NOVA: The Science of Music

Wednesday, February 7, 1990 2:00 p.m.

A videotape of the PBS program NOVA dealing with the acoustics of music will be shown. The program covers a variety of topics including construction of musical instruments, synthesizer development, and psychological phenomena associated with music. Both historical and modern developments of the selected topics are covered.

Measurement of Otoacoustic Emissions in Human Ears

Friday, March 2, 1990 4:00 p.m.

Dr. Craig Champlin
Speech Communication
The University of Texas at Austin

Otoacoustic emissions (OAEs) are low-level sounds that originate in the inner ear, but can be recorded in the human ear canal. These sounds come in two general classes sounds that occur during or following acoustic stimulation are called evoked OAEs, while sounds that occur in the absence of external stimulation are called spontaneous OAEs. The measurement of both classes of OAEs will be described. Several applications of this new measure of cochlear function will also be discussed.

Application of Stress Wave Measurement Techniques in Geotechnical Engineering

Friday, March 9, 1990 4:00 p.m.

Dr. Kenneth H. Stokoe, II
Brunswick-Abernathy Regents Professor
Department of Civil Engineering
The University of Texas at Austin

The use of stress waves in nondestructive testing and evaluation of geotechnical materials has increased significantly over the past two decades. Shear and Rayleigh waves are the two types of seismic waves most often employed in situ. The primary reason for their use, rather than compression waves, is that soils (particulate materials) are often saturated and the deformational characteristics of the soil skeleton are needed. Borehole and surface measurement methods are presented, with the equipment and analysis procedures highlighted. Several case histories, such as the in situ evaluation of natural earthen dams created during the 1980 eruption of Mount St. Helens, are discussed.

Linear and Nonlinear Acoustic Bloch Wave Propagation in a Periodic Waveguide

Friday, March 23, 1990 4:00 p.m.

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

A theoretical and experimental investigation of the propagation of linear and nonlinear acoustic waves in a waveguide loaded with a periodic array of scatterers is presented. It is first shown that the waves which occur in a periodic waveguide, with or without thermoviscous dissipation, are Bloch waves. The dispersion relation, impedance function, and traveling wave spectrum are derived for the case of a waveguide loaded with an array of rigidly terminated side branches. Comparisons of the theoretical results with measurements made in an air filled waveguide show very good agreement. Examples of some of the unusual wave behavior characteristic of Bloch waves will be presented. For the case of finite amplitude excitation a quasilinear solution has been found which shows that a bidirectional excitation of second harmonic Bloch waves takes place. Comparisons with both ordinary nonlinear dispersive theory and experimental results are made.

Evanescent Waves in Acoustics

Friday, April 6, 1990 4:00 p.m.

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

Evanescent waves, which are disturbances that are not true waves at all, turn up in many fields of science and engineering. Examples to be discussed in this seminar are primarily from acoustics. Evanescent sound waves arise in refraction (when total internal reflection occurs), in waveguide propagation (operation below cutoff), in propagation of plane waves through horns (operation below cutoff), in radiation due to flexural vibration of surfaces (when the flexural wave speed is less than the sound speed in the surrounding fluid), and in radiation by subsonically moving objects. Except for horns, the evanescent wave is associated with failure of the disturbance to move supersonically. Evanescent waves are also common in other fields, for example, optics (refraction beyond the critical incidence) and quantum mechanics (tunneling).

The Design Sensitivity and Control of Acoustic Power Radiated by Three-dimensional Structures

Friday, April 13, 1990 4:00 p.m.

Kenneth A. Cunefare
Department of Mechanical Engineering
Pennsylvania State University

The numerical treatment of a discrete quadratic expression for the total acoustic power radiated by a three-dimensional extended structure, derived from a boundary element formulation of the Helmholtz Integral Equation, leads to an improved understanding of the sensitivity and control of the radiation of acoustic power from such structures through the development and application of three novel analysis techniques. The partial differentials of the power expression with respect to a known surface velocity distribution lead to Acoustic Design Sensitivity analysis. Acoustic Design Sensitivity analysis quantifies the change in the total radiated power due to local changes in the surface velocity distribution. The partial differentials of the acoustic power expression with respect to unknown source velocities on active noise control sources and known noise source velocities on a structure lead to Active Noise Control Optimization analysis. Active Noise Control Optimization analysis determines the optimum magnitude and phase at which to drive active noise control sources to achieve the best possible reduction in the total radiated power from a noise source/control source combination. The partial differentials of the acoustic power with respect to a completely unknown velocity distribution, but with an imposed constraint to assure nontrivial solutions, lead to Weak Radiator analysis. Weak Radiator analysis determines how a structure should respond to minimize its ability to radiate acoustic power, not how an actual physical structure will respond.

