Transient Acoustic Field Produced by an Electric Spark in a Tube

Wednesday, January 25, 1989 4:00 p.m.

Professor David T. Blackstock
Department of Mechanical Engineering
and
Applied Research Laboratories
The University of Texas at Austin

An electric spark produces an intense acoustic pulse, which is called an N wave because its waveform resembles the letter N. An experiment is described in which both spark and receiver (a very broadband microphone) were located on the tube axis, a given distance apart. The received signal was found to be a series of pulses. Only the first pulse, which represents the wave that traveled straight down the axis, is a true N wave. Subsequent pulses represent waves reflected once, twice, three times, and so on, from the tube wall, which is in effect a cylindrical mirror. The reflected pulses are not N shaped. Four different waveform shapes are identified, each of which reappears every fourth pulse. The novel features of the pulse train are shown to be due to focusing that occurs each time the reflected waves cross the tube axis. Each focusing produces a 90° phase shift in all the frequency components of the pulse. At low intensities the four pulse sequence continues indefinitely. At high levels, however, the pattern changes. Nonlinear effects apparently cause 90° of the cumulative phase shift to be lost. The experiment was done several years ago, at which time our theoretical understanding of the phenomenon was only qualitative . Recent theoretical advances in focusing of intense beams give hope that the peculiar amplitude dependence of the pulse train pattern may be explained quantitatively.

Information Transmission in Oil Well Drill Pipe

Wednesday, February 1, 1989 4:00 p.m.

Professor Elmer Hixson
Department of Electrical Engineering
The University of Texas at Austin

A brief history of acoustic signaling from the bottom of an oil well will be presented. Then the transmission characteristics of stress waves in pipe with discontinuities every 30 ft (tool joints) is shown to consist of pass and stop bands. In practice the attenuation is found to be quite small thus reflections at the top and bottom of the hole are serious problem. An attempt to terminate the pipe with a piezoelectric transducer loaded by a resistor is described.

Active Electrical Damping of a Piezoelectric Crystal Transducer

Wednesday, February 8, 1989 4:00 p.m.

Chris Kenny
Department of Mechanical Engineering
The University of Texas at Austin

Piezoelectric crystals are commonly used for acoustic range finding. The crystal is oscillated to create a tone burst, turned off, and when the echo comes back the crystal is also used to receive the echo. The crystal has low internal damping and tends to ring after the sending pulse has been turned off, interfering with the returning echo. This limits close range distance measurements and makes signal processing more difficult. The purpose of this project is to actively damp the crystal vibrations using an electronic control circuit. By applying control, you can reduce ringing, and improve the performance of the range finder.

The Propagation of Shocks in a Tube

Wednesday, February 22, 1989 4:00 p.m.

Dr. Wayne Wright
Physics Department
Kalamazoo College
Kalamazoo, Michigan

Department of Mechanical Engineering
and
Applied Research Laboratories
The University of Texas at Austin

One of the best known predictions of nonlinear acoustics deals with propagation distortion of plane waves. An initially sinusoidal wave, for example, is expected to distort into a sawtooth. The sawtooth waveform is made up of abrupt discontinuities (shock fronts) joined head to tail by a linear change in pressure. In 1967, however, observations of finite amplitude waves in a tube showed that this simple picture needed modification. Although the shocks developed, they were not symmetric: the peaks were rounded, the troughs sharp. Indirect evidence indicated that the asymmetry was caused by dispersion associated with tube wall effects. An overview is given of related work that has been done at Kalamazoo College, the University of Rochester, and the University of Texas at Austin during the past two decades. Measurements and calculations that have been carried out with initially sinusoidal waves, and also with single shocks having amplitudes up to 0.6 atm (189 dB SPL), show that dispersion associated with the tube wall indeed does provide an adequate explanation of the shock distortion.

Acoustics of Bubbly Liquids, Part 1

Wednesday, March 1, 1989 4:00 p.m.

Professor A. Bedford and J. A . Hawkins
Department of Engineering Mechanics
The University of Texas at Austin

Gas bubbles in a liquid greatly alter the acoustic properties (both velocity and attenuation) of the liquid. This talk is a prologue to a seminar on the development of a theory for the acoustics of bubbly liquids with a distribution of bubble sizes. We will review a variational method for deriving the equations describing the acoustics of a liquid containing a distribution of bubbles of uniform size. The method involves introducing the kinetic energy associated with volume oscillations of the bubbles into Hamilton's principle. The resulting theory agrees very well with ultrasonic experiments. We will also discuss a generalization of the theory to a porous medium containing a bubbly pore fluid.

