Deciphering the Function of Low-amplitude Songs: Courtship, Aggression, and Hormones

Friday, January 17, 2014 4:00 p.m. ETC 4.150

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Across the animal kingdom, acoustic signals serve a variety of important functions in aggression, mate attraction, courtship, and alarm-related signaling. Previous research on the function of acoustic signals has focused predominantly on high-amplitude (loud), long-range songs (LRS), while largely ignoring the low-amplitude (quiet) songs produced during close-proximity, conspecific interactions. Low-amplitude songs can be divided into two classes: (1) soft, long-range songs (soft LRS), which do not differ structurally from a species' LRS, and (2) short-range songs (SRS), which can be widely divergent from a species' LRS in both spectral and temporal characteristics. During my dissertation, I focused on determining the function of low-amplitude songs in a North American songbird, the dark-eyed junco (Junco hyemalis). Male juncos produce a distinct soft LRS and SRS during the breeding season, and SRS is produced at two distinct tempos, slow and fast. I performed a series of experiments involving song playbacks and presentations of live, male and female conspecifics to free-living male juncos to determine the social contexts in which males produce low-amplitude songs and the behavioral and hormonal responses that different songs elicit. The results of these studies provide multiple lines of evidence suggesting that soft LRS may function in both male-male and male-female interactions, while slow SRS functions predominantly in male-female interactions associated with courtship. During simulated courtship interactions in the field, paired and unpaired males appeared to use distinct courtship strategies by differing substantially in LRS production, proximity to the female, and activity, but producing similar amounts of SRS and visual displays. Finally, a meta-analysis of North American breeding birds found that low-amplitude vocalizations are relatively common. Collectively, these results emphasize that future studies of acoustic signaling in any taxon should focus on all components of the acoustic repertoire including both high- and low-amplitude signals.

Synergetic Ablation of Tumors with Focused Ultrasound and Ethanol

Friday, January 24, 2014 4:00 p.m. ETC 4.150

Dr. Damir B. Khismatullin
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Focused ultrasound (FUS) emerges as a powerful technology for noninvasive, or minimally invasive, non-ionizing treatment of cancer and many other diseases. When operated at high intensity, FUS deposits a large amount of acoustic energy at the focal region within the target tissue (e.g., tumor), causing tissue heating and necrosis, the process known as thermal ablation. When operated at low intensity, FUS is capable of increasing the proliferative potential and functionality of living cells such as neurons and bone cells. As such, it can be used as a tool to treat neurodegenerative diseases, nerve injuries, and bone fractures. The major focus of previous studies was on using FUS as a standalone

therapeutic method. Several deficiencies of standalone FUS (e.g., small area of treated tissue, lengthy procedure, sophisticating scanning protocol) prevented its widespread use in clinics and approval by the FDA. In this talk, I will present recent in vitro and in vivo data from my laboratory showing that FUS is much more effective in therapy when it is used as an adjuvant to other therapeutic methods. According to our experiments, high-intensity focused ultrasound (HIFU) applied to tumors already exposed to ethanol lead to almost complete destruction of tumor cells even when the ethanol dose is much less than used in percutaneous ethanol injection (PEI), one of FDA-approved methods of chemical ablation. We hypothesize that this synergistic effect of HIFU and ethanol is caused by 1) enhanced delivery of chemical agents into tumor cells via HIFU–induced acoustic streaming in tumor tissue and reducing the cell membrane permeability by the sonoporation phenomenon, and 2) enhanced tissue heating rate by HIFU due to ethanol-induced localized reduction of the cavitation threshold. Key results are that 1) the HIFU ablation lesion volume increases dramatically and becomes more spherical (note that HIFU focal region is ellipsoidal in shape) with pre-treatment of tissues with ethanol, and 2) ethanol + HIFU but not ethanol alone or HIFU alone can completely eliminate cancer in xenograft mouse models. In the end of the talk, I will discuss our new project on spinal cord injury treatment by FUS and molecular medicine.

Bubbles: Ultrasound-Mediated Drug Delivery

Friday, January 31, 2014 12:00 p.m. ETC 2.136

Professor Christy K. Holland
Department of Internal Medicine and Biomedical Engineering Program
University of Cincinnati
http://www.ultrasound.uc.edu/people.html

Ultrasound is under development as a potent promoter of beneficial bioeffects for the treatment of cardiovascular disease. These effects can be mediated by mechanical oscillations of circulating microbubbles, referred to as ultrasound contrast agents, which can also encapsulate and shield a therapeutic agent in the bloodstream. Oscillating microbubbles can create stresses directly on nearby tissue or induce fluid motion that affect drug penetration into vascular tissue, lyse thrombi, or direct drugs and bioactive gases to optimal locations for delivery. Ultrasound-triggered release of nitric oxide from echogenic liposomes induces potent vasorelaxation in porcine carotid arteries in an *ex vivo* system. Recent *in vitro* and *ex vivo* data from a variety of clot and vascular models will be discussed.
This acoustics seminar is offered courtesy of the Chevron Centennial Seminar Series in the Department of Mechanical Engineering, and pizza will be served.