I.) Scattering of Sound by Sound in a Waveguide
II.) D.C. Pressure Generation in a Standing Wave Field

Friday, April 20, 1990 4:00 p.m.

Tom Van Doren
Mechanical Engineering
The University of Texas at Austin

I. Scattering of sound by sound: The interaction of two finite amplitude tones in a rectangular duct generates sound at the sum and difference frequencies of the two tones. This generation can be described using a quasilinear theory which is quite accurate for an infinite duct. An experiment is described in which a Helmholtz resonator is used as an acoustic filter for one of the tones to bound the interaction region and thus scatter the generated sum and difference frequency components outside the interaction region. The quasilinear theory is applied to the generation in the bounded region and is compared to the experiment.

II. D.C. pressure generation: A quasilinear theory for the generation of spatially varying but temporally constant pressure in a finite amplitude acoustic standing wave field will be discussed. This d.c. pressure generation will be demonstrated by acoustic levitation and acoustic fountaining.

Ballistic Shocks Used as Underwater Sound Sources

Friday, April 27, 1990 4:00 p.m.

Professor Dennis Wilson
Mechanical Engineering
The University of Texas at Austin

Several idealized linear models will be used to illustrate the fundamental difference in a sound pressure field produced by subsonic vs. supersonic body motion. This linear theory will then be modified to account for attenuation due to dispersion when finite amplitude waves are considered. Finally, some experimental results for ballistic shocks in water will be given.

Nonaxisymmetric Nonlinear Wave Propagation

Friday, May 5, 1990 4:00 p.m.

Eugene E. Kim
Mechanical Engineering
The University of Texas at Austin

A two-dimensional KZK (Khokhlov-Zabolotskaya-Kuznetsov) equation is used to model the nonlinear effects in a sound field that is excited by nonaxisymmetric source conditions. An algorithm developed in Norway, which numerically solves the KZK equation in the frequency domain, is employed after some modifications. Two nonaxisymmetric source conditions are considered: a single source with linear amplitude shading, and a pair of displaced sources which radiate at different frequencies. The latter case is used to study the effects of high intensity on the scattering of sound by sound.

Sound Wave Propagation Through Multiphase Materials

Friday, June 8, 1990 4:00 p.m.

T.S. Margulies
Johns Hopkins University

Theories for infinitesimal, planar sound wave propagation in a dilute suspension of rigid particles has been investigated by generally three approaches: (1) wave scattering, (2) hydrodynamic, and (3) ad hoc approaches specific to particular systems. Here, a hydrodynamic development that uses spatially averaged continuum balance and constitutive equations for multiphase materials is presented. Two alternative approaches derive equivalent results (i.e., a bicubic polynomial equation) for the complex propagation constant $\chi=-(\alpha+ik)$, where α is the spatial attenuation coefficient and k is the wavenumber. One approach uses linear momentum equations for each individual phase, while the other uses an overall linear momentum equation and a relative momentum equation, obtained by taking the sum and difference of the individual momentum equations for the continuous and particulate phases. The advantage of this latter approach is that it expresses the results in the form of a generalized Fick's law, and expresses the diffusion of particles, as well as the supply terms such a barophoresis, thermophoresis, and pycnophoresis, explicitly. Furthermore, an Einstein relation can be obtained by simply defining a diffusion

coefficient, and interpreting this coefficient in the linear momentum supply term that is proportional to the relative velocity as a Stokes' viscous drag force.

Waves of Negative Energy

Friday, September 14, 1990 4:00 p.m.

