lower body parts like the legs or foots show the transmission of the singing vibrations even to these remote body parts.

12:00

3aMU11. Changes in the vocal tract shape of sopranos at high pitch. Hironori Takemoto (NICT, c/o ATR 2-2-2 Hikaridai Seika-chou Soraku-gun, Kyoto 619-0288, Japan, takemoto@nict.go.jp), Kiyoshi Honda (CNRS), Takeshi Saitou (Kanazawa Univ.), Yosuke Tanabe (Hitachi America Ltd.), Hiroko Kishimoto (Showa Univ. of Music), and Tatsuya Kitamura (Konan Univ.)

As sopranos increase their fundamental frequency (F0) to sing at higher pitches, they also increase the first resonance frequency (R1) of their vocal tract. This is probably to avoid sudden F0 changes when F0 and R1 cross. It is unclear, however, how sopranos change vocal tract shape to increase R1. Therefore, the vocal tract shapes of two Japanese sopranos during production of the sung vowel /a/ in the modal register (A4 and D5) and in the falsetto register (G5) were measured by MRI. The measured vocal tract shapes were compared with each other and their area functions were extracted to calculate acoustic characteristics. Results showed that changes in the vocal tract shape were small between A4 and D5, while changes were large between D5 and G5. At G5, it was observed in both subjects that the lower jaw opened, the pharyngeal wall and tongue root advanced, and the larynx retracted. In addition, one subject shortened the laryngeal cavity length. All these changes achieved R1 increase, in agreement with the acoustic sensitivity function. Thus, in conclusion, sopranos selectively modified parts of the vocal tract with high sensitivity to R1. This research was partly supported by Kakenhi (Grant Nos. 21500184, 21300071, 22520156).

12:20

3aMU12. Analysis of high-frequency energy in singing and speech. Brian B. Monson (National Center for Voice and Speech, 136 S. Main, Ste 320, Salt Lake City, UT 84101, bbmonson@email.arizona.edu), Brad Story, and Andrew Lotto (University of Arizona, Speech and Hearing Science Dept., P.O. Box 210071, Tucson, AZ 85721)

The human singing and speech spectrum includes energy above 5 kHz, but this portion of the spectrum is typically ignored in speech and voice science. Generally it has been assumed that this high-frequency energy (HFE) contributes to only qualitative percepts of singing and speech, but prior work shows HFE contributes to several non-qualitative percepts, including speech intelligibility. To begin an in-depth exploration of HFE, a database of multi-channel anechoic high-fidelity recordings of singers and talkers was created and analyzed. Third-octave band analysis from the long-term average spectra (LTAS) showed that production level (soft vs. normal vs. loud), production mode (singing vs. speech), and phoneme (for voiceless fricatives) all significantly affected HFE characteristics. Female HFE levels were significantly greater than male levels only above 11 kHz. As expected, HFE was found to be highly directional toward the front of the singer/talker. While this information resulted from a study initially focused on singing voice aesthetic, it is pertinent to various areas of acoustics, including vocal tract modeling, voice synthesis, augmentative hearing technology (hearing aids and cochlear implants), cell phone technology, and training/therapy for singing and speech. [Work supported by NIH-NIDCD.]

Session 3aNSa

Noise, Engineering Acoustics, Physical Acoustics, and Signal Processing in Acoustics: Active Noise Control I

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Invited Papers

9:20

3aNSa1. Lessons learned for implementing near-field active control systems to achieve global control of fan noise. Scott D. Sommerfeldt and Kent L. Gee (Brigham Young University, Provo, UT 84602, scott_sommerfeldt@byu.edu)

Work has been ongoing for a number of years to develop compact active noise control systems that can effectively achieve global attenuation of radiated fan noise associated with information technology (IT) equipment. Both axial and centrifugal fans are used in IT applications, and both types of fans have been studied. An approach has been developed that can guide the user to properly implement near-field sources and sensors to achieve significant global attenuation of the fan noise. These concepts have been investigated experimentally in numerous configurations to verify the effectiveness of the approach. Both narrowband and broadband noise components have been targeted, and limitations on the attenuation that can be achieved have been established. The sensitivity of various configurations has also been studied, and it has been found that some implementations may be able to achieve greater attenuation, but are also much more sensitive to placement errors of the sources and sensors. This paper will overview the research to date and provide an overview of lessons that have been learned for effective implementation of near-field control techniques in order to achieve global attenuation.

9:40

3aNSa2. An active vibration isolation system for an air-compressor in marine applications. Tiejun Yang, Minggang Zhu, Xueguang Liu, Jingtao Du, and Zhigang Liu (Power and Energy Engineering College, Harbin Engineering University, Harbin 150001, China, yangtiejun@yahoo.cn)

Similar to a diesel engine, the main vibration sources of an air-compressor are to and fro inertial forces of its piston, rod, and crankshaft. An active vibration isolation system is developed for an air-compressor in a tug boat. This system consists of four inertial actuators and a DSP processor. A four-input and four-output adaptive control strategy is applied and the reference input signal comes from a laser tachometer on the shaft of the motor. The active vibration isolation experiment is conducted in a tug boat when only the air-compressor is working. The experimental results demonstrate that good vibration reductions are obtained at not only error sensor's locations but also the hull under the compressor. Some discussion and conclusions are given at last.

10:00

3aNSa3. Active control of noise in vehicle cabins. Jie Pan (School of Mechanical Engineering, University of Western Australia, Crawley WA 6009, Australia, pan@mech.uwa.edu.au), Yulan Liu, Jing Lu, and Xiaojun Qiu (The Institute of Acoustics, Nanjing University, Nanjing 210093, China)

Active noise control (ANC) technology has been applied to reduce low frequency noise in vehicle cabins. Different from ANC in laboratory conditions, installation of the ANC system in vehicles for a long term use requires the solution of a number of practical issues. This paper reports the progress of a couple of practical ANC installations, and the implication and solution of practical issues such as magnitude and frequency variations (corresponding to different vehicle operating conditions) of the primary and reference signals, and poor coherence between primary and reference signals.

3aNSa4. Head-mounted active noise control system and its application to reducing MRI noise. Nobuhiro Miyazaki and Yoshinobu Kajikawa (Kansai University, miya.nbhr@gmail.com)

We propose an active noise control (ANC) system for reducing periodic noise generated in a high magnetic field such as noise generated from magnetic resonance imaging (MRI) devices (MRI noise). The proposed ANC system utilizes optical microphones and piezo-electric loudspeakers and consists of a head-mounted structure to control noise near the user's ears. Moreover, internal model control (IMC)-based feedback ANC is employed because the MRI noise includes some periodic components and is predictable. Our experimental results demonstrate that the proposed ANC system (head-mounted structure) can significantly reduce MRI noise by approximately 30 dB in a high field in an actual MRI room even if the imaging mode changes frequently.

10:40–11:00 Break

11:00

3aNSa5. Difference potential based active noise shielding in three dimensional settings. Yiu Wai Lam (Acoustics Research Centre, University of Salford, Salford M5 4WT, UK, y.w.lam@salford.ac.uk), Sergey Utyuzhnikov (School of Mechanical, Aerospace and Civil Engineering, University of Manchester, M13 9PL, UK), and Liam Kelly (Acoustics Research Centre, University of Salford, Salford M5 4WT, UK)

Active noise shielding based on the Difference Potential Method has been developed and validated in previous publications. The key ability of the method, to provide global noise cancellation while automatically preserving wanted sound in multi-connected domains, has been demonstrated clearly in 1D experiments. In this paper, the tests are extended to 3D. The shielded domain is a 1mx1mx1m box with 1-3 sides open. Up to 4 control sources were used on each of the open sides to shield the domain from external noise. Noise attenuation of around 10dB was achieved up to about 350 Hz. The attenuation is lower than the >20dB attenuation achieved in previous 1D experiments. A reason for this is the sensitivity of the cancellation to the positioning of sensors and controls and the physical size of the control sources. Furthermore, up till now the method relies on separate measurements of the total sound field without the control sources. In realistic applications where noise and wanted sound are non-stationary, the total sound field has to be measured in real time with the control sources operating. In such cases a new mathematical formulation is needed, and this paper will discuss how such a solution can be achieved.

11:20

3aNSa6. Fixed point realization of partial updating adaptive algorithm for active noise control. Jing Lu, Kai Chen, and Haishan Zou (Institute of Acoustics, Nanjing University, Nanjing 210093, China, lujing@nju.edu.cn)

An efficient low cost realization of the partial updating FXLMS algorithm is proposed in this paper. Unlike the conventional partial updating adaptive filters, the modified sign-LMS algorithm is used to make it easier to be implemented in a fixed point DSP. Moreover, the calculation of the filtered reference signal is divided into several steps, which further reduces the whole computational burden. An active noise controller using TMS320C5502 DSP chip is designed based on the proposed algorithm. The experiment results demonstrate that at a reasonable updating rate, the proposed algorithm has exactly the same performance with the normal float-point FXLMS algorithm while the computational burden is much lower.

11:40

3aNSa7. A novel frequency-domain periodic active noise control algorithm with nonlinear secondary path. Ming Wu and Jun Yang (Institute of Acoustics, Chinese Academy of Sciences, 100190, mingwu@mail.ioa.ac.cn)

Frequency-domain periodic active noise control (FDPANC) algorithm is usually adopted for harmonic noise reduction. However it may fail to converge when the secondary path includes a nonlinear element. In this paper, the convergence behavior of FDPANC algorithm with nonlinear secondary path is analyzed and a sufficient condition for convergence is derived. Unlike the conventional FDPANC algorithm with linear secondary path, this sufficient condition for FDPANC algorithm with nonlinear secondary path is time-varying and depending on the coefficients of the adaptive filter. If system has a steady-solution, the sufficient condition can be satisfied for all iterations by selecting the proper initial values. In this situation, the adaptive filter will convergent to the optimum value and the disturbance signal can be eliminated totally. If system has no steady-solution, the sufficient condition cannot be satisfied for all iterations whatever the initial values are. Based on the sufficient condition for convergence, a modified FDPANC algorithm integrated with convergence detector is also proposed in this paper.