Bubble Pulsation and Translation Near a Soft Tissue Interface

Friday, January 31, 2014 4:00 p.m. ETC 4.150

Daniel R. Tengelsen
Department of Mechanical Engineering and Applied Research Laboratories
The University of Texas at Austin
https://www.arlut.utexas.edu

A Lagrangian formalism used previously to calculate the pulsation of a spherical bubble immersed in liquid and adjacent to a viscoelastic layer is extended here to include bubble translation. Previous models and experiments have shown that the direction of bubble translation near a viscoelastic layer is correlated with the direction of a liquid jet often produced by the bubble during collapse. The liquid jet is an important feature in the interaction between bubbles and neighboring surfaces. In this presentation we describe how to model the pulsation and translation of a spherical bubble near a liquid-solid interface, with emphasis on soft tissue, in order to determine the direction of bubble translation for a broad spectrum of material properties for both the liquid and viscoelastic medium, and for various distances between the bubble and the interface. The force on the bubble due to the presence of the liquid-solid interface is calculated using a Green's function that takes into account elastic waves, viscosity in the layer, and the viscous boundary layer in the liquid adjacent to the interface.

Arbitrary IIR Filter Design for Audio Applications

Friday, February 7, 2014 4:00 p.m. ETC 2.136

Dr. Thomas D. Kite
Audio Precision, Inc.
Beaverton, OR
http://ap.com

Digital infinite impulse response (IIR) filters are popular in audio signal processing applications because they typically have a much lower computational cost than finite impulse response (FIR) filters designed to the same specifications. However, IIR filter design is difficult, particularly for arbitrary frequency responses that span multiple octaves, as is common in audio. A recent technique known as frequency warping offers a new way to design arbitrary IIR filters with much greater accuracy than before.
Existing IIR design methods will be reviewed, and it will be shown how frequency warping is related to the popular bilinear transform. Using a multi-band approach pioneered by Bank, it will be shown how IIR filters can be designed for the entire audio band with accuracy limited only by filter complexity. A 30-pole filter designer controlled via GUIs will then be demonstrated, and it will be shown how high-order filters can alleviate common audio headaches such as the ragged frequency responses of loudspeakers.

Design of an Optical Microelectromechanical-System Microphone Toward Sub-15 dBA Noise Floor

Friday, February 21, 2014 4:00 p.m. ETC 4.150

Donghwan Kim
Department of Electrical and Computer Engineering
Microelectronics Research Center
The University of Texas at Austin
https://www.mrc.utexas.edu

Microelectromechanical-system (MEMS) microphones with optical readout have been previously demonstrated. These microphones are similar to capacitive MEMS microphones, but the optical microphone can achieve potentially higher signal-to-noise ratio. The optical microphone measures sound pressure by detecting displacement of a compliant diaphragm. The displacement is measured using a diffraction-grating-based interferometer. Although the optical microphone requires a backplate to support the diffraction grating, the perforation density of the backplate can be much higher as compared to conventional capacitive microphones. Higher perforation density results in lower air damping and lower thermal-mechanical noise. A prototype sensor was fabricated at The Microelectronics Research Center of the University of Texas at Austin. The preliminary test demonstrates a 22.6 dBA noise floor, and shows that the flow resistance near the diffraction grating due to the squeeze-film damping effect between the diaphragm and the backplate is the dominant source of damping. The 22.6 dBA noise floor is approximately 6 dB better than commercially available capacitive MEMS microphones. System modeling suggests a better backplate design is possible which increases the SNR of the optical microphone further by an additional 8 dB, resulting in microphones with 10 dB higher SNR than the current state-of-the-art.

Multimaterial Piezoelectric Fibers—Fabrics That Can Hear and Sing

Friday, February 28, 2014 4:00 p.m. ETC 4.150

Professor Zheng Wang
Department of Electrical and Computer Engineering
The University of Texas at Austin
http://www.ece.utexas.edu

Active fiber devices that can be electrically modulated at high frequencies promise a wide range of novel applications in energy transduction, sensing, and communications. I will present a novel technique of using thermal drawing to produce monolithic piezoelectric fibers that allow electrical modulation of their acoustic and optical properties. By integrating and poling ferroelectric materials, such as PVDF-TrFE copolymer in the fiber form, one can apply piezoelectric modulation to mitigate the high operational voltages typically required for electro-optical modulation. The fibers can be fabricated over kilometer-long lengths, and electrically actuated from a few Hz through a few MHz, and function as both receivers and transmitters. Beam steering and focusing are demonstrated using a flexible fiber phased array, which paves the way for dynamically reconfigurable acoustic emission and sensing of 3D acoustic fields for a variety of applications.

