Acoustics Seminar Abstracts 1994
University of Texas at Austin

Molecular Mechanisms of Acoustical Nonlinearity Biophysical Applications

Friday, January 21, 1994 4:00 p.m.

Dr. A. Sarvazyan
Rutgers University, New Brunswick, NJ
and
Institute of Theoretical and Experimental Biophysics
Russian Academy of Sciences, Pushchino, Russia

The acoustic nonlinearity parameter B/A of a liquid is a simple function of the pressure derivative of bulk modulus and is directly related to the character of intermolecular forces in that liquid. In this talk we present experimental data on contribution of various types of atomic groups (charged, polar and hydrophobic) of organic solutes to the value of B/A of aqueous solutions. The data is obtained from high precision measurements of speed of sound in aqueous solutions of biological molecules at a wide range of temperatures and pressures.

Acoustic measurements over a wide range of pressures and temperatures provide a unique possibility of multiparametric thermodynamic characterization of biomolecular systems and processes. We have developed an acoustical method and a device enabling one to obtain in a single experiment with a single sample, complete thermodynamic characterization of liquids and of physicochemical processes that occur in the liquid phase. Changes of enthalpy, entropy, free energy, and their pressure and temperature derivatives (heat capacity, volume, expansibility, compressibility, etc.) are calculated from pressure and temperature dependences of sound velocity in the liquid.

Synchronous, Picosecond Sonoluminescence

Friday, January 28, 1994 4:00 p.m.

Anthony A. Atchley
Physics Department
Naval Postgraduate School
Monterey, CA

A single gas bubble, acoustically levitated in a standing wave field and oscillating under the action of that field, can emit a single pulse of blue-white light. This emission, called sonoluminescence (SL), has a number of remarkable features. It is easily visible to the unaided eye. The duration of the SL pulse is less than 50 ps. The emission can be extremely stable and repetitive, and can last for hours. The spectrum is broadband and increases in intensity in the ultraviolet. Slight cooling of the host liquid significantly increases the intensity. Single SL pulses are isotropic and unpolarized. Several mechanisms, ranging from classical to quantum mechanical, have been proposed to account for this phenomenon. Yet, there is no completely satisfactory explanation. The purpose of this talk is to review some of the recent advances in the study of SL.

Adaptive Multi-Level Substructuring in Structural Acoustics Computation

Friday, February 4, 1994 4:00 p.m.

Matthew Kaplan
Department of Aerospace Engineering and Engineering Mechanics
The University of Texas at Austin

Computational structural acoustic analysis of submarines can be prohibitively expensive in certain frequency ranges because of the geometric complexity of the structure. A method for dealing with high order finite element models of submarines will be presented, which uses a subdivision of the submarine into substructures, each of which is divided into its own substructures, etc. Within each substructure, the finite element model is transformed to a representation in terms of approximate modes of vibration, which can be truncated severely to obtain a greatly reduced model. An adaptive procedure is used to determine which modes should be included in the model for optimal accuracy.

Use of Seismic Surface Waves in Geotechnical Site Investigations

Friday, February 11, 1994 4:00 p.m.

Barbara Luke
Civil Engineering Department
The University of Texas at Austin

Seismic surface waves propagated along the ground can be used to determine the variation in shear wave velocity of a soil profile with depth. The shear-wave velocity profile is used by the geotechnical engineer for purposes including design of foundations for dynamic loads, in situ assessment of ground conditions and evaluation of sampling disturbance. A robust measurement technique using seismic surface waves to determine shear wave velocity profiles in horizontally layered media has been developed at The University of Texas at Austin by Professor Kenneth H. Stokoe, II and his colleagues. This technique, called the Spectral-Analysis-of- Surface- Waves (SASW) Method, will be described and examples of its application to underwater soil sites will be discussed.

Music as Noise: Sound Transmission and Unbiased Annoyance

Friday, February 18, 1994 4:00 p.m.