12:00

3aNSa8. Varying auxiliary-noise-power for improved noise reduction in active noise control systems with online secondary path modeling. Shakeel Ahmed (Department of Communication Engineering and Informatics, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu, Tokyo 182-8585, Japan, s1196001@edu.cc.uec.ac.jp), Muhammad Tahir Akhtar (The Center for Frontier Science and Engineering (CFSE), The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu, Tokyo 182-8585, Japan), and Wataru Mitsuhashi (Department of Communication Engineering and Informatics, The University of Electro-Communications, 1-5-1 Chofugaoka, Chofu, Tokyo 182-8585, Japan)

Active noise control (ANC) systems with online secondary path modeling (SPM) comprise two adaptive filters: 1) The FXLMS algorithm-based ANC filter to cancel the primary noise, and 2) an LMS algorithm-based online SPM filter. The online SPM filter is a supporting filter and is needed for a stable operation of the FXLMS algorithm-based ANC filter. The online SPM is achieved by injecting an auxiliary noise, which however degrades the noise reduction performance of the ANC system. In this paper, a new method is proposed for varying the power of the injected auxiliary noise in accordance with the convergence status of the power of the error signal of

the SPM filter. Furthermore, in order to deal with the non-stationary noise sources, normalized step-sizes are employed for both the ANC and SPM filters. The proposed method for varying the auxiliary-noise-power achieves a good online SPM, and an improved noise reduction performance as compared with the existing methods. Furthermore, it has a reduced computational complexity as compared with the method proposed by Carini et. al. In order to verify the effectiveness of the proposed method, various scenarios of the input noise are considered in the simulation results presented in this paper.

12:20

3aNSa9. Active noise control systems integrated with infant cry detection and classification for infant incubators. Lichuan Liu and Kevin Kuo (Northern Illinois University, Dekalb, IL 60115, liu@niu.edu)

Infant incubators are widely used in neonatal intensive care units (NICU) for the pre-term or sick babies. In this paper, we propose an active noise control (ANC) system integrated with infant cry detection and classification function for infant incubators. The incubator ANC system reduces the high noise level which results in numerous adverse health effects for infants, and the cry detector and analyzer monitors the infants' physical conditions using the same ANC system hardware. The infant crying signals picked up by the error microphone of ANC inside the incubator are detected, the signals' features are extracted by using linear prediction coding (LPC), and Mel-frequency cepstral coefficients (MFCC) methods. The database of different signals and their associated infant health features will be established through training phase. The signal classification algorithm is based on shortest distance and Bayesian classifier. Simulation is conducted to evaluate the performance of proposed system using a Giraffe incubator from GE Healthcare. The experiments show that the proposed ANC system can reduce the harmful noise and the cry classification algorithm can recognize infant cries in order to develop the innovative, low cost methods to monitor the infant's health conditions.

WEDNESDAY MORNING, 16 MAY 2012   HALL C, 9:20 A.M. TO 11:40 A.M.

Session 3aNSb

Noise, ASA Committee on Standards, and Animal Bioacoustics: Assessment and Measurement of Park Soundscapes

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Invited Papers

9:20

3aNSb1. The ISO 12913 series on soundscape: An update, May 2012. Östen Axelsson (Department of Psychology, Stockholm University, SE-106 91 Stockholm, Sweden, oan@psychology.su.se), and on behalf of ISO/TC 43/SC 1/WG 54

In February 2009 the working group ISO/TC 43/SC 1/WG 54 "Perceptual assessment of soundscape quality", of the International Organization for Standardization (ISO), begun preparing the first International Standard on soundscape "ISO 12913-1 Acoustics –- Soundscape –- Part 1: Definition and conceptual framework". This paper presents the latest version of the definition of "soundscape" and its conceptual framework. At its current state of development the framework highlights seven general concepts and their relationships: (1) sound sources, (2) acoustic environment, (3) auditory sensations, (4) interpretation of auditory sensations, (5) responses, (6) context, and (7) outcomes. By providing a standard reference, the working group aims at international consensus in order to avoid ambiguity, and to enable conceptual progress in soundscape research. ISO 12913-1 is expected to be published as an International Standard in 2015. Subsequent parts of the ISO 12913 series will deal with minimum reporting requirements in soundscape research, and methods for measuring soundscape quality.

9:40

3aNSb2. Protecting soundscapes in U.S. National Parks: lessons learned and tools developed. Peter Newman (Colorado State University, peter.newman@colostate.edu), Kurt Fristrup, Karen Trevino (National Park Service), Steve Lawson (Resource Systems Group), Derrick Taff, Dave Weinzimmer, and Tim Archie (Colorado State University)

Researchers and protected area managers' are working together to protect natural soundscapes in U.S. National Parks. In this paper, soundscapes have been defined as the total acoustics environment and includes the sounds of nature and as well as anthropogenic noise (unwanted sounds). In particular, human-caused noise can mask the sounds of nature and detract from the quality of the visitor

experience and have negative impacts on wildlife in parks and protected areas. Over the past decade, researchers at Colorado State University have teamed up with the United States National Park Service (USNPS) to explore, build simulation models of, and derive management actions in National Parks in order to protect natural quiet and the soundscapes of national parks. This paper will provide an overview of challenges and successes of these efforts in order to create a list of lessons learned. In particular, results (maps, models and experiments) of studies in Denali National Park, Rocky Mountain National Park Yosemite National Park and Sequoia Kings National Park will be shown and presented in order to show how these data can lead to informed management decision making. This research was funded by the USNPS Natural Sounds Program as well as support from aforementioned parks.

10:00

3aNSb3. Further research on separating anthropogenic from natural sounds in a park setting. Jack Gillette, Jeremy Kemball, and Paul Schomer (Schomer and Associates Inc., 2117 Robert Dr., Champaign, IL 61821, gillett1@uni.illinois.edu)

This paper is a continuation of work presented last year on this subject. Last year's work involved separating nearly all anthropogenic sound from natural sound except for jet aircraft. This year a method to detect jet aircraft has been developed, so that now one is able to separate all anthropogenic sound from natural sound. Testing of the detection of non-aircraft anthropogenic sound has been continued with a wide body of data. For the detection of anthropogenic sound (other than jet aircraft) we rely on the assumption that nearly all of this sound involves the use of motors and, hence, except for aircraft, creates fundamental tones that are well below 1000 Hz, where as natural sounds (e.g., insects, birds, frogs) nearly always will create tones with fundamental frequencies above 1000 Hz. This paper present the results of the testing for aircraft noise detection and the additional testing of the detection of non-aircraft anthropogenic sound.

10:20

3aNSb4. A pretest of several versions of a survey questionnaire for use in Rocky Mountain National Park, USA. Paul Schomer and James Boyle (Schomer and Associates, Inc., 2117 Robert Dr., Champaign, IL 61821, schomer@SchomerAndAssociates.com)

This paper presents the results of a pretest of visitors' perception of the soundscape on hiking trails in the Bear Lake area of Rocky Mountain National Park, Colorado, USA. The pretest involved 5 versions of a procedure for administering the questionnaire. This pretest includes concurrent noise monitoring with the noise monitor generally spaced 1 to 2 km apart. For those versions of the pretest survey that included questions during the hike, the test booklet included a position and time recording GPS. Although the majority of visitors to the Bear Lake area go on 0.5 to 3 km long hikes, most hikers that we selected went on hikes that were in the length range of 5 to 10 km. The Bear Lake area is the busiest hiking area in Rocky Mountain National Park; it receives about 10 to 20,000 visitors per day during nice summer days. As a result, one source of anthropogenic sound that contributed negatively to the soundscape was the sound of other hikers; beyond about 1.5 km from the transit area, hikers on the trails thinned markedly. Based on the results of the pretest analysis, a full-scale test plan is recommended.

10:40–11:00 Break

11:00

3aNSb5. Assessment of tranquility in an urban church garden. Jin Yong Jeon, Inhwan Hwang, and Jooyoung Hong (Hanyang University, Seongdong-gu, Seoul, Korea, jyjeon@hanyang.ac.kr)

Tranquility in view of urban church soundscape was assessed by field measurements and soundwalks. The Cathedral Myeong-dong located in the heart of Seoul was selected as a measurement site. Five sites adjacent to the church buildings were selected for field measurements and audio recordings were conducted at the sites. From the field measurements, the temporal and frequency characteristics, and several acoustic parameters of the sound environment at each site were analyzed. In addition, a general questionnaire survey was conducted to identify people's perception on the current church soundscape and design elements to enhance the spaces. Individual soundwalks were also performed in order to evaluate soundscape perception in the church garden. From the results, the indicators representing tranquility sensation in urban church garden were investigated.

11:20

3aNSb6. The role of paying attention to sounds in soundscape perception. Dick Botteldooren, Michiel Boes, Damiano Oldoni, and Bert De Coensel (Ghent University, Gent, Belgium, dick.botteldooren@intec.ugent.be)

It has been stated frequently that the soundscape as perceived and appraised by the user of a space, extends beyond the physical stimulus. We argue that, when introducing to human-factor in analyzing a sonic environment, the sounds that people hear play an important role. This holds in particular for rather quiet and infrequent disturbance of park soundscapes. Auditory attention mechanisms are essential in the process. Attention can be drawn by saliency elements such as changes in time and frequency, but it can also be outward oriented and voluntary. These mechanisms could explain the special role of natural sounds in distracting attention from mechanical background hum in a park environment. These theoretical concepts have now been implemented in measuring equipment that allows estimating how often particular sounds will be heard by a human listener. The methodology includes biologically inspired feature extraction, learning based on co-occurrence of features and saliency, attention focusing, and inhibition of return. Extension to binaural measurements increasing the unmasking effect is also discussed.

Session 3aPA

Physical Acoustics and Biomedical Acoustics: Metrics and Objectivity in Cavitation Research

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Invited Papers

8:00

3aPA1. Cavitation thresholds and why to be wary! Victoria Bull (Physics Department, Institute of Cancer research, Royal Marsden Hospital, Sutton, Surrey SM2 5PT UK, victoria.bull@icr.ac.uk), Ian Rivens (Physics Department, Institute of Cancer Research, Sutton, Surrey, SM2 5PT, UK), and Gail ter Haar (Physics Department, Institute of Cancer Research, Royal Marsden Hospital, Sutton, Surrey, SM2 5PT, UK)

Many biological studies involving ultrasound exposure report acoustic cavitation "thresholds". The purpose of these is often to convince the reader either that cavitation activity was avoided, or that it definitely occurred as the exposure was "above the threshold". Formally, the cavitation threshold is the minimum negative pressure amplitude at which pre-existing bubbles begin to oscillate (non-inertial cavitation) or collapse (inertial cavitation). The cavitation nucleation threshold is that for which bubbles can be drawn out of solution and driven to oscillate. Since the true physical cavitation threshold of a medium can only be measured if it is possible to detect single bubble activity, quoted thresholds are more likely to represent a threshold for detection than for cavitation activity. Furthermore, they may not be relevant beyond the specific experimental conditions tested. In interpreting a negative pressure threshold for cavitation in tissue it is important to know, amongst other things: the tissue status and sample geometry (in order that the in situ pressure may be calculated); details of the ultrasound exposure; method of cavitation detection and detector geometry; data gathering, processing and interpretation methods; threshold definition; sample statistics. Without these details, results may be misleading.