Enhanced Ultrasound and Photoacoustic Imaging Using Photoacoustic Nanodroplets

Friday, March 7, 2014 4:00 p.m. ETC 4.150

Alexander S. Hannah
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Disease detection by noninvasive imaging requires contrast against the surrounding healthy tissue, which is insufficient using many available techniques, including clinical ultrasound (US) and recently emerging photoacoustics (PA). The introduction of exogenous contrast agents highlights selected regions, but these formulations have several shortcomings. Microbubbles used for US contrast are too large to reach tumor neovasculature, and their instability limits the time window for imaging. Contrast agents for PA are also flawed; dyes offer only a modest increase in signal, and metal nanoparticles must undergo regulatory approval before clinical translation. We have developed a dual contrast agent, named photoacoustic nanodroplets (PAnDs), which resolve these issues. These perfluorocarbon droplets are small enough to reach and extravasate from tumor neovasculature, and stable enough to allow for accumulation over several hours. The droplets can be optically triggered to induce particle vaporization, which emits a stronger PA signal than from thermal expansion of metal particles. The resulting gaseous microbubbles are a source of high US contrast as well. We have constructed a dye-loaded droplet comprised of biocompatible materials ready for clinical translation, as well as a droplet which can be triggered using an inexpensive 1064 nm laser source. We characterize the various properties of these nanodroplets and quantify image enhancement from remote triggering of the droplets, while investigating mechanisms of optical droplet vaporization. Additionally, we explore the use of high and low boiling point droplets for specific applications. Lastly we explore droplet formulations to molecularly target specific disease. These PAnDs improve image quality for US and PA modalities, and may encapsulate drugs for image-guided, controlled release of therapeutics.

Mitigation of Highway Traffic Noise with Quieter Pavements and Noise Barriers

Friday, March 21, 2014 4:00 p.m. ETC 4.150

Dr. Manuel Trevino
Center for Transportation Research
The University of Texas at Austin
http://www.utexas.edu/research/ctr

Noise associated with highway transportation has progressively become a nuisance to communities along roads. As transportation of people and goods continues to grow, roads expand, and noise levels rise. Nowadays, transportation agencies have become more environmentally sensitive and deal with pollution problems including noise. A number of factors affect the level of traffic noise, such as vehicle speed, terrain, grade, pavement surface characteristics, and shielding provided by walls, fences, buildings, or even dense vegetation. The most frequently used noise abatement measure has been the construction of noise barriers on the side of the road. The barriers, however, are only effective for receivers in the acoustic shadow of the wall. Other receivers are affected as much as they are without the barrier. In recent years, there has been a growing interest in designing and constructing quieter pavements as a

way to abate traffic noise by reducing noise at the source. By modifying some of its properties, pavements have been shown to produce lower noise levels than the “average” pavements. Two case studies exemplify noise mitigation: the first transparent noise barrier in Texas, on IH-30 in Dallas, and the Mopac Improvement Project, in Austin.

Acoustic One-way Manipulation by Metamaterials

Friday, March 28, 2014 4:00 p.m. ETC 4.150

Professor Bin Liang
Institute of Acoustics
Department of Physics
Nanjing University
Nanjing, China
http://acoustics.nju.edu.cn

Acoustic waves have long been thought to propagate as easily along two opposite directions in a given path. It can therefore be expected that the one-way propagation of acoustic waves, if could it be realized successfully, would have deep implications for acoustic devices, acoustic applications and the field of acoustics in general. Here a series of theoretical and experimental works will be reported on how to realize acoustic one-way manipulations by designing various kinds of acoustic metamaterials. The first theoretical model of an “acoustic diode” that enables the rectification of acoustic energy flux was proposed by coupling a nonlinear medium with a superlattice, and the prototype was fabricated experimentally. By introducing a nonlinear resonance cavity, the efficiency of the nonlinear acoustic diode was dramatically enhanced. On the other hand, different schemes of one-way acoustic manipulations have been developed in linear systems, resulting in significant improvements in aspects of transmission efficiency, bandwidth and waveform preservation, etc.

