Acoustics Seminar Abstracts 1998
University of Texas at Austin

Acoustical Consulting-The Profession and Industry

Friday, January 23, 1998 4:00 p.m.

Karen E. Hunt
EVI Audio
Austin, TX

This seminar shall offer perspective on and direction in the profession of acoustical consulting. The general public is largely unaware of what acoustical consulting is, what acoustical consultants actually do, or how to become one. There are no comprehensive programs on a graduate or undergraduate level which train a student to be an acoustical consultant. As a result, acoustical consultants vary in backgrounds and experience that include physics, engineering, architecture, acoustics, mathematics, and fine arts on both undergraduate and graduate levels. Most consultants start out with some core technical background, which is then molded by experience and mentorship on a professional level. Acoustical consulting work includes architectural acoustics, mechanical noise control, structural noise control, and audio/visual system design. The trials and tribulations of starting out within the acoustical consulting community and rising to a successful position shall be discussed, as well as how to find a job within this niche market. This seminar is open to anybody interested in architectural acoustics, interior design, audio system design and noise control. The focus of the seminar is on improving awareness of the acoustics/audio industry and how to find gainful employment therein.

Control of Beam Direction and Beamwidth of Loudspeaker Arrays

Thursday, February 5, 1998 4:00 p.m.

Professor Elmer L. Hixson
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By controlling the time delay and frequency function of each speaker in an array, the direction and coverage as a function of frequency can be controlled. Beamwidth can be held constant with frequency so that everyone in the coverage area will receive the same spectrum of sound. Examples of one-dimensional beam control will be presented using broadside and endfire line arrays. Then two-dimensional coverage control with crossed broadside and stacked endfire arrays will be demonstrated. Advantages of controlled loudspeaker arrays will be discussed.

Hammered Dulcimer Design: A Historical, Acoustical, and Player's Point of View

Friday, February 13, 1998 4:00 p.m.

Professor David Peterson
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The hammered dulcimer, a predecessor of the piano, has a long and still evolving lineage. Some recent design changes follow from solid acoustical principles and others merely demonstrate the folk process at work. Several aspects of the hammered dulcimer are distinctly different from the piano, creating a uniquely percussive sound subject to technical analysis: (1) soundboard bracing; (2) bridge construction (split string courses); (3) hammer and string interaction. The talk will include models, demonstrations, and a short selection of ragtime music performed (live) on dulcimer, violin, and guitar.

New Areas of Acoustics Research at Applied Research Laboratories

Friday, February 27, 1998 4:00 p.m.

Dr. G. Douglas Meegan
Applied Research Laboratories
The University of Texas at Austin
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This presentation will describe briefly several new acoustics research projects that are underway at Applied Research Laboratories. The common theme that links these projects is development of acoustical methods or technologies that are of potential commercial or industrial interest. The projects to be described include (1) detecting faults in engines by monitoring and processing vibrational and acoustic signatures, (2) automated detection and classification of land vehicles based on their acoustic and seismic signatures, (3) application of acoustic agglomeration methods for the capture of fine particulate matter, and (4) the development of sono lysogenesis methods for the purification of water without the use of chemicals. Proposed future research topics involving measurement of individual noise sources radiated from aircraft in flight will also be described.

Parametric Array in Air: Distortion Reduction by Preprocessing

Thursday, March 5, 1998 4:00 p.m.