8:20

3aPA2. The influence of thresholding passive bubble-acoustic signals on the quantification of physical effects. Richard Manasseh (Engineering & Industrial Sciences, Swinburne University of Technology, P.O. Box 218, Hawthorn, VIC 3122, Melbourne, Australia, rmanasseh@swin.edu.au), Yonggang Zhu (Fluid Dynamics, CSIRO, P.O. Box 56, Highett, VIC 3190, Melbourne, Australia), Hubert Chanson (Civil Engineering, University of Queensland, QLD 4072, Brisbane, Australia), Andrew Ooi (Mechanical Engineering, University of Melbourne, VIC 3010, Melbourne, Australia), Alexander Babanin (Engineering & Industrial Sciences, Swinburne University of Technology, P.O. Box 218, Hawthorn, VIC 3122, Melbourne, Australia), and Irena Bobevski (Psychology and Psychiatry, Monash University, Monash Medical Centre, Clayton, VIC 3168, Melbourne, Australia)

Passive emissions of sound by bubbles provide potentially useful data in many natural and engineered systems. Bubble-acoustic data are used to predict the severity of volcanic eruptions, identify undersea gas seeps, and measure ocean wave breaking. In these natural cases, and in many chemical engineering and metallurgical processes, statistics on the bubble size are sought; the bubble size controls the rate of gas to liquid mass transfer as well as fluid dynamical aspects such as mixing. However, owing to uncertainty in the physics generating the acoustic amplitude, bubble-size determination remain essentially empirical, requiring an threshold to select data. The impact of various thresholding and data-windowing techniques is discussed. Examples are given on the data from a chemical engineering aerator, a plunging jet, and a case in which diagnostic statistics can be used to identify the threshold giving the optimum sensitivity and specificity for detecting the breaking of wind-waves. Once found, the optimum threshold can be used to infer relevant physics from the acoustic signal alone.

8:40

3aPA3. Cavitation micro-bubble behavior in ultrasound field for HIFU therapy enhancement. Yoichiro Matsumoto (The University of Tokyo, Hongo, Bunkyo-ku, Tokyo, Japan, ymats@fel.t.u-tokyo.ac.jp), Kohei Okita, and Shu Takagi

The incepted cavitation micro-bubbles at the target tissue are used to enhance tissue heating in High-Intensity Focused Ultrasound therapy. The control of the inertial cavitation is required to achieve the efficient tissue ablation. The high-intensity ultrasound is used to incept a cavitation, so that the duration time is short enough to prevent the tissue coagulation. The low-intensity ultrasound follows just after the high-intensity ultrasound to continuously drive the cavitating micro-bubbles and coagulate the tissue. Following the experiment,

we simulate the focusing of ultrasounds through a mixture containing micro-bubbles with considering the size and number density distributions in space. The numerical simulation shows that the heating region coincides with the cavitation incepted region by high-intensity ultrasound where the micro-bubbles are remaining as cavitation nuclei. The numerical results elucidate well the experimental ones.

9:00

3aPA4. Postexcitation collapse as a characteristic of single ultrasound contrast agent destruction. Daniel King and William OBrien Jr (University of Illinois Urbana-Champaign, IL, daking3@illinois.edu)

Measurement of the response of single, unconstrained ultrasound contrast agents (UCAs) is useful for facilitating experiment interpretation and theoretical comparison. An experimental setup has been developed to characterize the acoustic large amplitude response of microbubbles called double passive cavitation detection (PCD) which consists of three confocally aligned transducers. The symmetric single bubble responses from within the confocal region are analyzed for the presence or absence of a postexcitation signal (PES), a rebound characteristic response to large amplitude pressures that may follow the initial harmonic UCA response. Experimental sensitivity to the PES is explored by receiving with transducers of different frequencies. Theoretical models indicate postexcitation rebound occurs following shell rupture and inertial cavitation of the UCA. The postexcitation response curves as a cavitation metric are useful for characterizing distinct collapse thresholds among UCAs which arise due to material differences; additionally, the thresholds may be considered as destruction thresholds and compared to a variety of in-vitro and ¬in-vivo studies to aid in understanding the resultant bioeffects in these studies. (NIH Grant R37EB002641.)

9:20

3aPA5. Spatiotemporal quantification of therapeutically relevant cavitation for ablation and drug delivery by ultrasound. Constantin-C. Coussios, Carl Jensen (Institute of Biomedical Engineering, Department of Engineering Science, University of Oxford, Oxford OX3 7DQ, UK, constantin.coussios@eng.ox.ac.uk), Rob Ritchie (Clinical HIFU Unit, Churchill Hospital, Oxford OX3 7LJ, UK), Miklos Gyongy (Faculty of Information Engineering, Pázmány Péter Catholic University, Budapest, Hungary), Natalie Hockham, Bassel Rifai, Eleonora Mylonopoulou, James Choi, and Jamie R.T. Collin (Institute of Biomedical Engineering, Department of Engineering Science, University of Oxford, Oxford OX3 7DQ, UK)

Stable and inertial cavitation have been shown to play a key role in several therapeutic ultrasound applications, ranging from non-invasive ablation to drug delivery. In order to achieve meaningful quantification of therapeutically relevant cavitation, a hypothesis as to the underlying mechanism by which bubbles enhance energy delivery and momentum transfer to their surroundings must first be formulated. Based on this hypothesis, correlations can be sought between time-based or frequency-based metrics of a relevant cavitation 'dose' and the desirable associated bioeffects, enabling the establishment of thresholds for therapeutically relevant processes to occur. However, the problem is complicated further by the fact that a single type of cavitation activity rarely occurs throughout an ultrasound exposure, or throughout the acoustic field of a therapeutic transducer. A recently developed method, known as passive acoustic mapping, makes it possible to obtain real-time maps of inertial and stable cavitation activity and could thus enable improved dosimetry of therapeutically relevant cavitational processes. The use of passive acoustic mapping for spatiotemporal classification and quantification of cavitation will be illustrated in the context of HIFU ablation, drug release from thermosensitive liposomes and drug delivery.

9:40

3aPA6. Effect of microbubble-induced microstreaming on the sonoporation. Dong Zhang and Juan Tu (Key Laboratory of Modern Acoustics (MoE), Institute of Acoustics, Nanjing University, Nanjing 210093, China, dzhang@nju.edu.cn)

In the present work, MCF-7 cells mixed with polyethylenimine: Deoxyribonucleic acid (DNA) complex and microbubbles were exposed to 1-MHz ultrasound with low acoustic driving pressures (0.05-0.3 MPa). The sonoporation pores generated on the cell membrane were examined with scanning electron microscopy. The results show that larger sonoporation pores would be generated with the increasing acoustic pressure or longer treatment time, which could be useful for the enhancement of DNA transfection efficiency, the mean diameters of pores ranged from 100nm to 1.25 μm. The calculated results based on Marmottant model indicate that the microstreaming-induced shear stress might be involved in the mechanisms of the low-intensity ultrasound induced sonoporation. [This work is supported by the National Basic Research Program 973 (Grant No. 2011CB707900) from Ministry of Science and Technology, China, National Natural Science Foundation of China (11174141), and the Fundamental Research Funds for the Central Universities (Grant Nos. 1103020402, 1116020410 and 1112020401)]

10:00

3aPA7. Quantification of bubble population in bubbly liquids. Won-Suk Ohm (Yonsei University, Seoul 120-749, Korea, ohm@yonsei.ac.kr)

Estimation of bubble spectra is usually performed through the inversion of attenuation and/or dispersion measurements of bubbly liquids [see, for example, Commander and Prosperetti, J. Acoust. Soc. Am. 85, 732-746 (1989)]. However, the inversion method often fails to yield accurate bubble spectra, as the bubble resonance starts to play a significant role. An alternative approach is to infer the bubble population from the sound of Minnaert-like bubble oscillations within the bubble cloud [Leighton and Walton, Eur. J. Phys. 8, 98-104 (1987)]. In this talk, a survey of the existing methods for bubble spectrum estimation is given with a particular emphasis on the pros and cons of each method under different circumstances.

10:20

3aPA8. Measurement of density and size distribution of oscillating cavitation bubbles using optical spectrometer. Takanobu Kuroyama, Tadashi Ebihara (University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577, kuroyama@aclab.esys.tsukuba.ac.jp), Koichi Mizutani (Unviersity of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577), and Takeshi Ohbuchi (National Defense Academy, 1-10-20 Hashirimizu, Yokosuka, Kanagawa 239-8686)

Measuring of properties of acoustic cavitation bubbles, such as size distribution and density distribution, is important to estimate the physical and chemical effects of the cavitation bubbles. In this paper, the optical spectrometer is applied to measure the bubble density in the cavitation field. In previous study, it has been proposed that a size distribution measurement method of the acoustic cavitation bubbles using the optical spectrometer by the authors. The size distribution measurement of the oscillating bubbles was successfully achieved by measuring the far-field (Fraunhofer) diffraction pattern of the bubbles, which was obtained by introducing the laser light to the cavitation bubbles. In addition to the previous study that focused on the diffracted light pattern, the bubble density is measured from the diffracted light intensity in this paper. The obtained results suggest that the proposed method can measure the bubble densities successfully.

10:40–11:00 Break

11:00

3aPA9. Evolution of acoustic cavitation structures induced by a liquid jet. Lixin Bai, Jingjun Deng, and Chao Li (Ultrasonic Physics and Exploration Laboratory, Institute of Acoustic, Chinese Academy of Sciences, No. 21, Bei-Si-huan-Xi Road, Beijing, China, lixin.bai@gmail.com)

Temporal evolution and spatial distribution of acoustic cavitation structures induced by a liquid jet in a 20 kHz ultrasonic field were investigated experimentally with high-speed photography. It is revealed that a large-scale flare structure is produced by a liquid jet shooting towards a transducer radiating surface. A few large bubbles and numerous small bubbles are formed on the interface of liquid jet. The size of large bubbles differs almost by an order of magnitude from that of small bubbles. The flare structure hits the radiating surface, spread and adhere. The liquid jet is arrested and a thin bubbly layer lying at the radiating surface is formed. The cavitation cloud will evolve from one structure to another without the interference of liquid jet. (a) Most bubbles move towards the center, and the bubbly layer will become thicker at the centre than at the periphery like a lens. (b) Large bubbles accumulate at the center and skip off the surface, and the lens structure becomes a conical structure. (c) Large bubbles align themselves along the axial line, and the conical structure becomes a fishbone structure. Many other interesting phenomena were observed. The liquid-jet method is useful for the investigation of cavitation structure. This work is supported by the National Natural Science Foundation of China (Grant No. 11174315) and the National Science and Technology Major Project of China (Grant No. 2011ZX05032-003).