L. A. Ostrovsky
Institute of Applied Physics of the USSR Academy of Sciences
603600 Gorky, USSR

The concept of negative energy waves in hydrodynamics and acoustics is discussed. Being excited, such waves decrease the total energy of a system which is possible only in nonequilibrium, potentially unstable systems, e.g., in a fluid with shear flow. Any kind of dissipation (viscosity, radiation from the system, etc.) in such systems may cause instability, i.e. exponential growth of the wave amplitude. Examples of such a behavior are given. Nonlinear stages of the instability are also discussed.

NOVA: Chaos

Monday, September 17, 1990 4:00 p.m.

The new science of chaos is covered in a general manner. Strange attractors, sensitivity on initial conditions, and other chaos ideas are discussed. Many of the original researchers explain their work, including Michael Barnsley, Jerry Gollub, and UT's Harry Swinney. Applications of chaos theory to weather and biological systems are also covered.

A Variational Model for Bubbly Liquids: Reflection of a Plane Wave from a Bubbly Liquid Half-Space

Monday, September 24, 1990 4:00 p.m.

J. A . Hawkins, Jr. and Dr. A. Bedford
Applied Research Laboratories The
The University of Texas at Austin

Using a variational technique, we have investigated the acoustic properties of bubbly liquids with a distribution of bubble sizes [J. A. Hawkins, Jr. and A. Bedford, J. Acoust. Soc. Am. 86 (SI), S42 (A) 1989]. We have shown that our results are consistent with those of Commander and Prosperetti [K. W. Commander and A. Prosperetti, J. Acoust. Soc. Am 85 732- 746 (1989)], whose model for the acoustics of bubbly liquids likewise assumes a distribution of bubble sizes. They also analyzed the reflection and transmission of waves normally incident on a layer of bubbly liquid. In this talk we analyze the reflection of normal and oblique plane waves at the interface between a liquid and a bubbly liquid. Before discussing the reflection problem, we summarize the derivation of the dispersion relation for a bubbly liquid with a distribution of bubble sizes and present phase velocity and attenuation curves based on our model. The derivation of the reflection coefficients for the reflection of plane waves from a bubbly liquid half-space is presented and the resulting reflection coefficient curve is shown.

Ultrasonic Velocimetry and Imaging in Two-Phase Pipe Flow

Monday, October 1, 1990 4:00 p.m.

Assistant Professor Steve Morris
Department of Petroleum Engineering
The University of Texas at Austin

Downhole multiphase flow measurements play an important role in the efficient recovery of hydrocarbon resources. Knowing what fluids are present at any depth in a well, and what their respective flow rates are at that point, enables the petroleum engineer to make better decisions. The wide variety of flow regimes which can occur in a well make for an extremely difficult measurement problem. Acoustical techniques seem promising, though. Results from an exploratory study of ultrasonic Doppler velocimetry and imaging, as applied to two- phase pipe flow, will be presented. Experiments were done in oil-water and air-water regimes, using both vertical and inclined pipe positions.

Introducing . . .the Water Tank Facility for Ultrasonics

Monday, October 8, 1990 4:00 p.m.

James TenCate, Michalakis Averkiou, and Chun-Fai Cheng
Department of Mechanical Engineering
The University of Texas at Austin
and
Applied Research Laboratories

Over the past year or so, the acoustics group in the Mechanical Engineering Department has been putting together a water tank facility for ultrasonics on the 7th floor of the ETC. Most of the hardware is finished and enough software has been written so that experiments are now beginning. This seminar will include (1) an overview of the tank itself; (2) a discussion of the computer controlled positioning apparatus; (3) some words about interfacing the tank positioning apparatus and other instruments to a Macintosh using LabVIEW; and (4) discussion of some experiments we have planned. Sound boring? It won’t be. We’ll conclude by going upstairs for a look at the real thing and see a few demonstrations of what can be done.

Nonlinear Interactions Between Waves in Astrophysical Disks

Monday, October 22, 1990 4:00 p.m.