Acoustics of Bubbly Liquids, Part 2

Wednesday, March 8, 1989 4:00 p.m.

J. A. Hawkins and Dr. A. Bedford
Department of Engineering Mechanics
The University of Texas at Austin

Bubbles of gas occur naturally in a layer near the ocean surface and in ships' wakes. Well established continuum theories exist for the propagation of acoustic waves through a bubbly liquid when the bubbles are of uniform size. However, naturally occurring bubble populations have a distribution of sizes. Since bubble resonance effects dominate the acoustic response of bubbly liquids, a theory based on a single bubble size cannot predict the acoustics of a liquid containing a distribution of bubble sizes. We will describe two approaches based on Hamilton's principle for analyzing the acoustics of bubbly liquids containing a distribution of bubble sizes. First, we treat the mixture as a liquid containing bubble "continua" of several discrete sizes. Our second approach is to assume that a continuous distribution of bubble sizes exists in the liquid. Surprisingly, the second approach results in a simpler theory. We show that the phase velocity and the attenuation of acoustic waves can be determined for an arbitrary distribution of bubble sizes.

Bioacoustic Underpinnings of Formation and Organization of Frog and Toad Choruses: Possible Mechanisms for Optimization of Mating Call Detectability

Wednesday, March 22, 1989 4:00 p.m.

Jim Fox
Department of Psychology
The University of Texas at Austin

A hypothesis is examined that male frogs and toads form choruses so as to derive certain acoustic advantages resulting from call overlap. Computer models of hypothetical choruses demonstrate that chorusing may result in the augmentation of per capita active space (area of mating call detectability). Several behavioral variables are examined for their effects on active space. Based on these effects, Acris crepitans choruses are examined to determine whether they are organized so as to maximize active space, within the behavioral constraints of the species.

Three-dimensional Extraction and Reproduction of Signals from an Interfering Sound Field

Monday, March 27, 1989 4:00 p.m.

Kimitoshi Fukudome
Department of Acoustic Design
Kyushu Institute of Design
Fukuoka, Japan

This paper describes a method for the three-dimensional reproduction of any constituent sound signals existing in the interfering sound field. The method is composed of three parts. (1) Estimation of incident directions and spectra of unknown sound sources using sphere-baffled microphones and the diffractive information of the sphere. (2) Extraction of sound source signals by adding the output signals of the extraction filters that are fed by the sphere-baffled microphones. Characteristics of the filters are determined according to the estimated results of the incident directions and the diffractive information. (3) Three-dimensional reproduction of any constituent sound signals using headphones. The right and left signals of the headphones are generated after convolving the head-related transfer characteristics with the constituent sound source signal. The validity of the present method has been verified by computer simulation. Finally, the problems to be considered at the implementation are described.

Simulation and Experiments on Active Noise Control in a Duct Using an Adaptive Digital Canceler

Wednesday, April 5, 1989 4:00 p.m.

Dominique Laget
Department of Electrical Engineering
The University of Texas at Austin

Noise attenuation can be obtained by superposition of two noises. Active noise control uses a secondary source to perform this superposition. This method can be more successful than passive cancelers when the frequency of the noise is low or there is need for an air flow. Adaptive control takes into account variations of the characteristics of the noise or of the transducers. Here an application of this method to active noise control in a duct is presented. State of the art in simulation, applications, and results with the LMS algorithm will be discussed.

Acoustic Propagation in a Periodic Structure, Part I: Linear Propagation

Wednesday, April 12, 1989 4:00 p.m.

Chuck Bradley
Department of Mechanical Engineering
The University of Texas at Austin

Linear wave propagation in periodically inhomogeneous media is characterized by the division of the frequency spectrum into regions known as passbands and stop bands, the waves associated with which are propagated and attenuated, respectively. Other unusual phenomena associated with these waves (known as Bloch waves) are: bands of frequencies with a single effective wavelength, backward wave spectra, and purely progressive propagation in the presence of scatterers. A dispersion relation is derived for zeroth order propagation in a rectangular waveguide which is periodically loaded with rigidly terminated side branches. A 25.4 mm x 38.1 mm x 6 m waveguide was built with 38.1 mm deep side branches at .1 m intervals. Experimental results show dispersion and band structure which compare well with the analytic results. Qualitative aspects of nonlinear propagation i n these media will also be discussed.