Dr John T. Post
Applied Research Laboratories
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Thomas D. Kite
Department of Electrical and Computer Engineering
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and

Professor Mark Hamilton
Department of Mechanical Engineering
The University of Texas at Austin
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In a parametric array, highly directional low-frequency sound is generated by the self-demodulation of an intense, amplitude-modulated high-frequency sound beam as a result of nonlinear propagation effects. Although several examples of using parametric generation by an ultrasonic carrier as an audio loudspeaker have been discussed in the literature, practical constraints have received little attention. In this seminar we discuss an effect of transducer bandwidth that must be overcome in order for the “audio spotlight” to become a practical, high-fidelity source for reproduction of music. The importance of transducer bandwidth can be seen by noting that the far-field solution predicts a demodulated secondary waveform along the axis of the beam that is proportional to the second time derivative of the square of the modulation envelope. The secondary wave is therefore generated with high levels of harmonic distortion, even for moderate modulation indices. Integrating the modulation signal twice and taking the square root removes this distortion; however, the resulting reduction in distortion is limited by the bandwidth of the ultrasonic transducer.

Modeling and Measurement of Nonlinear Surface Acoustic Waves

Friday, March 6, 1998 4:00 p.m.

Professor Mark Hamilton and Ronald Kumon
Department of Mechanical Engineering
The University of Texas at Austin
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Although nonlinear surface acoustic waves are the foundation for analog devices currently used to perform nonlinear signal processing operations, empirical models that describe these waves at moderate amplitudes were sufficient to advance this technology. A comprehensive theoretical model has been developed which describes the nonlinear evolution and shock formation associated with a wide variety of surface waves (Rayleigh, Scholte, and Stoneley waves, and including effects of anisotropy and piezoelectricity). The general framework of this theory will be outlined, and the first comparisons of theory with measurements of shock formation in surface waves propagating in isotropic and anisotropic solids will be presented. The measurements were made possible by recently developed techniques for generating and detecting nonlinear surface waves with lasers.

Global Seismic Tomography: A Snapshot of Convection in the Earth

Friday, April 3, 1998 4:00 p.m.

Dr. Steven Grand
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The Earth is a dynamic planet in which the plate tectonics is the surface expression of active flow in the deep mantle. Although the kinematics of plate tectonics is fairly well understood, the pattern of flow in the deep Earth that results in the surface motions are not at present well known. Most of our detailed knowledge of the deep Earth has resulted from determining the speed of P (compressional) and S (shear) waves that propagate through the interior of the planet. Until the 1980's most seismic studies of the Earth focused on the change in seismic wave speed with depth. The last 15 years have seen much effort in mapping out the three-dimensional variation in P and S wave speeds throughout the Earth. Results from our studies of the three-dimensional seismic structure of the mantle show several interesting features. Convergence zones at the surface are correlated with large linear high wave speed anomalies well into the deep mantle and in some cases all the way to the core-mantle boundary. This result indicates that surface rock that begins sinking can reach the core in some cases. The images show, however, that there are several boundaries to vertical flow near 650 and 1300 km depth within the Earth. Massive slow anomalies are found beneath 3-4 regions of the planet extending from the core-mantle boundary to, in one case, the surface of the Earth. The anomalies are well over 1000 km in radius in the deep mantle. Such large structures are not predicted by present numerical calculations of flow in the Earth. Their size and nature may also be related to a change in material property associated with depths near 650 and 1300 km depth.

Theoretical Study of Straight and Ragged Edge Noise Barriers

Monday, April 13, 1998 4:00 p.m.

Penelope Menounou
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Experimental investigations have shown that noise barrier performance can be improved by making the top edge randomly ragged. A new method termed Directive Line Source Model is presented for predicting the sound field (pressure time waveform) due to diffraction by straight and ragged edge barriers. It is shown that the diffracted field is equivalent to radiation from the edge of the barrier, but modified by a certain directivity function. The straight or ragged edge of the barrier is modeled as a directive line source, straight or ragged, respectively. The results obtained by the Directive Line Source Model are in good agreement with known analytical solutions and experimental results. Furthermore, the new model

provides useful qualitative results: (i) the performance of a ragged edge barrier varies significantly with receiver position, (ii) the shape of the diffracted signal remains roughly the same when the receiver moves away from the barrier, but it changes appreciably when the receiver moves parallel to the edge. Finally, because the model is easy to apply, it is a promising tool for further research on noise barriers.