11:20

3aPA10. High-speed observation of bubble dynamics influenced by surfactant molecules. Pak-Kon Choi and Shota Deno (Meiji University, 1-1-1 Higashimita, Tama-ku, Kawasaki, Japan, pkchoi@isc.meiji.ac.jp)

Surfactant molecules affect the dynamics of acoustic bubbles such as the oscillation of expansion and contraction and a bubble coalescence when adsorbed with bubble/liquid interface. A high-speed shadowgraph of acoustic bubbles was observed in surfactant SDS solutions using a high-speed camera with a speed of a million fps. The experimental results of time evolution of bubble diameter showed that a surfactant-adorbed bubble favors a spherical oscillation. Histograms of maximum bubble diameters obtained at several frequencies indicated that the number of large-size bubble considerably decreased compared to the case of pure water and this tendency was marked at higher frequencies. The histograms measured at various SDS concentrations at 87 kHz showed that the decrease in the number is significant

at 5 mM. The results are elucidated in terms of electrostatic repulsion between charged bubbles, which inhibits the bubble coalescence.

11:40

3aPA11. An axisymmetric model of ultrasound contrast agent collapse following shell rupture. Daniel A. King, Jonathan B. Freund, and William D. O'Brien, Jr. (University of Illinois, Urbana-Champaign, IL, daking3@illinois.edu)

Widely used spherically symmetric models of ultrasound contrast agents (UCA) are unable to capture complicated collapse behaviors when the UCA shell ruptures. Observations from acoustic passive cavitation detection analysis of collapsing UCAs as well as images from high speed videos of UCA destruction suggest that including spatial asymmetry in the shell interface conditions of models may be useful for studying collapse, onset of fragmentation, and initiation of postexcitation rebound. The concept of lipid shell rupture is incorporated into an axisymmetric boundary element method formulation as a circular hole developing during the growth phase of an initially spherical bubble. The different material interfaces are represented by a spatially varying surface tension due to different pressure discontinuity conditions from the inner gas region to the outer fluid region. Results from the simplified geometrical model simulations demonstrate that shell fragments may influence the evolution of collapsing UCA and indicate the possibility of microbubble jetting following lipid shell rupture. (NIH Grant R37EB002641.)

12:00

3aPA12. Theoretical microbubble dynamics in a homogeneous viscoelastic medium at capillary breaching thresholds. Brandon Patterson, Douglas Miller, and Eric Johnsen (University of Michigan, 1231 Beal Ave., Walter E. Lay Automotive Engineering Laboratory, 2016 Ann Arbor, MI 48109-2133, awesome@umich.edu)

In order to predict ultrasound-induced bioeffects in diagnostic and therapeutic procedures, the dynamics of cavitation microbubbles in viscoelastic media must be determined. For this theoretical study, measured 1.5-7.5 MHz pulse pressure waveforms, which were used in experimental determinations of capillary breaching thresholds for contrast enhanced diagnostic ultrasound in rat kidney (Miller et al. Ultras. Med. Biol. 2008;34:1678), were used to calculate cavitation nucleated from contrast agent microbubbles. A numerical model for cavitation in tissue was developed using the Keller-Miksis equation (compressible Rayleigh-Plesset equation), with various viscoelastic models (Kelvin-Voigt, Maxwell and Standard Linear Solid). From this model, the bubble dynamics corresponding to the experimentally obtained capillary breaching thresholds were determined. For example, the particular value of the maximum radius and temperature corresponding to this threshold was determined for a range of ultrasound pulses and bubble sizes, and was shown to be frequency-dependent. It was observed that the bioeffects thresholds do not correspond exactly to inertial cavitation thresholds, suggesting the possibility of a more complex mechanism of injury. We plan to identify local, secondary bioeffect mechanisms, which might be constant for threshold conditions at different frequencies.

12:20

3aPA13. Theoretical cavitation thresholds in vivo and their relationship to the mechanical index. Charles C. Church (University of Mississippi, University, MS 38677, cchurch@olemiss.edu)

The mechanical index (MI) displayed on the screens of most modern diagnostic ultrasound machines is a relative indication of bioeffect risk. The current definition of the MI, the ratio of the rarefactional pressure in situ to the square root of the center frequency of the acoustic wave, is based on an analytic evaluation of the threshold for violent cavitation of pre-existing gas bubbles in biologically relevant fluids, i.e., water and blood. An alternative approach assuming spontaneous nucleation of bubbles when these liquids are under tension produced by an acoustic field indicated that the threshold was nearly independent of frequency in water but directly proportional to frequency in blood. More recently, it has been suggested that the lipid

bilayers surrounding and within individual cells may rupture when subjected to a rarefactional pressure, thereby producing cavitation nuclei that may be further acted upon by the acoustic field. By combining theoretical thresholds for bilayer-nucleation and cavitation in tissue, it is shown that the maximum acoustic pressure permitted by the US FDA for the safe use of diagnostic ultrasound is lower than necessary in most circumstances. An evidence-based safety threshold for non-thermal effects of diagnostic ultrasound will be proposed. (NIH Grant R21EB013763-01)

WEDNESDAY MORNING, 16 MAY 2012   S423, 8:20 A.M. TO 12:40 P.M.

Session 3aPP

Psychological and Physiological Acoustics: Cortical Neuroimaging Techniques in Auditory Perception and Cognition

Adrian (KC) Lee, Cochair
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Lin Chen, Cochair
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Invited Papers

8:20

3aPP1. Mapping the human cortex associated with auditory processing in space, time and frequency using different neuroimaging techniques. Adrian KC Lee (Dept. of Speech and Hearing and Inst. For Learning and Brain Sci. (I-LABS), Portage Bay Bldg. Rm. 204, Box 357988, Univ. of Washington, Seattle, WA 98195, akclee@uw.edu)

Functional magnetic resonance imaging (fMRI), Magneto- and Electro-encephalography (M-EEG) are neuroimaging techniques that have been used extensively to study human auditory perception and cognition. Due to the different spatial and temporal resolutions associated with these methods, each technique offers a different unique window into how our cortex participates in auditory tasks. In this talk, a summary of how each presentation in this session leverages the strengths of these neuroimaging techniques to map how our cortex dynamically responds to different sound features will be presented. Other methodological advances that are particularly relevant to experiments in auditory perception and cognition will also be discussed. Funded by USA-NIH R00DC010196.

8:40

3aPP2. Using functional magnetic resonance imaging to explore the representation of binaural cues in human auditory cortex. G Christopher Stecker (University of Washington, 1417 NE 42nd St, Seattle, WA 98105, cstecker@uw.edu), and Susan A McLaughlin (University of Washington, 1417 NE 42nd St, Seattle, WA 98105)

Functional magnetic resonance imaging (fMRI) was used to examine representations of interaural differences of level (ILD) and time (ITD) in human auditory cortex (AC). In one experiment, ILD of amplitude-modulated sounds varied parametrically across 12-s blocks, with a single image acquired at the end of each block (i.e., using a "sparse" imaging protocol). In another experiment, ILD or ITD varied parametrically across brief (1-s) presentations, and responses measured from continuosly-acquired images using an "event-related" paradigm. Whole-head echo-planar imaging (~3x3x3 mm resolution) was conducted at 3T (Philips Achieva), with sounds presented via insert earphones (Sensimetrics). Blood-oxygenation-level-dependent (BOLD) signals were analyzed on each individual's cortical surface using FSL, Freesurfer, and MATLAB. In this presentation, results will be discussed in terms of (1) the tuning of BOLD responses to ILD and ITD; (2) the relationship between tuning to ILD and tuning to monaural intensity; (3) ILD-related information as assessed using multi-voxel pattern analysis; (4) adaptation of the BOLD response as a function of trial-to-trial variation in binaural cues; and (5) whether the BOLD responses reflect physical versus perceptual (e.g., perceived location or loudness) aspects of auditory experience. [Supported by NSF DBI-0107567, NIH R03-DC009482-02S1, R01-DC011548, T32-DC005361]

9:00

3aPP3. Decoding feature information in human auditory cortex—A comparison of auditory perception, short-term memory and imagery. Annika Carola Linke and Rhodri Cusack (The University of Western Ontario, The Brain and Mind Institute, London, ON N6A SB7, Canada, alinke2@uwo.ca)

The flexible nature of auditory cortex, the complexity of real-world sounds, and limitations of the methods for neural measurement in humans have made it difficult to investigate auditory feature information processing in the human brain. Which precise features are encoded in auditory cortex and the roles they play in different cognitive tasks remained unclear. New methods for functional magnetic resonance (fMRI) provide solutions to these limitations. New acquisition sequences make less noise, improving the suitability of fMRI for auditory research. Real-time adaptive fMRI and multivariate pattern analysis methods are robust to individual differences in anatomy and exploit information in distributed neural networks. They allow assessment of which acoustic and abstracted features of simple and natural sounds are represented in human auditory regions during perception, and cognitive tasks such as change detection and imagery. The results indicate that auditory cortex is recruited for processes beyond analyzing simple feature information, playing an important

role in maintaining sounds in short-term memory and encoding abstracted information during imagery. This research was supported by the Medical Research Council (UK) and The Brain and Mind Institute, University of Western Ontario.

9:20

3aPP4. Hemispheric specialization in auditory processing of Chinese lexical tones: a study using whole-head recordings of EEG. Xiao-Dong Wang, Feng Gu, and Lin Chen (University of Science and Technology of China, Hefei 230027, China, wxd@mail.ustc.edu.cn)

It has long been established that the left hemisphere is specialized for speech whereas the right for music. However, it remains elusive whether the labor division between the two hemispheres is determined by function or acoustic property of stimuli. The confusion in the literature raises a possibility that the two factors are involved at different levels of auditory perception, respectively. In the present study, we demonstrate the dependence of hemisphere specialization on acoustic properties of stimulus in early auditory processing. We frequently presented to Mandarin Chinese speakers a meaningful consonant-vowel syllable and infrequently varied either its lexical tone or initial consonant to result in changes in word meaning. The lexical tone contrasts evoked a stronger pre-attentive electric response, as revealed by whole-head recordings of the mismatch negativity, in the right hemisphere than in the left but the consonant contrasts produced an opposite pattern. This hemisphere dominance was acoustically dependent since lexical tones and consonants in Chinese have an equal function in defining word meaning but have distinct spectral and temporal features. Our finding suggests that dominant involvement of functional cues in hemisphere specialization is only possible at a higher level of auditory processing.

9:40

3aPP5. Benefit and limitation of combining MEG and fMRI to study correlates of perception in the auditory cortex. Alexander Gutschalk (Department of Neurology, University of Heidelberg, Im Neuenheimer Feld 400, 69120 Heidelberg, Germany, Alexander.Gutschalk@med.uni-heidelberg.de), Iris Steinmann, Katrin Wiegand, and Andrew Dykstra

MEG is a strong tool for cognitive hearing research, because it allows for studying the brain's function in silence and with high temporal precision. However, MEG's ability to clearly separate neighboring sources, e.g. primary and secondary auditory cortex, is limited. While fMRI is more precise with respect to the latter requirement, it lacks the previous two advantages. Here we will demonstrate two examples of combined MEG and fMRI: The first example is perceptual awareness under informational masking. MEG revealed a distinct negative response that is evoked when listeners indicated to be aware of targets in presence of an informational masker, but not when targets were successfully masked. Earlier activity from primary auditory cortex was evoked by all targets and was independent of perceptual awareness. Nevertheless, fMRI shows that activity related to awareness is, at least in part, also generated in the primary auditory cortex. The second example is periodicity pitch; while MEG has consistently revealed responses related to periodicity and supposedly pitch in lateral Heschl's gyrus, fMRI results have been inconsistent. In a direct comparison, we could show that fMRI activity is not predominantly related to the evoked pitch response in MEG, demonstrating limitations for the combination of the techniques.