Mathematical Model of Nonlinear Acoustics in Inhomogeneous Fluids

Wednesday, April 19, 1989 4:00 p.m.

Edel Reiso
Department of Mathematics
University of Bergen
and
Department of Mechanical Engineering
The University of Texas at Austin

The propagation of finite amplitude sound waves produced by real sources in an in homogeneous and thermoviscous fluid is considered. A nonlinear parabolic equation in the normalized sound pressure amplitude is derived using singular perturbation methods. It describes a narrow beam and reduces to the KZK equation for a homogeneous fluid. The equation can be solved numerically using the method of finite differences. In the linear case with an axisymmetric source, numerical and asymptotic results are presented. Possible applications of the model are discussed.

Reflection of Focused Sound from Curved Rigid Surfaces

Wednesday, April 26, 1989 4:00 p.m.

Michalakis A. Averkiou
Department of Mechanical Engineering
The University of Texas at Austin

Target geometry and orientation significantly affect the current accuracy of high precision ultrasonic proximity sensors. The reflection of focused sound (that is generated by a source with either a uniform or Gaussian distribution) from curved, rigid targets has been investigated using solutions obtained from the parabolic approximation of the wave equation. Both the focusing of the source and the curvature of the target are modeled by quadratic phase factors. The solutions obtained describe the reflected field from concave and convex targets in both axisymmetric and nonaxisymmetric configurations. Propagation curves, beam patterns, and scattering trajectories are used to illustrate the combined effects of diffraction and target curvature on the reflected sound field. Transfer functions are obtained by comparing the received to the transmitted acoustic power for the case of a monostatic acoustic sensor.

Dry Runs for the Presentations at the 117th Meeting of the Acoustical Society of America

Wednesday, May 17, 1989 4:00 p.m.

“Reflection of Focused Sound From Curved, Rigid Surfaces”
by Michalakis A. Averkiou and Mark F. Hamilton

“Effects of Absorption on the Scattering of Sound by Sound”
by Corinne M. Darvennes, Mark F. Hamilton, Jacqueline Naze Tjotta, and Sigve Tjotta

“Finite Amplitude Acoustic Propagation In a Periodic Structure”
by Charles E. Bradley

“An Omni-Directional, Ultrasonic Acoustical Source for Three-Dimensional Position Monitoring In Air”
by Jack Leifer and Ilene J. Busch-Vishniac

Asymptotic Solutions of Burgers’ Equation and Statistical Investigation of Random Waves

Wednesday, June 28, 1989 3:00 p.m.

Y. G. Shchemelev
Department of Radiophysics
Gorky State University, USSR

It has become clear that Burgers’ equation is a standard equation for a wide class of waves in nonlinear, nondispersive media, worthy of accepting a place alongside the classical linear hyperbolic equation. It is possible to derive an asymptotic solution from an approximation of the exact integral solution in the vicinity of the extremal points of the integrand. The solution can be represented in a very simple form in this case. In particular, this method allows geometrical interpretation of the solution of Burgers’ equation. This form of solution is especially convenient for statistical investigations of Burgers’ equation when an initially random disturbance develops into shock waves. The process is described in terms of spectral properties of the signal that change when a random signal is propagated in a nonlinear medium.

Propagation of Impulsive Signals in Stratified Anisotropic Media

Monday, October 2, 1989 3:00 p.m.

Jan Garmany
Institute for Geophysics
The University of Texas at Austin

Of all elastic wave propagation problems, none eludes our intuition more than anisotropy. Even the formidable problem of propagation in a 3D heterogeneous medium seems less intimidating because we have an intuitive sense (and some computational tools) for the behavior of classical rays and diffraction in isotropic media. Although ray theoretical methods for anisotropic media exist, their form is quite forbidding and does not lend itself to simple interpretation. Since rays are difficult to understand intuitively in anisotropic media, it is even less likely that we would develop an understanding for their rates of divergence, which control wave amplitudes and phases in the ray approximation. To further complicate matters, phase shifts introduced at caustics in anisotropic media may be opposite those derived for isotropic propagation. In this talk, I show how to obtain a qualitative understanding of travel times, amplitudes, and phases of impulsive arrivals in stratified anisotropic media without resorting to ray tracing. In stratified media, working in the slowness domain provides the most direct approach to predicting the effects of anisotropy. In addition, I remark on some new results on turning rays in stratified media and their possible consequences for the inverse travel time problem in anisotropic media.