Three-Dimensional Localization of a Close-Range Acoustic Source using Interaural Cues

Friday, April 24, 1998 4:00 p.m.

Paul Calamia
Department of Electrical and Computer Engineering
The University of Texas at Austin
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No abstract available.

Quality and Technical Issues Related to Acoustical Measurements Traceable to National Standards: Case Studies in Austin

Friday, May 1, 1998 4:00 p.m.

Jeff G. Schmitt
Acoustic Systems and Dell Computer Corp.
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http://www.dell.com

Laboratories wishing to make measurements that are traceable to primary national standards must insure that the instruments used to make the measurements are calibrated in a manner that maintains strict traceability to these national primary standards, and they must use testing procedures that conform to international and industry test standards. The National Institute of Standards and Technology (NIST) maintains these primary standards and, through its National Voluntary Laboratory Accreditation Program (NVLAP), serves as an accreditation body for laboratories that desire to assure strict traceability of measurements. Two examples of NVLAP accredited acoustics laboratories exist within the Austin technical community. Acoustic Systems maintains an accredited laboratory that makes architectural (transmission loss, sound absorption, noise reduction, etc.) and sound emission (sound power) measurements. Dell Computer has recently opened an accredited test facility for conducting noise emission measurements (sound power) on computer and business equipment. This seminar will introduce the NVLAP accreditation process and the basic requirements of an ISO Guide 25 quality program. A general overview of the Acoustic Systems and Dell Computer acoustics programs will be given. Several projects that may provide opportunities for student research, thesis topics and/or employment opportunities with both companies will be described.

Do Shape Details Affect the Acoustic Response of a Room? An Historical Survey of Mode Count Formulas, Including Recent Development

Friday, May 8, 1998 4:00 p.m.

Professor C. L. Morfey
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More than 80 years ago, Weyl showed that the number of Helmholtz-equation eigenvalues smaller than k2, in a 3D enclosure of arbitrary shape, approaches k3V/6 pin the short-wavelength limit. He also conjectured a correction term k2S/16 p, but was unable to prove it. These results, which have been confirmed and generalized by many authors since, imply a smoothed modal density which is controlled by the volume and surface area of the room, independently of shape details. However, few people working in architectural acoustics believe that shape is unimportant. An attempt will be made to resolve this paradox by showing how actual mode counts deviate in a non-random manner from the corresponding smoothed mode count formulas, both for 2D and 3D regions. Topics to be covered include: (i) History and acoustical significance of mode count estimates; (ii) Direct numerical verification of mode count predictions for 2D annular regions; (iii) Cylindrical rooms of arbitrary cross-section; (iv) Irregularities-a simplified analysis for 2D and 3D enclosures; (v) Superresonances and flutter echoes; (vi) Statistics of mode count irregularities-theory and numerical results; (vii) Variance of the number of modes in a narrow band of eigenvalues.

Test Devices To Study Effects of Intense Low Frequency Sound on Mouse Lung

Friday, September 4, 1998 4:00 p.m.

Professor David Blackstock
Department of Mechanical Engineering
and Applied Research Laboratories
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Research is being carried out at the University of Rochester on the effects of intense low frequency underwater sound on mouse lung. A sound pressure level as high as 190 dB (re 1 microbar) at frequencies in the range 100-1000 Hz was needed. One device that has been used is the G40, a hydrophone calibrator used by the Navy. It is a vertical tube filled to a depth of about 45 cm and vibrated from the bottom by a piston. A second device (German design) is also under consideration The tissue to be tested is placed between two submerged metal plates, which are rigidly connected and driven as a unit by a shaker. An analysis of the fields produced by these two devices is presented. Results obtained with mice exposed in the G40 show that a destructive lung resonance occurs at about 300 Hz when the level is above a certain threshold.

Acoustic Streaming Produced by Focused Sound Beams with Shocks

Friday, September 18, 1998 4:00 p.m.