10:00

3aPP6. Hijacking gamma oscillations during auditory attention. Barbara Shinn-Cunningham (Center for Computational Neuroscience and Neural Technology, Boston University, 677 Beacon St., Boston, MA 02215, shinn@cns.bu.edu), Hari Bharadwaj (Biomedical Engineering, Boston University, 677 Beacon St., Boston, MA 02215), and Adrian KC Lee (Speech and Hearing Sciences, Portage Bay Bldg. Room 206, University of Washington, Box 357988, Seattle, WA 98195)

Neuroelectric imaging methods (electroencephalography and magnetoencephalography) can reveal cortical activity phase locked to amplitude modulation in sensory inputs for frequencies up to about 100 Hz. The neural response at the input modulation frequency is known as the visual or auditory steady-state responses (VSSR or ASSR, depending on input modality). In vision, VSSR strength is modulated by attention: energy in the frequency modulating an attended object is enhanced, while the VSSR to a distracting object is suppressed. However, in the literature, attention causes less consistent effects on the auditory steady-state response. We combined M/EEG to study how the ASSR is modulated when listeners focus spatial attention on one of two speech streams. We find that attention enhances the ASSR power at the frequency of an attended stream in auditory cortex contralateral to the attended direction. The attended-stream modulation frequency also drives phase-locked responses in left, but not right precentral sulcus (which is associated with control eye gaze and spatial attention). This asymmetric activation of the attentional network helps explain seemingly contradictory results of past auditory studies, most of which used dichotic rather than binaural simuli and analyzed results in sensor space or assumed particular dipole solutions rather than doing whole-brain analysis.

Contributed Papers

10:20

3aPP7. Cortical activation during the perception of intelligible and unintelligible speech as measured via high- density electroencephalography. Rene Utianski (Arizona State University, P.O. Box 870102, Tempe, AZ 85287-0102, rutiansk@asu.edu), John Caviness (Mayo Clinic Scottsdale, 5777 East Mayo Boulevard, Phoenix, AZ 85054), Julie Liss (Arizona State University, P.O. Box 870102, Tempe, AZ 85287-0102), Andrew Lotto (University of Arizona, P.O. Box 210071, Tucson, AZ 85721-0071), and Kaitlin Lansford (Arizona State University, P.O. Box 870102, Tempe, AZ 85287-0102)

High-density electroencephalography (EEG) was used to evaluate cortical activity patterns during the auditory processing of speech presented at various levels of degradation in a sentence verification task. 25 healthy participants listened to true-false sentences produced with one of 3 channel levels (1, 6, 16), ranging from unintelligible, moderately intelligible, and highly intelligible. Behavioral data were collected via button press (reaction time and accuracy) for each sentence. The analysis of cortical activation patterns includes 1) the identification of independent components that account for variations of activity associated with degradation levels and 2) the examination of associated event-related potentials. Statistical analyses will be performed on individuals' cortical activity, in tandem with behavioral data. Preliminary results reveal differences in the timing and magnitude of frontal and temporal lobe activation that coincide with task difficulty. Results of the present investigation will inform hypotheses about regions of interest for further investigation and will bear on models of connected speech perception, including the neurobiological underpinnings of individual differences and manifestations in a listener's understanding of degraded speech.

11:00

3aPP8. Cortical activation associated with the unmasking effect of perceived separation on speech perception. Huahui Li (Department of Psychology, Speech and Hearing Research Center, Peking University, Beijing 100871, huahui.li.2319@gmail.com), Lihua Mao (Department of Psychology, Peking University, Beijing 100871), Xihong Wu, and Liang Li (Department of Psychology, Speech and Hearing Research Center, Peking University, Beijing 100871)

Spatial separation between the sound images of the target speech and the masker can improve recognition of the target speech, especially when the masker is irrelevant speech. In the present study, functional magnetic resonance imaging (fMRI) was used to investigate the neural basis of the unmasking effect of the perceived spatial separation. Target sentence was presented along with either steady-state speech-spectrum noise or irrelevant 2-talker speech at the signal-to-noise ratio of -8 dB through headphones. Position of the target image and that of the masker image were manipulated separately by modulating the time interval between the left and the right headphones, thus the two images were either co-located or separated. Sparse temporal sampling was used to avoid the influence of scanner noise. The results show that bilateral superior temporal gyrus (STG) activation was larger under the speech-masking condition relative to the noise-masking condition. When the masker is speech but not noise, the target-masker co-location was associated with more activation in left post parietal lobe and bilateral precentral/postcentral gyrus relative to the target-masker separation. The results suggest that more demand of both attention resource and central processing are required when the target speech is perceived as co-located with the speech masker.

11:20

3aPP9. Behavioral and physiological measure for pitch matching between electrical and acoustical stimulation in cochlear implant patients. Chin-Tuan Tan, Benjamin Guo (New York University, School of Medicine, Department of Otolaryngology, 550 First Avenue NBV 5E5, New York, NY 10016, Chin-Tuan.Tan@nyumc.org), Brett Martin (City University of New York, Speech and Hearing Sciences, 365 Fifth Avenue, Room 7107, New York, NY 10016), and Mario Svirsky (New York University, School of Medicine, Department of Otolaryngology, 550 First Avenue NBV 5E5, New York, NY 10016)

This study examines behavioral and physiological measures of pitch matching in cochlear implant (CI) users who have residual hearing in the contralateral ear. Subjects adjusted the frequency of an acoustic tone to match the pitch percept elicited by electrical stimulation in the other ear, when stimulation was alternating across two ears. In general, the selected acoustic frequencies did not line up perfectly with the center frequencies of the analysis bands corresponding to each stimulation electrode. Similar alternating electro-acoustic stimuli were used to record Auditory Evoked Potentials on 8 NH subjects and 3 CI patients. NH subjects were presented with a fixed tone in one ear, while tones in the other ear varied within a few octaves from the fixed tone. CI patients were stimulated with six different audible tones including their pitch-matched tones, while receiving electrical stimulation in the electrode. N1 latency for NH subjects was minimized when the same frequency was presented to both ears. Similarly, N1 latency for CI patients who are able to pitch match was minimized when the tone was at the pitch matched frequency of the stimulated electrode. These results suggest that N1 latency can be a possible objective measure of pitch matching. (Work supported by NIH/NIDCD 1K25DC010834-01;PI:Tan, PSC-CUNY;PI:Martin, and NIH/NIDCD R01-DC03937;PI:Svirsky.)

3aPP10. Cortical and brainstem differentiation of neural responses to hits versus misses. Scott Bressler (Boston University, Auditory Neuroscience Laboratory, 677 Beacon Street Boston, MA 02215, scbressler72@gmail.com), Vincent Lin, Diana Aksyonova, and Barbara Shinn-Cunningham (Boston University)

Near threshold, the same physical stimuli sometimes are perceived, but sometimes go unheard. Past visual studies have shown cortical evoked response potentials (ERPs) recorded via electroencephalography (EEG) are greater when an input is perceived than when it is not detected. Here, this approach was extended to ask whether there are detectable differences in neural activity in response to detected and undetected sounds, and whether these differences are present not only cortically, but also even earlier in the auditory system. Listeners are asked to detect the presence of a threshold-level tone complex presented in noise, presented amidst "no tone complex" catch trials. Tone-present trials are binned based on perceptual outcome ("hits" versus "misses"). Cortical ERPs from "hits" trials were found to be more robust than ERPs from "misses." Moreover, post-stimulus alpha activity (8-12 Hz) differs; specifically, "misses" showed sustained alpha activity beginning 200 ms post-stimulus, while "hits" showed an amplitude decrease in alpha around 250-300 ms. FFRs from the same EEG data for "hits" and "misses" are being compared to determine whether perceptual differences are observable early in the auditory processing stream.

12:00

3aPP11. Feature-specific cortical plasticity after rapid perceptual learning during speech segregation: a MEG study. Yi Du (Department of Psychology, Speech and Hearing Research Center, Key Laboratory on Machine Perception (Ministry of Education), Peking University, Beijing 100871, China, duyi23@126.com), Yu He (Rotman Research Institute, Baycrest Centre for Geriatric Care, Toronto, Ontario, M6A 2E1, Canada), Xihong Wu (Speech and Hearing Research Center, Key Laboratory on Machine Perception (Ministry of Education), Peking University, Beijing 100871, China), Liang Li (Department of Psychology, Speech and Hearing Research Center, Key Laboratory on Machine Perception (Ministry of Education), Peking University, Beijing 100871, China), and Claude Alain (Rotman Research Institute, Baycrest Centre for Geriatric Care, Toronto, Ontario, M6A 2E1, Canada; Department of Psychology, University of Toronto, Ontario, M8V 2S4, Canada)

This study examined whether 1-hour perceptual training could elicit feature-specific improvement of performance and corresponding cortical plasticity in humans during speech segregation by using magnetoencephalography (MEG). One group of participants learned to segregate concurrent vowels by using difference in fundamental frequency (f_0) while the other group learned to use difference in sound location. MEG recordings were conducted after the training and required participants to identify the two different vowels, which may have the same f_0 and location or differ in f_0 only, location only or both f_0 and location. Compared to Control Group who didn't receive pre-scan training, the trained groups showed behavioral improvements specific to the trained cues which were paralleled by feature-specific changes on brain activities. That is, f_0-difference-induced changes in dipole source-waveforms in auditory cortex were only modulated in Frequency Group, while location-difference-induced changes were only modulated in Location Group. Furthermore, Frequency Group showed stronger activations in auditory "what" pathway than Location Group when processing f_0-difference, while Location Group revealed stronger activation in auditory "where" pathway than Frequency Group when processing location-difference. The double-disassociation in both behaviors and neuromagnetic responses indicates that rapid perceptual learning could elicit highly feature-specific plasticity in human cortex during speech segregation.

12:20–12:40 Panel Discussion

Session 3aSA

Structural Acoustics and Vibration and Noise: Aircraft Cabin Noise

Anders Nilsson, Cochair
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Bilong Liu, Cochair
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Invited Papers

8:20

3aSA1. Prediction method of aircraft interior noise and validation testing. Haoming Qin and Kai Pan (Aircraft Strength Research Institute, Xian City, 710065, China, qinhming@163.com)

VA-one software is based on Statistical Energy Analysis theory. In this paper, acoustic modeling and prediction of interior noise of Fuselage Acoustic Research Facility (FARF) are accomplished with this software. With its support, the subsystem partition method and modeling method of airframe are proposed; further validation by testing method is also studied. With several different kinds of sidewall structures, the FARF is excited by speaker arrays and shakers while acoustic and vibration energy were measured and added into model as input. The interior damping loss factor was obtained by reverberant time measurement. Then the sound pressure level was predicted. Good coherent between prediction and measurement was obtained while methods of testing and data processing are validated. All these are very important to improve the capability of prediction of interior noise of aircraft.