E. T. Vishniac
Department of Astronomy
The University of Texas at Austin

Accretion disks are extremely common objects, formed as the result of the collapse of gas onto a central object. The perturbation equations for such disks can be solved to yield a variety of waves. These waves are extremely similar to waves found in the ocean and atmosphere of our own planet. In particular, we find that accretion disks support sound waves and internal waves similar to those found in the ocean. This analogy can be used to provide important insights into the nonlinear behavior of accretion disk waves. In

particular, it appears likely that some combination of waves present in accretion disks are responsible for generating a magnetic dynamo and transporting angular momentum. In this talk I will discuss the nonlinear couplings between internal waves and sound waves in accretion disks, stressing the points of similarity and divergence with respect to the dynamics of our ocean.

Dispersion Relations for Acoustics

Monday, October 29, 1990 4:00 p.m.

Dr. Thomas Griffy
Department of Physics
The University of Texas at Austin

Causality, the physical requirement that the effect not precede the cause, implies certain relations between the speed of propagation of a signal and its attenuation. These relations are called dispersion relations or Kramers-Kronig relations. This tutorial seminar will introduce the K-K relations and discuss their applications to acoustic propagation.

Auditory Enhancement and Suppression in Normal-Hearing Persons with Reduced Speech Recognition in Noise

Monday, November 5, 1990 4:00 p.m.

Dr. Linda M. Thibodeau
Department of Speech Communication
The University of Texas at Austin

Auditory enhancement and suppression have been suggested as possible mechanisms underlying one’s ability to understand speech. Using a forward-masking paradigm, enhancement and suppression effects were evaluated in two groups of normal-hearing persons who differed in their ability to recognize high-frequency words in noise. Although all subjects showed some degree of enhancement and suppression, there were differences in the degree of suppression that occurred as stimulus duration was varied. One current rehabilitative strategy for persons having difficulty understanding speech in noisy environments is the use of an FM system. After reviewing the psychoacoustic findings, a demonstration of the benefits of an FM system will be demonstrated.

A Time Domain Computer Algorithm for Pulsed Nonlinear Sound Beams

Thursday, November 15, 1990 4:00 p.m.

Yang-Sub Lee
Department of Mechanical Engineering
The University of Texas at Austin

A time domain computer algorithm for solving the KZK (Khokhlov-Zabolotskaya-Kuznetsov) nonlinear parabolic wave equation has been developed for pulsed, axisymmetric, finite amplitude sound beams. The KZK equation accounts consistently for the combined effects of the thermoviscous dissipation, diffraction, and nonlinearity on sound beams radiated by directive sources. The main advantage of the algorithm is the efficiency with which calculations can be performed for tone bursts. New results include predictions of the entire process of self-demodulation, in which high frequency tone bursts evolve into distorted replicas of their envelope functions.

On the Absorption of Finite Amplitude Sound Waves

Monday, November 19, 1990 4:00 p.m.

Ping Wah Li
Applied Research Laboratories and the Physics Department
The University of Texas at Austin

Experiments show that when a tissue is exposed to high intensity ultrasound, the temperature increase can be much more than that expected on the basis of linear theory. It is believed that this is caused by nonlinear effects, which enhance the efficiency of absorption of sound waves. The goal of the present research is to study theoretically the absorption of finite-amplitude sound waves. In the seminar, I am going to review some previous results obtained by using weak shock theory in the frequency domain. A new time-domain approach will then be presented. Unlike the frequency domain approach with inevitably involves summations of infinite series, the new approach can provide simpler solutions for elementary sound waves, such as a continuous sinusoidal wave and an N wave pulse. However, in order to include both nonlinear absorption and ordinary absorption, which arises from small signal affects, the Burgers' equation must be used. Results based on the solution of Burgers' equation which have been worked out recently will be discussed. It is found that ordinary absorption has a significant contribution to the total absorption, both close to and far from the source. A comparison of the results from Burgers' equation, weak shock theory and linear theory will be discussed at the end of the seminar.

The Plasma Sound Source Sea Trip

Monday, December 3, 1990 4:00 p.m.

Robert L. Rogers
Applied Research Laboratories
The University of Texas at Austin

A sea trip in the Gulf of Mexico was performed on the RV Longhorn. Tests were conducted on the plasma sound source (PSS) at various depths and energies. Basic information was obtained regarding the PSS acoustic signature and spectrum. These appear to be the first results in which acoustical and electrical parameters were measured at kilojoule energy levels. Some of these results will be presented, and the adventures on the Longhorn will be discussed.