Steven Younghouse
Department of Mechanical Engineering
The University of Texas at Austin
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Recent experiments with focused ultrasound at frequencies and intensities commonly encountered in biomedical applications have revealed substantial acoustic streaming (dc flow) associated with the formation of shocks. It is the momentum transferred to the fluid due to acoustic absorption, which is especially strong at the shocks, that produces the streaming. In this seminar we report results from numerical simulations of acoustic streaming generated by such beams. The sound beam is modeled with a nonlinear parabolic wave equation. We modified an existing time-domain algorithm for solving the wave equation for pulsed beams to accommodate periodic signals. This modification was made in order for the shock structure to be described accurately. The streaming is modeled with hydrodynamic equations that include hydrodynamic nonlinearity and are therefore valid at the large Reynolds numbers encountered in experiments. The Reynolds numbers are based on the streaming velocity in the focal region of the beam, along with lengths corresponding to dimensions of the flow field. Comparisons with measurements reported in the literature demonstrate the validity of the approach. The simulations demonstrate clearly the dependence of acoustic streaming on shock structure.

A Theoretical Model for Parallel Noise Barriers

Friday, September 25, 1998 4:00 p.m.

Won Suk Ohm
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When residential areas line both sides of a highway, each side needs a noise barrier. The conventional approach for modeling parallel noise barriers has been mostly based on using the single barrier theory with image sources to model the reflected fields. This approach does not take into account diffraction in the field between the two barriers and thus tends to predict higher insertion loss degradation than that shown in field measurements. A theoretical model is proposed to include diffraction in the part of the field due to single or multiple reflections. For the reflected field between the barriers, a barrier is assumed to act as a baffled sound source whose pressure amplitude and phase are given by that of the reflected wave. The source field and the barrier shape are unrestricted. In this case, only the reflected portion of the incident wave propagates back to the opposite barrier, and the angular spectrum method is used to calculate the field from the various reflections. The new method shows some improvements over the conventional method in that (1) it yields a prediction of insertion loss degradation more in line with field measurements, and (2) the number of reflections (or image sources) for a reasonable level of convergence is only half of that for the conventional method.

Sensitivity of a Computational Version of the Kirchhoff Integral Theorem to Surface Discretization

Friday, October 2, 1998 4:00 p.m.

Anderson Mills
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The Kirchhoff Integral Theorem can be used to calculate far field quantities from known values on a surface surrounding an acoustic source distribution. Because of interest in predicting the noise generated by turbomachinery, far field pressure is chosen as the calculated quantity. A computational version of the K.I.T. allows numerical approximation of pressure fields from complex sources which have no analytical expression for far field pressure. The discretization of the Kirchhoff surface causes error in this approximation, but the error can be controlled to produce results of a desired accuracy. Grid point spacing, grid layer separation, time sampling, and grid size and shape are characteristics of the discretization shown to affect the error in the calculations. Grid layer separation distance has the strongest effect on the accuracy of the results.

Use of Magnetostrictive Material to Perform Parametric Phase Conjugation of Ultrasonic Beams

Friday, October 23, 1998 4:00 p.m.

Dr. Leonid M. Krutyansky
General Physics Institute
Russian Academy of Sciences
Moscow, Russia

This report reviews an investigation of phase conjugation of ultrasonic beams performed in recent years by our group at the General Physics Institute in collaboration with the Moscow Institute of Radio-Engineering Electronics and Automation. A number of prospective applications require real-time phase conjugation with large amplification and accurate reproduction of the incident sound field. The phase conjugation is accomplished using an external electromagnetic field to parametrically modulate the acoustic field in a magnetostrictive material. The modulation is very efficient in magneto-ordered materials in which the sound speed is highly sensitive to an external magnetic field. Phase conjugation with 80 dB amplification was achieved with nickel-based polycrystalline ferrites. Temporal dynamics of the conjugate wave amplitude satisfy the solution for a parametric layer in an infinite medium. Nonlinear limitation of the conjugate wave amplitude is discussed. Experiments were carried out to study and enhance the directional characteristics of the conjugating element. Optical stroboscopic visualization reveals accurate reproduction of incident sound field by the conjugate wave field. Self-targeting of conjugate beams on solitary and multiple objects in liquid has been clearly demonstrated.