8:40

3aSA2. Sound random incidence absorption characteristics of a thin plate with PZT shunted with passive electrical circuits. Chen Xiang (IACAS, chenxiang@mail.ioa.ac.cn)

Sound absorption of a thin plate with PZT shunted with passive electrical circuits in diffuse field Sound absorbing properties of a plate with piezoelectric shunted circuit in diffuse field is investigated in this paper. A theoretical model of a thin plate with piezoelectric patch and electrical circuit under random sound incidence is proposed and numerically analyzed. Measurement is also carried out in a reverberation room and found to be in good agreements with the theoretical model. Theoretical and measured results confirmed that this technology has a potential to improve sound absorption at low frequency

9:00

3aSA3. Cabin noise controlling on MA600. Feng Hou and Qun Yan (Aircraft Strength Research Institute, 710065, China, carsper623@gmail.com)

MA600 is one turbo-propeller driven regional aircraft modified from MA60, which has considerable high interior noise level. Project on MA600 cabin noise reduction involve numbers flight test, huge laboratory measurement campaign as well as numerical simulations. Based on the understanding of noise sources and their transmission path learned from both test and simulation, an integrated acoustic treatment plan was drawn and implemented on the MA600 to reduce the interior sound pressure level while weight reduction was also archived.

9:20

3aSA4. Near-field effect as sound transmission through a panel-cavity system. Bilong Liu (The Key Laboratory of Noise and Vibration, Institute of Acoustics, Chinese Academy of Sciences, 100190, Liubl@mail.ioa.ac.cn)

Evidence from measurement indicates that sound pressure level inside cabin is dominant for the seats close to the windows. It could be 3~6 dB(A) higher than that of the seats close to the corridor for a commercial aircraft during cruising. This near-field phenomenon of transmitted sound is modeled and investigated by the sound transmission through a panel-cavity system. The distribution of transmitted sound pressure level behind the flexural panel is calculated and the effect of local absorption layer behind the flexural panel is specially included for a comparison. Simple measurement is also carried out to show that the size and thickness of local absorption layer is sensitive to the near-field of transmitted sound.

9:40

3aSA5. The experimental research of acoustic property of anti-ice shield for propeller aircrafts. Kai Pan and Haoming Qin (Aircraft Strength Research Institute, Xian City, 710065, China, pankai.er@126.com)

For propeller driven aircraft, the structural noise caused by periodic aerodynamic load on the fuselage hence transmitted into cabin is dominating, especially on the propeller rotating plane. The anti-ice shield is effective against such. Through experimental research, the sound isolation property of the anti-ice shield from one particular aircraft was improved, and the routine of acoustic property optimization was summarized.

3a WED. AM

10:00

3aSA6. The aircraft acoustics research and achievements of AVIC. Wenchao Huang and Hai Yang (Aircraft Strength Research Institute, Xian City, 710065, China, va-623@163.com)

Passing through decades of research, development, applications and improvements, the AVIC has sent their ARJ-21 and MA-600 for the first flight and drawing greater prospect for future. The acoustic research for aircraft in AVIC mainly focus on three aspects: interior noise environment for passenger comfort, exterior noise emission for mandatory airworthiness regulation and sonic fatigue for safety issue, while integrated design strategy, optimization routine and validation procedure were developed, supporting aircrafts development and aiming the future.

Contributed Papers

10:20

3aSA7. Measurement of the noise radiation of the panels subjected to turbulent boundary layer pressures. Daoqing Chang (Institute of Acoustics, Chinese Academy of Sciences, No. 21, Bei-Si-huan-Xi Road, Beijing, China, changdq@mail.ioa.ac.cn), Xiang Chen (Institute of Acoustics, Chinese Academy of Sciences, No. 21, Bei-Si-huan-Xi Road, Beijing, China), Zhongchang Qian (Institute of Acoustics, Chinese Academy of Sciences, No. 21, Bei-Si-huan-Xi Road, Beijing, China), and Bilong Liu (Institute of Acoustics, Chinese Academy of Sciences, No. 21, Bei-Si-huan-Xi Road, Beijing, China)

The noise radiation of the panels with different treatments under a turbulent boundary layer (TBL) excitation is tested in an anechoic wind tunnel. The averaged dimensionless spectrum for the response and the radiated sound power of panels with different size, stiffening and damping treatments are collected at the condition of various flow speeds. Numerical analysis of panel parametric sensitivity on the radiated noise due to TBL excitation is also presented for a comparison.

10:40–11:00 Break

11:00

3aSA8. Prediction and measurement of acoustical property for natural fiber reinforced composite laminates. Weidong Yang, Yan Li, and Yongdong Pan (Tongji University, 200092, kevin_yangwd@hotmail.com)

Owing to the advantages of low density, low cost, easy availability and biodegradability, natural fibers are promising for industrial use in fiber-reinforced composite materials. Porous structures of natural fibers greatly contribute to the excellent sound absorption properties and multilayered composite panels also possess good sound insulation. Natural fiber reinforced composite (NFRC) laminates were manufactured in view of the process requirements of industrial production. Acoustic properties of NFRC, such as absorption coefficient, transmission coefficient and transmission loss, were measured by transfer function method in four-microphone impedance tube. Moreover, a theoretical model of multilayer material system of NFRC was proposed and the predicted results calculated by transfer matrix method are consistent with experimental measurement. This model can be used to predict acoustic properties of multilayered laminate system of NFRC.

11:20

3aSA9. Sound transmission through a double panel structure jointed with rubber isolators. Zhongchang Qian, Daoqing Chang, and Bilong Liu (Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, No. 21, North 4th Ring Road West, Haidian District, Beijing 100190, P.R. China, qianzhongchang@mail.ioa.ac.cn)

Sound transmission through an aircraft sidewall structure is investigated theoretically and experimentally in this paper. The studied configuration is composed of double-leaf lightweight partitions jointed with discrete placed rubber isolators. The effects of isolator stiffness, damping and spacing on sound transmission loss are calculated and tested. The influence of acoustic absorption treatment filled in the cavity is also included for a comparison. Furthermore, two methods which refers to space-harmonic and modal superposition expansions are employed for infinite and finite dimensions. At last, some approaches for sound transmission loss optimization are proposed.

11:40

3aSA10. Civil aircraft cabin noise resource acoustic characteristic and transmission path analysis. Qian Shi (The Olympic Building, No. 267, North 4th Ring Road, Haidian Disctrict, Beijing 10083, P.R. China, shiqian@comac.cc)

Typically, there are mainly 4 different noise resources critical to cabin +F1184noise: auxiliary power unit (APU) noise, environment control system (ECS) noise, engine noise and turbulent boundary layer (TBL) noise. Because of the different acoustic characteristic and transmission path for each resource, their impacts to cabin noise level are not the similar. A vibration and noise test under ground and flight status of an in-service civil aircraft was conducted. Based on the test results, comparing the data under different test status, the acoustic characteristic and transmission path are analyzed for the 4 noise resources in this paper, including distribution characteristic, spectrum characteristic and transmission path. APU noise mainly affects the rear fuselage, ECS noise transmits by ducts, engine noise and TBL noise transmit through side panel.

12:00

3aSA11. The study on sonic response analysis method for civil aircraft structure. Yu Wang, Jiazhen Zhang, Xiaoling Zheng (Beijing Aeronautical Science & Technology Research Institute of COMAC, Beijing 100083, China, wangyu2@comac.cc), and Jun Liang (Center for Composite Materials and Structure, Harbin Institute of Technology, Harbin 150001, China)

Sonic fatigue problem is one of the important terms of civil aircraft airworthiness examination. In this paper, two different engineering analysis methods are employed to study the sonic response characteristics of a kind of typical commercial aircraft structure (skin-string-frame structure). Whereafter the sonic response experiment for this structure is carried out, and the resonance frequency and root mean square (RMS) stress are measured. According to the comparison of engineering analysis results and experimental results, the analysis error and effectiveness of these two methods are studied. The resonance frequency analysis results for both methods are in good agreement with experimental results, and the prediction results of RMS stress are also acceptable in engineering.

Session 3aUWa

Underwater Acoustics: Propagation

Megan Ballard, Cochair
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Zhaolu Peng, Cochair
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Contributed Papers

8:20

3aUWa1. Acoustic wavefront tracing in range-dependent ocean. Oleg A. Godin (CIRES, University of Colorado at Boulder and NOAA/Earth System Research Laboratory/Physical Sciences Division, Mail Code R/PSD99, Boulder, CO 80305-3328, Oleg.Godin@noaa.gov), and Nikolay A. Zabotin (CIRES, University of Colorado at Boulder, Boulder, CO 80309)

It has been established experimentally and confirmed by numerical simulations that early arrivals of acoustic waves at long-range propagation in a deep ocean are stable and identifiable despite strong perturbations of the ray paths due to sound-speed fluctuations primarily induced by internal gravity waves. It is wavefronts rather than rays that are typically observed in underwater acoustic experiments. Wavefronts are much more stable with respect to environmental perturbations than individual rays, which form the wavefronts. The relative stability of the wavefronts takes place because scattering of the end points of rays resulting from weak environmental perturbations occurs primarily along wavefronts of the unperturbed wave with the same travel time [O. A. Godin, J. Acoust. Soc. Am. **122**, 3353–3363 (2007)]. When wavefronts are much more stable than rays, the traditional approach, which relies on ray tracing to determine wavefronts' position, may be counterproductive and sometimes misleading, especially for highly structured environments such as the ocean with internal waves and "spice." This paper presents an efficient numerical technique for modeling acoustic wavefronts and timefronts in range-dependent ocean without solving ray equations. The acoustic wavefront tracing code has been benchmarked using analytic solutions of the eikonal equation. [Work supported by ONR.]