Bond Graph Modeling of Frog Vocal Production

Friday, April 4, 2014 4:00 p.m. ETC 4.150

Professor Nicole M. Kime
Department of Biological Sciences
Edgewood University
http://biology.edgewood.edu

The túngara frog, Physalaemus pustulosus, is a well-known model for investigating the evolution of acoustic communication. All male frogs in the genus Physalaemus produce a species-specific “whine”. Túngara frogs and some populations of its sister species, P. petersi, also produce a second complex call component, a “chuck” or “squawk” that relies upon the presence of an enlarged fibrous mass that extends from the vocal folds. Females generally prefer complex calls to simpler whines. The evolution of laryngeal morphology has thus been influenced by sexual selection. In spite of evidence for a correlation between structure and function, the mechanism by which the fibrous mass interacts with other elements of the vocal system during the production of whines and chucks remains unknown. We have recently been using bond graphs, a lumped element modeling technique, to investigate the biomechanics of vocal production in túngara frogs. These models explore the production of whines and chucks, the mechanics

of the fibrous mass, and interactions between different components of the frog vocal system. A bond graph approach to vocal system modeling will be advantageous to understanding the evolution of groups of morphological traits within the integrated vocal systems in a variety of animals.

More than Imaging: Cancer and Cardiovascular Therapies via Focused Ultrasound

Tuesday, April 8, 2014 11:00 a.m. ETC 2.102

Dr. Linsey Phillips
University of North Carolina at
Chapel Hill & NC State University

Cancer and cardiovascular disease are two of the most common diseases affecting industrialized countries like the United States. Diagnosis and treatment are complex for these diseases, often requiring extensive imaging exams and chronic, expensive therapies. Ultrasound has the capacity for both imaging and therapy, and is less expensive and less invasive than other diagnostic and therapeutic modalities. The thermal and mechanical effects induced by ultrasound have significant therapeutic potential. In the last decade, focused ultrasound has gained popularity as a method to localize therapeutic effects including drug delivery, gene delivery, and blood-brain barrier opening. At high intensities, focused ultrasound can achieve temperatures sufficient to ablate biological tissue, and has the potential to eliminate a variety of cancers non-surgically. Focused ultrasound therapy is currently approved by the FDA for uterine fibroid and bone metastasis ablation. Few methods exist to selectively target chemotherapeutic drugs to cancer, and side effects from accumulation in non-targeted tissues remain a problem. However, focused ultrasound and targeted microbubbles overcome this major limitation of existing therapies by enabling localized, enhanced drug delivery with sub-millimeter precision. I investigate how ultrasound can improve detection and treatment of cancer and cardiovascular diseases by combining “theranostic” agents with ultrasound. Through my future research, I aim to explore new, clinically translatable therapeutic applications of focused ultrasound and acoustically active agents to treat diseases. To reach these objectives, I will use a combination of acoustics and biology, building on my 10 years of experience with ultrasound and microbubbles.

Large-scale Bayesian Inverse Wave Propagation

Friday, April 18, 2014 4:00 p.m. ETC 4.150

Professor Omar Ghattas
Department of Mechanical Engineering and Department of Geological Sciences
Director of the Center for Computational Geosciences
Institute for Computational Engineering and Sciences
The University of Texas at Austin
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Inverse problems governed by wave propagation–in which we seek to reconstruct the unknown shape of a scatterer, or the unknown properties of a medium, from observations of waves that are scattered by the shape or medium–play an important role in a number of engineered or natural systems. We formulate the inverse problem in the framework of Bayesian inference. This provides a systematic and coherent

treatment of uncertainties in all components of the inverse problem, from observations to prior knowledge to the wave propagation model, yielding the uncertainty in the inferred medium/shape in a systematic and consistent manner. Unfortunately, state-ofthe-art Markov chain Monte Carlo methods for characterizing the solution of Bayesian inverse problems are prohibitive when the forward problem is of large scale (as in our 100-1000 wavelength target problems) and a high-dimensional parameterization is employed to describe the unknown medium (as in our target problems involving infinite-dimensional medium/shape fields, which result in millions of parameters when discretized). We report on recent research aimed at overcoming the mathematical and computational barriers for large-scale Bayesian inverse wave propagation problems. These include:

- a high order, parallel, adaptive hp-non-conforming discontinuous Galerkin (DG) method for acoustic/elastic/electromagnetic wave propagation
- infinite-dimensional formulations of Bayesian inverse problems and their consistent finite-dimensional discretizations;
- a stochastic Newton MCMC method for solution of the statistical inverse problem that reduces the number of samples needed by several orders of magnitude, relative to conventional MCMC;
- fast low rank randomized SVD approximation of the Hessian based on compactness properties; and
- applications to Bayesian inverse wave propagation in whole Earth seismology with up to one million earth model parameters, 630 million state variables, on up to 100,000 processors.

This work is joint with George Biros, Tan Bui-Thanh, Carsten Burstedde, James Martin, Georg Stadler, Hari Sundar, and Lucas Wilcox.