David A. Nelson
Acoustic Systems Acoustical Research Facility
The University of Texas at Austin

Music is often perceived as noise pollution, especially when it invades one’s solitude or one’s own music-making. This is generally a major issue in multi-unit residential buildings and in music facilities for rehearsal, broadcast and recording. However, current noise control methods of design and classification do not address the ongoing trend in popular music towards strong bass content. Analysis of broadcast music signals using unbiased annoyance [E. Zwicker, “On the Dependence of Unbiased Annoyance on Loudness” Proceedings of Internoise 89, pp. 809-814] indicates that i) contemporary music can be

adequately modeled as pink noise from 50 to 4000 Hz, ii) after passing through a partition the 63 Hz octave band dominates loudness and unbiased annoyance, iii) existing single number ratings [such as STC] cannot identify structures with critical low frequency resonances, thus potentially overestimating performance against this type of noise. Ramifications for noise control practice and effective single number ratings are explored.

Sounds From the Ear

Friday, 25 February 1994 4:00 p.m.

Dennis McFadden
Department of Experimental Psychology
The University of Texas at Austin

In addition to receiving, analyzing, and processing sounds for use by the brain, the inner ear (cochlea) is also able to produce sounds that can be detected with the aid of a small microphone system sealed into the external ear canal. One form of these ear-generated sounds, called spontaneous otoacoustic emissions (SOAEs), is essentially pure tones that are apparently continuously emitted from birth. These sounds will be demonstrated and possible mechanisms for their production discussed. For some reason, females have more SOAEs than males, and it will be shown that ears having SOAEs also have greater hearing sensitivity than ears without SOAEs. Other experiments studying SOAEs in identical and fraternal twins will be described, and genetic and prenatal factors contributing to SOAEs considered.

Experimental Investigation of Propagation and Reflection Phenomena in Finite Amplitude Sound Beams*

Wednesday, March 9, 1994 2:00 p.m.

Michalakis A. Averkiou
The University of Texas at Austin

Measurements of finite amplitude sound beams are compared with theoretical predictions based on the KZK equation. Attention is devoted to harmonic generation and shock formation related to a variety of propagation and reflection phenomena. Both focused and unfocused piston sources were used in the experiments. Measurements of propagation curves and beam patterns of focused pistons in water, both in the free field and following reflection from curved targets, are presented. A novel method for using focused beams to measure target curvature is developed. Measurements of pulsed sound beams from plane pistons in water and glycerin are also presented. Very short pulses (less than 2 cycles), tone bursts (5-20 cycles), and frequency modulated (FM) pulses (10-30 cycles) were measured. Acoustic saturation of pulse propagation in water is investigated. Self-demodulation of tone bursts and FM pulses was measured in glycerin. A quasilinear analytical solution for the entire axial field of a self-demodulating pulse is derived in the limit of strong absorption.

*Final oral defense of Ph.D. dissertation.

Nonlinear Tube Waves

Thursday, March 10, 1994 2:00 p.m.

David Johnson
Schlumberger- Doll Research
Ridgefield, Connecticut

We consider the nonlinear characteristics of an acoustic tube wave propagating along the axis of a fluid-filled circular borehole in an elastic solid which is locally isotropic but whose properties may vary radially. The analysis is carried out in the quasi-static (i.e., low frequency) limit. We express the amplitude of second harmonic generation as well as the pressure dependence of the tube wave speed in terms of the fluid and formation nonlinear parameters. Our results show that if there is no radial variation of the shear modulus of the solid then both the amplitude of the second harmonic generation and the tube wave speed are independent of the third-order elastic constants of the solid. If there is radial variation of the shear modulus then our numerical calculations indicate that both the second harmonic generation and tube wave speed are dominated by the nonlinear parameters of the solid. Perturbation theory demonstrates that the nonlinear response is scaled by the value of the third-order elastic constants, scaled by the degree and depth of alteration of the shear modulus.

Modeling Sound Propagation in a High Porosity Fibrous Material

Friday, March 25, 1994 4:00 p.m.