8:40

3aUWa2. Spatiotemporal variability of underwater sound fields near steep slopes. Timothy F. Duda (Woods Hole Oceanographic Institution, AOPE Dept. MS 11, Woods Hole, MA 02543, tduda@whoi.edu), Ying-Tsong Lin (Woods Hole Oceanographic Institution, AOPE Dept. MS 11, Woods Hole, MA 02543), Weifeng Gordon Zhang (Woods Hole Oceanographic Institution, AOPE Dept. MS 12, Woods Hole, MA 02543), Aurelien Ponte, and Bruce D. Cornuelle (Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0209)

Studies using idealized bathymetry have shown that steep slopes can have important effects on the geometric structure of ocean sound fields. Other studies have provided insight into the temporal variability of sound fields in the moving ocean. There is a general understanding that both effects occur together in the ocean, but their relative importance is not fully known, nor is the way they interact. The processes are often linked because slopes can generate strong internal tides and waves. Here, the coupled spatial and temporal variability is investigated using time-stepped three-dimensional (3.5-D) sound propagation modeling. The needed ocean sound-speed information is generated using modern regional ocean modeling. Solutions of the 3D parabolic acoustic wave equation are generated for a few hundred hertz. The spatial patterns of sound reveal that temporal intensity variation

(scintillation) caused by internal tides can be enhanced at areas where sound encounters steep slopes. The magnitude of the effect is measured by repeating the simulations with a smoothed seafloor substituted for the realistic seafloor. The effect of internal tide strength on the interaction is quantified similarly. The effects of tide strength and seafloor steepness on spatial patterns of the sound field horizontal correlation length are also investigated.

9:00

3aUWa3. Acoustic propagation modeling in environments which induce horizontal refraction and mode coupling. Megan Ballard (Applied Research Laboratories at the University of Texas at Austin, P.O. Box 8029, Austin, Texas 78713-8029, meganb@arlut.utexas.edu)

In typical applications of modeling underwater sound propagation, three-dimensional effects are assumed to be relatively weak and two-dimensional models are applied on a vertical plane to predict acoustic signals. However, this assumption breaks down for many shallow-water environments. For example, evidence of horizontal refraction has been documented in the context of nonlinear internal waves and sloping bathymetry. In this work, three-dimensional effects are modeled using a coupled-mode technique which includes the effects of out-of-plane scattering. Several examples of propagation in three-dimensional environments will be presented. A decomposition of the field into modal amplitudes will be used to identify features in the environment responsible for the observed effects on the acoustic field. [Work supported by ONR]

9:20

3aUWa4. The effect of random bottom bathymetry on mode structure and coherence in shallow water propagation. Jennifer Wylie and Harry DeFerrari (University of Miami—RSMAS Division of Applied Marine Physics, 4600 Rickenbacker Causeway, Miami, Fl 33149, jennie.wylie@gmail.com)

Ideal flat bottoms in shallow water propagation channels produce predictable surface-reflected-bottom-reflected (SRBR) mode structures. Further, modes have predictable group velocities so that arrivals patterns for pulse transmissions can be identified by travel time. But bathymetry is rarely truly flat to a fraction of an acoustic wavelength over ranges of a few km. Here, we examine the mode pattern deviation from the flat bottom case as random variations in bathymetry are introduces. A PE propagation model with range dependent bottom reveals that mode structures become distorted with increasing fluctuation in bathymetry. Higher order modes deteriorate first and the fundamental mode propagates longest without distortion. For higher order modes, RMS fluctuations greater than $1/2$ the acoustic wavelength destroy recognizable mode structure as compared to the smooth bottom case. If the fluctuations are further increased to 1 wavelength, discreet modes give way to continuous ones and energy is smeared in space and arrival time and mode arrivals become incoherent and undetectable with the commonly used phase coherent signal processing methods. The coherence of modes has implications on both temporal and spatial coherence. The

3391 J. Acoust. Soc. Am., Vol. 131, No. 4, Pt. 2, April 2012

Acoustics 2012 Hong Kong **3391**

3a WED. AM

models are used here to predict the frequency/depth/range limits on coherence for simple statistical description of bottom bathymetry fluctuations.

9:40

3aUWa5. Analysis of acoustic fluctuation of the different tracks by the internal waves. Fan Li (No. 21, Beisihuanxi Road, Institute of Acoustics, Chinese Academy of Science, Beijing 100190, China, lifanyuxin@sohu.com), Xinyi Guo, Tao Hu, Li Ma, and Yaoming Chen

Internal waves in shallow-water cause sound speed profiles variations and acoustic transmission abnormity. The acoustic data show arrival time variations and mode coupling phenomena. The 2009 experiment collected high quality environmental and acoustic data and were used to analyse the effect of internal waves on the acoustic transmission. One notable feature of the experiment is that internal crossed two tracks at different incidence angles. The paper compare acoustic fluctuation character at two different tracks and use mode filter method to investigate the mode coupling caused by internal wave. The correspondence between data and simulation results show that the alternate of mode 2 and mode 1 were observed at the track which is vertical with the internal wave direction. The alternate of Mode 3 and first two modes occur at the another track.

10:00

3aUWa6. The mode coupling and effect on ambient noise vertical directionality caused by internal waves in shallow water. PengFei Jiang, Jian-Heng Lin, XueJuan Yi, and Guojian Jiang (Qingdao Lab of Institute of Acoustics, Chinese Academy of Sciences, No. 8, Shangqing Road, Shibei District, Qingdao 266023, Shandong Province, China, joyouc@126.com)

Experiments show that internal waves can cause the fluctuation of the depth of thermocline in shallow water, which may bring about two results: one is the change of hit number of sound rays and sea bottom, the other is mode coupling. The former changes the sound intensity, and the latter changes the sound energy distribution. The previous studies show that internal waves cause mode coupling by changing the sound propagation paths, which can fill the noise notch. In the calculation, it is found that the notch is deepened when some solitary internal waves are present. The reason is that the sound wave excited by the distant sources which are located on the palne near the sea surface propagates through the soliton which is a single downward undulation. The mode coupling from low-order modes to higher-order modes happens first, then the reverse conversion occurs. However, the former coupling is stronger, the lower-order modes fall off and the filling ability is weakened, so the notch is deeper.

10:20

3aUWa7. Passive measurement of lengthways transfer function in ocean waveguide using ambient noise. Xinyi Guo (Key Laboratory of Underwater Acoustics Environment, Institute of Acoustics, Chinese Academy of Science, Beijing 100190, China, guoxinyi@mail.ioa.ac.cn), Fan Li, Li Ma, and Yaoming Chen

This paper introduces a function of correlation between two hydrophones, basing on the Kuperman-Ingenito ocean ambient noise model. There is a similarity in form between the correlation function and the transfer function in ocean waveguide from a point source to a receiver. Thus, the noise correlation function between two hydrophones in vertical location can extract actual transfer function, then the acoustics line arrival structure of propagation in lengthways waveguide can be analyzed. In this paper, the transfer function in lengthways ocean waveguide can be obtained from broadband ambient noise correlation function of vertical line array. There are some analyses about physical significance of noise interference basing on compared simulation and experience. This method can be used to research layered sea floor considering the arrival time structure of each propagation route.

10:40–11:00 Break

11:00

3aUWa8. Long range propagation modeling of offshore wind turbine noise using finite element and parabolic equation models. Huikwan Kim, Gopu R. Potty (Department of Ocean Engineering, University of Rhode Island, Narragansett, RI 02882, hkkim524@my.uri.edu), James H. Miller (NATO Undersea Research Centre, La Spezia, Italy), Kevin B. Smith (Department of Physics, Naval Postgraduate School, Arlington, VA 22203), and Georges Dossot (Department of Ocean Engineering, University of Rhode Island, Narragansett, RI 02882)

Noise generated by offshore wind turbines and support structures radiates and propagates through the air, water and sediment. Predicting noise levels around wind turbine structures at sea is required to estimate the effects of the noise on marine life. We used Finite Element (FE) and Parabolic Equation (PE) models to predict long range propagation of noise from the construction and operation of offshore wind turbines. FE analysis produced pressure outputs at short ranges were used as a starting field for a modified PE propagation model. Furthermore, we investigated the optimum range for the transition to PE modeling. The effects of various sediment types were also considered determining the pressure starting field. In FE analysis models, we implemented the axisymmetric elements and implicit dynamic analysis with pressure impact loading and vertical acceleration boundary conditions to simulate pile driving and operational noise radiation. We will present the PE long range pressure field outputs from the offshore pile driving and operation for a shallow water environment around Block Island, Rhode Island.

11:20

3aUWa9. Quantitative predictions of impact pile driving noise in water using a hybrid finite-element propagation model. Mario Zampolli, Marten J.J. Nijhof, Michael A. Ainslie, Christ A.F. De Jong, Erwin H.W. Jansen (TNO Acoustics and Sonar Group, 2597 AK The Hague, The Netherlands, mario.zampolli@tno.nl), and Ahmad T. Abawi (Heat Light and Sound Research Inc., La Jolla, CA 92307, U.S.A.)

The quantitative prediction of noise radiated into the underwater environment during offshore impact pile driving is a topic of major interest to the underwater acoustics community. This problem is addressed by using a hybrid model consisting of a high fidelity local model describing the vibrating pile and its vicinity, and an efficient model for the propagation of the sound to large distances from the pile in the underwater waveguide. The local model is an axisymmetric linear frequency domain structural acoustic finite-element model, and the propagation model is based on ring-source Green's functions in the water and in the sediment surrounding the pile, obtained by horizontal wavenumber integration. The coupling between the two models is achieved via the Helmholtz integral, in which the pressure and normal displacement in the media surrounding the pile are obtained by sampling the finite-element model results and the Green's functions are obtained from the propagation model. The simulation results are compared to measurements conducted during pile driving operations, showing that the quantitative prediction of the sound exposure levels with such a tool is possible.

11:40

3aUWa10. Air-to-water sound propagation at low frequency in shallow water. Zhaohui Peng and Guangxu Wang (State Key Laboratory of Acoustics, Institute of Acoustics, Chinese Academy of Sciences, Beijing 100190, pzh@mail.ioa.ac.cn)

Owing to great difference of acoustic characteristic impedance between air and water, sound transmission loss from an airborne source into underwater is very high. So, it is very difficult to do experimental research on air-to-water sound propagation. High power of air source is needed to receive signals with high signal-noise-ratio at long range. A fog whistle was used as the source during an experiment conducted for air-to-water sound propagation in the South China Sea in July 2011. A HLA was laid on the sea bottom

3392   J. Acoust. Soc. Am., Vol. 131, No. 4, Pt. 2, April 2012

Acoustics 2012 Hong Kong   3392

at the depth of 90m. The high-power fog whistle was hung on a research ship floating near the HLA. The maximum distance between the whistle and the HLA was 7.5km. The transmission at low frequencies were analyzed and compared with the theoretical predictions.

12:00

3aUWa11. Environmentally robust time reversal processing based on multiple constraint method. Jae Hoon Joo (LIG Nex1, 702, Sampyeong-dong, Bundang-gu, Seongnam-city, Gyeonggi-do, Korea, joojaehoon@lignex1.com), Jea Soo Kim, Jung Hong Cho (Korea Maritime Univ., Dept. of Ocean Engineering, Korea Maritime Univ., 727, Yeong-do), and Sang Taeck Moon (LIG Nex1, 702, Sampyeong-dong, Bundang-gu, Seongnam-City, Gyeonggi-do, Korea)

Time-reversal processing (TRP) uses the signals from a probe source to refocus the signal at the probe source location by back-propagating the

time-reversed version of the received signal. However, the performance of TRP can be degraded by the mismatches due to the non-static environment where propagation condition changes during the time between receiving a probe signal and back-propagating the time reversed signal. In this presentation, two methods for the environmentally robust TRP based on the multiple signal vectors with singular value decomposition and minimum variance with multiple constraint method has been numerically simulated and compared under the condition of mismatches. Multiple sound speed profile, probe source location and tilted array are used to make the TRP robust. The results show that the focal point using robust TRP is well maintained when compared to the conventional TRP. Both methods are efficient for the robustness of time varying environment.