Measuring the Acoustic Parameters of Fish Schools

Friday, April 25, 2014 4:00 p.m. ETC 4.150

Craig Dolder
Department of Mechanical Engineering
Applied Research Laboratories
The University of Texas at Austin
http://www.arlut.utexas.edu

While the literature contains extensive in situ measurements of scattering by fish schools, significant uncertainties exist with respect to characterizing the size, quantity, and distribution of fish within the schools that confound accurate measurement-model comparison. Measurements of the sound speed through collections of live fish (Danio rerio) were conducted in a laboratory setting. The sound speed was investigated using a resonator technique which yielded inferences of the phase speed within the fish school though measurements of the resonances of a one-dimensional waveguide. Fish densities were investigated ranging from 8.6 to 1.7 fish lengths per mean free path. Measurements agree well with a predictive model that is based on shell-free spherical bubbles, which indicates that the phase speed is not significantly affected by the fish flesh or swimbladder morphology for the species studied. The variation in phase speed due to individual fish motion within the model school was measured to be up to ±5.6%. This indicates that precise knowledge of the fish position is required to achieve greater model accuracy. To complement the phase speed measurements, the attenuation through a cloud of encapsulated bubbles was evaluated through insertion loss measurements. Multiple arrangements of balloons of radius 4.68 cm were used to surround a projector. The insertion loss measurements indicated an amplification of around 10 dB at frequencies below the individual balloon resonance frequency and an insertion loss of around 40

dB above the individual balloon resonance frequency. Analytical modeling of the bubble collection predicted both the amplification and loss effect, but failed to accurately predict the level of amplification and insertion loss. Finally, effective medium models and full scattering models (requiring knowledge of bubble size and position) were evaluated for a model fish school. The two models agree for forward scattering for all frequencies except those immediately around the individual bubble resonance frequency. Back scattered results agree at low frequencies, however as soon as the wavelength becomes smaller than four mean free paths between fish the models diverge. Ramifications of these findings and potential future research directions are discussed.

Estimates of Source Range Using Horizontal Multi-path in Continental Shelf Environments

Friday, September 5, 2014 4:00 p.m. ETC 4.150

Dr. Megan S. Ballard
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The University of Texas at Austin
www.arlut.utexas.edu

A method has been developed to estimate source range in continental shelf environments that exhibit three-dimensional propagation effects. The technique exploits measurements recorded on a horizontal line array of a direct path arrival, which results from sound propagating across the shelf to the receiver array, and a refracted path arrival, which results from sound propagating obliquely upslope and refracting back downslope to the receiver array. A hybrid modeling approach using vertical modes and horizontal rays provides the ranging estimate. According to this approach, rays are traced in the horizontal plane with refraction determined by the modal phase speed. To obtain an estimate of source range, the principle of reciprocity is used such that the rays originate from the center of the array with launch angles equal to the estimated bearing angles of the direct and refracted paths. The location of the source in the horizontal plane is estimated from the point where the rays intersect. In this talk, the technique is applied to data recorded on a horizontal line array located about 12 km east of the southern coast of Florida. The effects of unknown environmental parameters, including the sediment properties and the water-column sound-speed profile, on the source range estimate are quantified. Error resulting from uncertainty in the measured bathymetry and location of the receiver array will also be addressed.

Shear Waves in Viscoelastic Wormlike Micellar Fluids

Monday, September 15, 2014 1:00 p.m. RLM 11.204

Professor Joseph R. Gladden
Department of Physics
National Center for Physical Acoustics
The University of Mississippi
ncpa.olemiss.edu

In viscous Newtonian fluids, support of shear waves is limited to the viscous boundary layer. However, non-Newtonian fluids, which have a shear modulus, support shear waves over much longer distances. Wormlike micellar fluids are an interesting class of non-Newtonian fluids in which surfactant molecules,

aided by the addition of salts, self-aggregate into long and flexible cylindrical structures. The dimensions and topology of these structures depend on concentration, surfactant/salt ratio, and temperature. We will present studies in which acoustic shear wave propagation is used to better understand various structural phases of this system as a function of concentration and temperature. These studies indicate 2 distinct phase transitions between 0 (water) and 600 mM surfactant. Birefringent properties of this fluid make the acoustic field simple to visualize using crossed polarizers. We will also present neutron scattering results on microstructure, relaxation in static shear strain fields, and rheological studies to help flesh out the story on this complex fluid.