An Array Filtering Implementation of a Constant Beamwidth Acoustic Source

Monday, October 9, 1989 3:00 p.m.

Jeff Harrell
Department of Electrical Engineering
The University of Texas at Austin

For acoustic arrays (microphones or loudspeakers), the main beamwidth of the radiation pattern is determined by the spacing between the elements in terms of λ. Thus area coverage depends upon frequency. We have demonstrated that by controlling the spacing and the frequency response of each element in an array, constant directivity of the main lobe over a wide frequency range can be achieved. Large powers can be achieved with relatively low energy densities at each element.

The Accelerando Project

Friday, October 20, 1989 4:00 p.m.

Professor Russell F. Pinkston
Department of Music
The University of Texas at Austin

An inexpensive real time computer music system has been developed at the Electronic Music Studios of The University of Texas at Austin. The system was designed to facilitate both teaching and composition; it can be implemented with any standard microcomputer having a MIDI interface or parallel port , a generic MIDI keyboard, and an external, user-programmable DSP module. The DSP module, called accelerando, contains a single Motorola 56001 and is equipped with MIDI, Yamaha Digital Cascade, and a general-purpose parallel port. The accelerando can be controlled directly by a host computer or function independently as a standard MIDI device. Software has been written to allow the module to be used for digital recording and playback, effects processing, and direct synthesis. A symbolic compiler, called Patchwork, has also been developed, which allows synthesis and DSP algorithms to be constructed graphically. This paper provides a general overview of the system and describes the rationale behind specific aspects of the design.

Absorption Due to Shocks in a Finite-Amplitude Sound Wave

Friday, October 27, 1989 4:00 p.m.

David T. Blackstock
Department of Mechanical Engineering
and
Applied Research Laboratories
The University of Texas at Austin

The amount of heating of a material through which sound passes depends on the acoustic absorption of the sound wave. Absorption of small-signal sound is well understood, but in many applications, particularly in medical ultrasonics, the sound is of finite amplitude. Absorption of finite-amplitude sound is dealt with in this talk. Calculations have been made for the case in which dissipation at shocks in the acoustic waveform dominate the absorption. Particular waves considered are a sinusoidal wave (which distorts and forms a sawtooth), an N wave, and a shock wave having an exponential tail.

Dry Runs for the Presentations at the 118th Meeting of the Acoustical Society of America

Friday, November 17, 1989 4:00 p.m.

“A High-frequency Omnidirectional Source for a Robot End Effector”
by Jack Leifer and Ilene J. Busch-Vishniac

“Effects of Boundary Conditions on the Propagation and Interaction”
by Jacqueline Naze Tjotta, James A. TenCate, and Sigve Tjotta

“The Application of Hamilton’s Principle to a Bubbly Liquid of Finite Amplitude Sound Beams”
by James A. Hawkins and Anthony Bedford

“Effects of Focusing on the Scattering of Sound by Sound”
by Corinne Darvennes, Mark Hamilton, Jacqueline Naze Tjotta, and Sigve Tjotta

“Active Attenuation of Pure Tones in a Lined Duct Using Adaptive Filtering”
by Dominique Laget and Elmer L. Hixson

Lattice Dynamics: Theory of Acoustics in Solids on the Atomic Scale

Monday, December 4, 1989 3:00 p.m.

Dr. F.W. de Wette
Department of Physics
The University of Texas at Austin

Lattice dynamics describes the vibrational motions in solids on the atomic scale; acoustics is the long-wave-length or acoustic limit of this description. After a short introduction of the formalism of lattice dynamics and of the notion of phonons, representative results for phonon dispersion relations will be presented. Next experimental methods for measuring these dispersion relations will be briefly reviewed. Phonon related properties of solids and effects of anharmonicity will be discussed. Finally, time permitting, some remarks will be made about surface effects.

Applications of Higher-Order Spectral Analysis to Nonlinear System Identification

Friday, December 8, 1989 4:00 p.m.

Dr. Edward J. Powers
Department of Electrical and Computer Engineering
The University of Texas at Austin

In this presentation, the key ideas underlying the use of digital higher-order spectral analysis to identify nonlinear systems are described. Of particular importance is the fact that the approach to be described is valid for non-Gaussian as well as the more commonly assumed Gaussian excitations. The practicality and feasibility of the approach, as well as the deleterious consequences of assuming Gaussian excitation when, in fact, it is not, will be demonstrated with experimental data.