WEDNESDAY MORNING, 16 MAY 2012

S426 + S427, 8:20 A.M. TO 11:20 A.M.

Session 3aUWb

Underwater Acoustics: Target Scattering

Aubrey Espana, Cochair
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Mario Zampolli, Cochair
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Contributed Papers

8:20

3aUWb1. Research on recognizing a cylindrical object using the 3-D formation from highlight and shadow of side scan sonar image. Jieun Lee (Soongsil Univ., 525 Hyoungnam Engineering Dept., Soongsil Univ., Sangdo-dong, Dongjak-gu, Seoul, oldfashion04@naver.com), Taebo Shim, Taejung Kim (Soongsil Univ., 525 Hyoungnam Engineering Dept., Soongsil Univ., Sangdo-dong, Dongjak-gu, Seoul), and Jooyoung Hahn (ADD, P.O. Box 18, Jinhae, Kyuongnam 645-600, Korea)

There are many researches on recognizing and classifying a cylindrical object using side scan sonar images. In this paper we segment object, shadow of object and background of the images in order to extract the cylindrical object from the segmented object information and figure out whether it corresponds to the cylindrical object what we want to find. Shadow of cylindrical object estimated from 3-dimensional segmented space is compared with the shape of shadow got from morphological method. Many objects of different shape such as cylindrical, cylindrical object-likes and non- cylindrical objects are used as a background objects to simulate the objects are mixed with similar objects. Result shows that more than 90 % of the objects were recognized as objects in a comparably short time of order of 1 second.

8:40

3aUWb2. Submerged target scattering: comparison of combined finite element/simplified acoustics models to data. Kevin Williams, Aubrey Espana, Steven Kargl (Applied Physics Laboratory, University of Washington, Seattle, WA 98105, williams@apl.washington.edu), and Mario Zampolli (TNO Defense, Security and Safety, Oude Waalsdorperweg 63, P.O. Box 96864, 2509 JG The Hague, Netherlands)

The environment and the location of the target within that environment affect the scattering from elastic targets in ocean waveguides. Computational power is now realizable to compute the target scattering, in-situ, via

finite elements. However, these calculations still require high cost computer facilities and in the end do not offer physical insight into processes involved. Here we compare two models, with different levels of simplification, to data acquired from an Aluminum target machined to replicate an Unexploded Ordnance (UXO). The first model treats the scattering using two-fluid Green's function propagators in combination with finite element calculations of the target scattering as placed within the waveguide. The second model uses free field, plane wave incidence, finite element results for the target scattering in conjunction with simple ray based propagation to account for the waveguide environment. The data/model comparisons are discussed in light of the physical insight they can help provide, the speed of the calculation and the level of fidelity they achieve. [Work supported by ONR and SERDP, USA].

9:00

3aUWb3. Low- to mid-frequency scattering from submerged targets partially buried in the sediment at an oblique angle. Mario Zampolli (TNO Acoustics and Sonar Group, 2597 AK The Hague, The Netherlands, mario.zampolli@tno.nl), Aubrey L. Espana, Kevin L. Williams (Applied Physics Laboratory, University of Washington, Seattle, WA 98015, U.S.A.), and Philip L. Marston (Washington State University, Pullman, WA 99164, U.S.A.)

The scattering from elastic targets in the low- to mid-frequency regime is affected by the environment surrounding the target. For axisymmetric targets with the axis of symmetry parallel to the water-sediment boundary, previous work has dealt with the change in the target strength as a function of frequency and aspect angle in relation to the burial depth in the sediment. The present work deals with the extension of a finite element model, based on the decomposition of the acoustic and elastic fields into azimuthal Fourier modes, to the case of a target buried at a tilt angle. The interaction between the target and the sediment is represented by the model up to the first order of the scattering series, which means that the scattering of the incident field and of the target reflected field is taken into account, but the rescattering of the boundary reflected echo from the target is neglected.

3393   J. Acoust. Soc. Am., Vol. 131, No. 4, Pt. 2, April 2012

Acoustics 2012 Hong Kong   **3393**

Model results up to 30 kHz are compared to experimental data for a 2 foot long aluminum cylinder of 1 foot diameter buried in sand at a tilt angle.

9:20

3aUWb4. Study on inverse problem of acoustical resonance scattering by elastic shells. Wang Fangyong (NHangzhou Applied Acoustics Research Institute, No. 96, HuaXing Road, Hangzhou, China, sklwfy@gmail.com), Cao Zhengliang, and Du Shuanping (NHangzhou Applied Acoustics Research Institute, No. 96, HuaXing Road, Hangzhou, China)

For the complexity of the analytical expressions for acoustical scattering by even the most simplistic elastic bodies such as spheres and cylinders, inversion of the exact direct problem in analytical way is almost infeasible. So, this paper mainly studies the inverse problem in a numerous way. Low-frequency(ka<50) resonance spectra of targets with varied parameters including longitudinal wave velocity, shear wave velocity, material density and shell thickness are theoretically calculated using Resonance Scattering Theory(RST), and in what way the elastic parameters affect the resonance signature is analyzed and concluded. The results obtained have great significance on active classification research based on acoustical resonance scattering.

9:40

3aUWb5. Predicting the acoustic response of targets in an ocean environment based on modal analysis of finite element calculations. Aubrey España, Kevin Williams (APL-UW, 1013 NE 40th St., Box 355640, Seattle, WA 98125-6698, aespana@apl.washington.edu), Mario Zampolli (TNO Defense, Security and Safety, Oude Waalsdorperweg 63, P.O. Box 96864, 2509 JG The Hague, Netherlands), and Philip Marston (Washington State University, Department of Physics and Astronomy, P.O. Box 642814, Pullman, WA 99164-2814)

Low frequency sound is a viable means for the detection of elastic targets in contact with the ocean floor. The incoming sound, with wavelengths on the order of the target dimensions, can excite resonant modes of the target leading to enhancements in the scattered field. A hybrid model has been developed to predict the acoustic scattering from cylinders, pipes and unexploded ordnance (UXO) in proud or buried configurations in the ocean sediment. The model exploits the symmetry by decomposing the 3-D problem into a sum of 2-D independent Fourier modal sub-problems. This hybrid modeling technique has been shown to agree well with experimental measurements conducted in a pond [A.L. España et al., J. Acoust. Soc. Am. 130, 2330 (2011)]. Presently, these hybrid model results are used to examine the target response on a mode-by-mode basis. A modal map is generated by keeping track of the number of dominant modes contributing to the bright features observed in the acoustic template. For features that are predominantly due to one or two modes, simple analytical models can be used to predict their evolution as a function of target/sensor geometry within the ocean waveguide. [Work supported by ONR and SERDP.]

10:00

3aUWb6. The effects of lumped mass attachments on vibro-acoustic behavior of a fluid-loaded plate. Danzhu Yu, Sheng Li (School of Naval Architecture at Dalian University of Technology, No. 2, Linggong Road, Ganjingzi District, Dalian City, Liaoning Province, 116024, P.R. China, summerydz@163.com), and Yunfei Chen (School of Naval Architecture at Dalian University of Technology & Underwater Test and Control Laboratory)

The effects of attachments on the dynamics of a master structure are of fundamental significance. In this study, the changes in the vibro-acoustic behavior of a fluid-loaded plate due to variations in lumped mass attachments are examined. The finite element for modeling the structure with lumped mass attachments is coupled with the Rayleigh integral for the acoustic fluid to solve the structure – fluid interaction problem and to obtain the response of the coupled system. The changes in the modal parameters due to the variations in attachments are determining from a model reduction method. The Monte Carlo simulation is used for the uncertainty analysis of the vibro-acoustic behavior. Both the mean and the standard deviation of the changes attributable to the attachments are discussed. A baffled plate with water loading/air loading is involved in the study. The numerical results show that the effects and the changes-in-impedance on the master plate due to the attachments vary with the frequency spectrum.

10:20

3aUWb7. Study on an underwater focused acoustic phased array and the sound fields characteristics. Xinwu Zeng (College of Opto-Electric Science and Engineering, National University of Defense Technology, Changsha 410073, China, x.w.ZENG@139.com)

Regarding to the fact that the hydrodynamic characteristics of supercavitating torpedoes strongly depend on the supercavity envelops, this paper describes a high intensity underwater focused acoustic phased array used to remotely disrupt this envelope surface. First, the demand of designing an underwater focused acoustic phased array was discussed, and then an efficient sound field calculation formula for the convex spherical-section phased array was obtained. Furthermore, the effects of element size and array aperture on the valid focusing region of above array were analyzed based on pseudo-inverse method. It is demonstrated, via simulation, that the arrays composed of minimum element size with large beam angle perform well on the intensity of focus pressure, and the valid focusing region under the similar size of emission area. However, the change of valid focusing region is small when merely enlarge the aperture of array. And the possible application of multiple-focus pattern was investigated.

10:40–11:00 Break

11:00

3aUWb8. A theoretical simulation to the arc expansion process in underwater discharge. Yibo Wang (College of Opto-Electric Science and Engineering, National University of Defense Technology, Changsha 410073, China, yibowang.nudt@gmail.com)

A one-dimensional simulation to the arc expansion process in underwater discharge is carried out in this paper towards its final destination—the estimation of the acoustic output in the arc expansion process. Theoretical models for these four sub-processes which are strongly coupled in the arc expansion process, are built up. Based on these theoretical models, a simulation code is developed and the time-evolution data of some key parameters in the arc expansion process are simulated, from which the acoustic output is finally estimated.

Awards Ceremony

Jing Tian
President, Acoustical Society of China

Mardi C. Hastings
President, Acoustical Society of America

Acoustical Society of China

Presentation of Acoustical Society of China Awards

Dah-You Maa Acoustical Award of the Acoustical Society of China

Honorary Membership in the Acoustical Society of China to Leo L. Beranek

Acoustical Society of America

Presentation of ASA Fellowship Certificates

Joel A. Lewitz	Sten Ternstrom
William Shofner	Christopher O. Tiemann
Annemarie Surlykke	

Presentation of Acoustical Society of America Awards

R. Bruce Lindsay Award to Constantin-C. Coussios

Silver Medal in Engineering Acoustics to Gary W. Elko

Honorary Fellowship to Dah-You Maa

Gold Medal to William A. Kuperman

3p WED. PM