Acoustical Foundations of Scales, Tempered Tuning, and Pitch Perception

Friday, September 19, 2014 4:00 p.m. ETC 4.150

Dr. James M. Gelb
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While seemingly disparate, the musical scales used throughout the world are in fact surprisingly universal. This talk touches on all aspects of this universality, from the perspectives of the acoustical properties of instruments (acoustics), the frequency resolution of the ear (signal processing), and the pattern-matching strategies of the brain (psychoacoustics). The lecture begins with an explanation of the distinction between, and the physical generation of, approximate pure tones (e.g., those produced by Helmholtz resonators and tuning forks) and complex tones (distributions of tones) produced by actual instruments. The science behind bowing and the reasons for the rich harmonic structure of the violin will be explored. The Helmholtz theory of consonance (pleasant-sounding intervals), as well as modern refinements of the theory that take critical bands in the ear into account, are discussed. This segues into an explanation of the non-uniform spacing of notes in the ubiquitous pentatonic and diatonic scales, which in turn leads to the topic of tempered tuning—the compromise between perfectly “just” intervals (frequency ratios of fundamentals involving small integers) and equal-tempered tuning used to freely support modulation (the switching between musical keys on the fly). Interesting aspects of tempered tuning (including the physical cause of the Wolf interval) are singled out for discussion, so as to avoid getting lost in the myriad of historical tuning schemes. The lecture concludes with an investigation of a pattern-matching model to explain pitch perception, drawing from results of a recent experiment conducted at ARL.

Statistical Inference of Seabed Sound-Speed Structure in the Gulf of Oman Basin

Friday, September 26, 2014 4:00 p.m. ETC 4.150

Dr. Jason D. Sagers
Applied Research Laboratories
The University of Texas at Austin
http://www.arlut.utexas.edu

Addressed is the statistical inference of the sound-speed depth profile of a thick soft seabed from broadband sound propagation data recorded in the Gulf of Oman Basin in 1977. The acoustic data are in the form of time series signals recorded on a sparse vertical line array and generated by explosive

sources deployed along a 280 km track. The acoustic data offer a unique opportunity to study a deep-water bottom-limited thickly sedimented environment because of the large number of time series measurements, very low seabed attenuation, and auxiliary measurements. A maximum entropy method is employed to obtain a conditional posterior probability distribution (PPD) for the sound-speed ratio and the near-surface sound-speed gradient. The multiple data samples allow for a determination of the average error constraint value required to uniquely specify the PPD for each data sample. Two complicating features of the statistical inference study are addressed: (1) the need to develop an error function that can both utilize the measured multipath arrival structure and mitigate the effects of data errors and (2) the effect of small bathymetric slopes on the structure of the bottom interacting arrivals.

Modeling Sound Propagation Through an Incompressible Flow

Friday, October 3, 2014 4:00 p.m. ETC 4.150

Sumedh M. Joshi
Center for Applied Mathematics
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http://www.cam.cornell.edu

Sound propagating in a moving fluid will be advected, refracted, and Doppler shifted by the patterns in the moving flow. For example, a pulse of sound impinging on an inviscid shear layer is advected in the direction of the shear flow, in addition to being reflected from the shear-layer interface. To model such sound-flow interactions, it was assumed that the background flow was known and satisfied the incompressible Navier-Stokes equations. Furthermore, it was also assumed that the sum of the acoustic and hydrodynamic fields satisfied momentum and mass conservation. Finally, the sound propagation was assumed to be linear. These assumptions lead to hyperbolic conservation laws that were discretized and solved with a time-domain finite difference model. To demonstrate, a few example flows and their resulting sound fields will be presented, and I will also discuss a modeling effort that attempts to quantify the degree to which the acoustic scattering from an idealized tornado funnel can be used to infer properties of the tornado. The modeling suggests that although there is a measurable acoustic reflection, practical concerns suggest that acoustics are not a viable method of inferring tornado properties.

Snapping Acoustic Metamaterials: Enhanced Material Nonlinearity and Absorption of Mechanical Energy

Monday, October 13, 2014 3:00 p.m. ECJ 1.202

Dr. Michael R. Haberman
Applied Research Laboratories and
Department of Mechanical Engineering
The University of Texas at Austin
http://www.arlut.utexas.edu
http://www.me.utexas.edu

Acoustic metamaterials (AMM) are material systems whose overall performance originates from engineered sub-wavelength structure rather than the inherent material properties of their constituents. This relatively new topic in applied physics has garnered attention in the scientific community because of the potential role in realizing exotic behavior such as acoustic cloaking, negative refraction, and one-way sound transmission. This talk discusses a new AMM that was designed to amplify acoustic absorption and nonlinearity for potential use in new acoustical devices and vibro-acoustic coating materials. The AMM consists of a nearly incompressible viscoelastic matrix material containing a low volume fraction of sub-wavelength metamaterial structures (inclusions) that possess a non-monotonic stress-strain response. A nonlinear multiscale material model is presented that captures the strain-dependent evolution of the stiffness of the homogenized medium. That material model is then used to determine the effective quadratic and cubic parameters of nonlinearity of the AMM. Those parameters of nonlinearity are compared with those of conventional materials and examples of one-dimensional wave distortion effects are provided. The forced nonlinear multiscale dynamics in the AMM is then explored using a modified Rayleigh-Plesset model to highlight the influence of pre-stress and inclusion-scale dynamics on macroscopic energy absorbing capabilities for this AMM.