Phase Conjugated Ultrasonic Beams of Finite Amplitude

Friday, October 30, 1998 4:00 p.m.

Professor Yuri Pyl'nov
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Electronics and Automation
Moscow, Russia

This report is devoted to the first experimental study of nonlinear propagation of phase conjugated ultrasonic beams, carried out in the General Physics Institute (Moscow). Parametric pumping of magnetostrictive ceramics with an alternating magnetic field produces a conjugate wave of high intensity. Since the intensity of the conjugate wave leads to finite amplitude effects not described by linear theory, a question arises as to what extent the structure of the conjugate wave field may differ from that of the incident field. Time waveforms were measured using spectral analysis of light diffraction by the sound field, which permits digital acquisition of single pulses. With this method it is possible to determine the harmonic components and therefore the corresponding time waveform for strongly nonlinear conjugate sound waves. Measurements of peak pressure and intensity, averaged across the beam, were also obtained in this way. The results are compared with numerical calculations made at UT Austin. Quantitative agreement is obtained in the region before shock formation, but current bandwidth limitations of the measurement system prevent quantitative comparisons beyond shock formation. Nevertheless, despite substantial nonlinear distortion of the conjugate wave, reasonably accurate reproduction of the incident field structure with the finite amplitude conjugate wave field may be obtained.

Binaural Localization of Non-Impulsive Noise in a Reverberant Environment

Friday, November 6, 1998 4:00 p.m.

Joseph B. Gaalaas
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The accuracy to which human listeners can localize non-impulsive, broadband noise stimuli in a reverberant environment was studied. Physical measurements of the stimuli were obtained with the use of a manikin equipped with a microphone at each ear. The primary objective of the study was to use the physical measurements to predict localization performance and to compare the prediction with results from the psychoacoustic experiments. A recent model of processing by the ear was used to find the information available from left and right ears for higher level processing. A form of cross-correlation was utilized to extract interaural time difference (ITD) information. Interaural level differences (ILD) were also studied through examination of the ratio of the power measured at each ear. The results indicate that very few ITD cues are available to the listeners in the experiment and, with several reasonable assumptions, one can account for measured localization performance on the basis of high-frequency ILD alone.

Acoustics of the Piano

Thursday, November 19, 1998 4:00 p.m.

Dr. Thomas D. Rossing
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Northern Illinois University
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http://www.physics.niu.edu/fakepages/rossing.htm
http://www.physics.niu.edu
http://www.niu.edu

The modern piano, which is a direct descendant of the harpsichord, has become the most versatile and popular of all musical instruments. In order to explain the production of sound in a piano, we consider the mechanics of the piano action, the vibrations of the strings and the bridge, and the vibrational modes of the soundboard, and the radiation of sound. Experimental modal testing and holographic interferometry are among the methods used in these studies in the laboratory.

Combustion Aerosol Evolution in Acoustic Fields

Friday, December 4, 1998 4:00 p.m.

Professor Ofodike Ezekoye
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This seminar will present some of the work done in our group on the effects of acoustic fields on soot production and subsequent growth in combustion systems. First, the aero-thermo-chemical dynamics of soot production in a flame will be described. Computational results for the soot spatial distribution and production rates in flames will be provided. Then, preliminary experimental results on the effects of immersing a sooting flame in an acoustic field will be shown. Finally, our work in aggregation of post-flame soot will be discussed. In this final section we will provide experimental, theoretical and computational results on aerosol aggregation in acoustic fields.