Submarine Sonar

Friday, October 17, 2014 4:00 p.m. ETC 2.136

Dr. F. Michael Pestorius
Applied Research Laboratories
The University of Texas at Austin
http://www.arlut.utexas.edu

Modern submarines use sonar almost exclusively for ship navigation, obstacle avoidance, contact detection and warfare missions. Rudimentary sonars were first developed in World War I and they reached fairly high levels of sophistication in World War II. However, submarines up to about 1960 were basically surface craft that could submerge for relatively short periods of time. The marrying of nuclear power to the submarine created a true undersea capable ship. With this development came a major improvement in submarine sonars. The development of the US submarine force since the advent of nuclear power with emphasis on the continuing development of active and passive sonar will be addressed in this seminar. The Applied Research Laboratories at UT Austin have long been involved in sonar research and development. General information about submarine sonars will be outlined.
Dr. Mike Pestorius, a UT graduate (PhD EE), is a retired submariner who spent close to 27 years in the Navy. He served on several submarines and commanded a ballistic missile submarine, the USS Mariano G. Vallejo (SSBN 658), for 4 years. After retiring from the Navy, he served 12 years as director of Applied Research Laboratories at UT and then 4 years as technical director of the international office in the London office of the Office of Naval Research.

Seismic Attenuation, Dispersion and Anisotropy in Porous Rocks: Mechanisms and Models

Monday, November 3, 2014 1:30 p.m. ARL Auditorium

Dr. Boris Gurevich
Curtin University and CSIRO
Perth, Australia
http://www.csiro.au

Understanding and modelling of attenuation of elastic waves in fluid-saturated rocks is important for a range of geophysical technologies that utilise seismic, acoustic or ultrasonic amplitudes. A major cause of elastic wave attenuation is viscous dissipation due to the flow of the pore fluid induced by the passing wave. Wave-induced fluid flow occurs as a passing wave creates local pressure gradients within the fluid phase and the resulting fluid flow is accompanied with internal friction until the pore pressure is equilibrated. The fluid flow can take place on various length scales: for example, from compliant fractures into the equant pores (so-called squirt flow), or between mesoscopic heterogeneities like fluid patches in partially saturated rocks. A common feature of these mechanisms is heterogeneity of the pore space. I will explore how this heterogeneity affects attenuation, dispersion and anisotropy of porous rocks. I give a brief outline of a consistent theoretical approach that gives quantitative estimates of these phenomena and discuss rigorous bounds for attenuation and dispersion, which represent an extension of Hashin-Shtrikman bounds to viscoelastic media.
Boris Gurevich has MSc from Moscow State University (1981) and PhD from Moscow Institute of Geosystems (1988). In 1990s he worked at a number of institutions in Russia, Germany, UK and Israel before joining Curtin University and CSIRO in Perth, Australia in 2001 as Professor of Petroleum Geophysics. From 2010 he has served as head of Curtin's Department of Exploration Geophysics and Director of the Curtin Reservoir Geophysics Consortium. His research interests include rock physics, poroelasticity, diffraction imaging and time lapse seismic monitoring.

Design and Construction of Acoustic Test Chambers

Friday, November 7, 2014 4:00 p.m. ETC 4.150

Dr. Douglas F. Winker
ETS-Lindgren
Cedar Park, Texas
http://www.ets-lindgren.com

ETS-Lindgren manufactures acoustic test chambers for a wide variety of clients and applications. This presentation will discuss case studies of test and measurement solutions. The design and construction of ETS-Lindgren's acoustic lab facility in Cedar Park, Texas will be discussed in detail. ETS-Lindgren's lab consists of a hemi-anechoic chamber and a reverberation chamber suite. The hemi-anechoic chamber was designed to obtain a noise floor of <0 dBA at frequencies above 100 Hz. Another design goal was a 2 m radius free field above 80 Hz that is compliant with ISO 3745. It features a 200 m^3 volume inside the wedges. To achieve the design goals, several aspects were considered including ambient levels, vibration isolation, HVAC noise, free field performance, and future development in the area. The design solutions for each of these areas will be presented. The reverberation chamber suite consists of two reverberation chambers designed to perform transmission loss tests and sound absorption testing. The source chamber has an internal volume of 214 m^3 and the receive room has an internal volume of 418 m^3. Design considerations will be discussed including vibration isolation, wall panel design, and diffuser placement. Additionally, the design and construction of the transmission loss coupling will be addressed.

Electro-Mechanical Modeling of Piezoelectric Fluid Ejectors for High Viscosity Liquids

Friday, November 14, 2014 4:00 p.m. ETC 4.150

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The controlled atomization of high viscosity liquids to produce individual droplets of uniform diameter remains an ongoing technological challenge. Traditional atomization techniques for the production of single droplets—inkjet printers—do not extend to high viscosity materials as fluid ejection ceases. Other atomization methods, such as horn-based ultrasonic atomization, have demonstrated the capability to atomize such materials but a detailed understanding of the mechanism that enables fluid ejection is lacking. The underlying physical mechanisms that govern atomization of high viscosity materials (> 10 mPa·s) by piezoelectric transducer-driven fluid ejectors remain poorly understood, requiring an in-depth understanding of the acoustics underlying the fluid ejection process. This presentation focuses on the principle acoustic phenomena that regulate atomization of high viscosity materials—fluid cavity/transducer interactions and waveform propagation within the fluid cavity—to ascertain an upper viscosity bound on the materials that can be atomized by piezoelectric transducer-driven fluid ejectors. A coupled electro-mechanical analytical modeling framework is developed by decomposing fluid ejector geometries into simplified acoustic elements with closed-form solutions joined together through boundary conditions. These simplified acoustic models maintain the dominant sources of viscous dissipation and dispersion within the modeling framework to provide an accurate estimate of the acoustic field amplitude which is the driving mechanism for fluid ejection. By comparing the acoustic pressure amplitude to that required to yield fluid ejection at the aperture, obtained by CFD modeling and scaling analysis, an upper limit on liquid viscosity for atomization can be determined. The electro-mechanical modeling framework is also applied to explore new concepts of piezoelectric transducer-driven fluid atomizers in an effort to achieve the controlled atomization of high viscosity materials.

Biologically Inspired Microphones

Friday, November 21, 2014 4:00 p.m. ETC 4.150

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The parasitoid fly Ormia Ochracea has the remarkable ability to locate crickets using audible sound. This ability is, in fact, remarkable as the fly’s hearing mechanism spans only 1.5 mm, which is 50 times smaller than the wavelength of sound emitted by the cricket. The hearing mechanism is, for all practical purposes, a point in space with no significant interaural time or level differences to draw from. It

has been discovered that evolution has empowered the fly with a hearing mechanism that utilizes multiple vibration modes to amplify interaural time and level differences. Here, we present a fully integrated, man-made mimic of the Ormia's hearing mechanism capable of replicating the remarkable sound localization ability of the special fly. A silicon-micromachined prototype is presented which uses multiple piezoelectric sensing ports to simultaneously transduce two orthogonal vibration modes of the sensing structure, thereby enabling simultaneous measurement of sound pressure and pressure gradient.

Analysis of Acoustic Scattering from Large Fish Schools Using Bloch Wave Formalism

Wednesday, December 3, 2014 4:00 p.m. ARL A009

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In the open ocean, acoustic scattering of SONAR signals in the 1-10 kHz frequency range is dominated by large fish schools, where multiple scattering effects between the air-filled swim-bladders of the fishes within the school are strong. These schools are typically large in comparison to the acoustic wavelength and the fish typically swim in nearly-periodic arrangements with a separation distance of approximately one body length. Hence, the fish school can be studied simply and effectively by invoking the formalism of Bloch waves in periodic media. Analysis of the periodic school is aided through the Bloch theorem, which reduces the study of the entire school to the study of a unit cell containing a single fish's swim-bladder. Application of the Bloch formalism to the school requires study of acoustic reflection from a semi-infinite half-space composed of an infinite arrangement of air swim bladders in water; this media is denoted a fluid phononic crystal (PC). The reflection is considered, using a finite element discretization of the unit cell, via an expansion of Bloch waves for the transmitted wave field. Next, scattering from a large finite school is studied through the context of the Helmholtz-Kirchhoff integral theorem where the semi-infinite PC pressure, determined by the Bloch wave expansion, is used as the integral's inputs. A general model using the Bloch formalism and encompasses the internal fish structure, fish biologic properties, and realistic school effects such as varying school geometry and disorder, will be explored. Transient analysis of the frequency dependent scattering, using the proposed model, may assist SONAR operators to better classify large fish schools based on the observed characteristics of the scattered field. Comparison of results is accomplished through a finite element model (two dimensions) and a low frequency analytical multiple scattering model (three dimensions).

A Brief History of Sediment Acoustics

Friday, December 5, 2014 4:00 p.m. ETC 4.150

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The acoustic behavior of sediments has been studied extensively. The earliest models were based on the assumption that sediments behaved like fluids. Since sediments generally can support shear stresses, the assumptions made when using fluid models were found to be tenuous at best, and many of these models have been replaced with those treating the sediment as an elastic or viscoelastic medium. However, it has recently been shown that model predications and experimental results are in better accord when the sediment is assumed to behave as a poroelastic medium governed by Biot theory. This talk intends to serve as a primer on the development of fluid, elastic, and poroelastic sediment models and will attempt to give historical justification supporting the uses and limitations of each. Recent attempts at formulating more sophisticated and comprehensive sediment models such as the Viscous Grain Shearing model of Buckingham and the Extended Biot model of Chotiros will be discussed as well.