Dr. C. L. Morfey
Institute of Sound and Vibration Research
University of Southampton
United Kingdom

Sound transmission through the fuselage of a fully-trimmed aircraft is harder to predict than for the untrimmed “green” aircraft, because of the trim panels and thermal insulation; yet it is desirable that accurate predictions be made at the design stage. A European research project (“BRAIN”) has been set up, running for three years from 1 January 1993, to provide the necessary fundamental knowledge and methods.

In the seminar I will outline work in progress at Southampton on the modeling of sound in a fibrous insulation blanket. The fibre-fluid interactions are being modeled in detail at the level of an individual fibre. This information can then be used to set up an equivalent-medium model for both the structural and acoustic wave modes in the blanket. In addition to the linear acoustic model, our work is addressing possible nonlinearity in the sound transmission process. A tentative nonlinearity criterion will be presented for the viscous drag between a single cylindrical fibre and the surrounding fluid, in the low Stokes number regime (S<<1).

Digital Signal Processing Realization of Maximum Length Sequence Based System Response Measurements

Friday, April 1, 1994 4:00 p.m.

Craig Blome
Department of Electrical Engineering
The University of Texas at Austin

Results of a study of computationally efficient methods of system impulse response measurement are presented. Techniques using binary pseudorandom stimuli known as maximum length sequences are reviewed and their performance in the presence of additive noise and system nonlinearities is discussed. Some simple modifications to accepted practice are shown to substantially improve the linear response estimate obtained in the presence of system nonlinearities. Experimental data confirms the improvement. Applications in architectural acoustics and transducer measurement will be discussed.

Sound Propagation in Horns*

Friday, April 15, 1994 3:00 p.m.

John T. Post
Electrical and Computer Engineering
The University of Texas at Austin

Acoustic horns have been used for thousands of years, but only since the pioneering effort of A. G. Webster approximately eighty years ago have horns been studied in a quantitative manner. In this presentation, the improvements to Webster's original horn model are reviewed and the general lack of analytical progress since Webster is noted.

In an attempt to extend the traditional methods of analysis, a semi-analytical technique first presented by Rayleigh is pursued but found to offer a negligible improvement to Webster's horn equation. Free of the limitations associated with analytical techniques, a boundary element method has been developed and employed to numerically analyze the acoustic impedance and far-field directivity of axisymmetric horns. New techniques have been developed for measuring both the acoustic impedance at the throat, and the far-field directivity of horns. The numerical predictions obtained by the boundary element method compare favorably to experimental results.

*Final oral defense of Ph.D dissertation.

Ultrasonic NDE in Thick Laminated Composites

Friday, April 22, 1994 4:00 p.m.

Dr. Corinne M. Darvennes
Department of Mechanical Engineering Tennessee
Technological University

Delamination sizing in thick composites using ultrasonic techniques is a challenging problem. High frequency waves are needed to provide a sharp image of the defects, but they are attenuated rapidly and do not provide a reliable defect estimate. Another problem is the anisotropy of composites, because the ultrasonic beam deforms as it propagates in the material and produces a warped image of the defects. Several methods currently being studied to solve these problems will be presented.

Study of the Effects of High Powered Low Frequency Sonar on Divers

Friday, April 29, 1994 4:00 p.m.

Dr. Michael F. Pestorius
Applied Research Laboratories

The Navy is developing a long range, low frequency active (LFA) sonar. With the demise of the Soviet Union, the deep water submarine threat is perceived to have diminished and the Navy is interested in using LFA in shallow water where exposure of swimmers and diver will occur. ARL:UT is heading a study to determine the effects on humans during exposure to high intensity, low frequency (several hundred Hertz) sound. The effects being studied include: auditory, vibrotactile, cardiac, pulmonary, performance, and rectified diffusion. Data to date has shown that auditory, thermal, cavitation, and rectified diffusion effects will not be the limiting below a sound pressure level of 160 dB//lμPa. Further tests planned for May at the Navy Experimental Diving Unit in Panama City, Florida will determine the effects on the psychophysiological responses of pressure and diver dress.

Wind Dependence of Low Frequency Ambient Noise at a Deep Site in the Pacific Ocean

Friday, May 6, 1994 4:00 p.m.

Joan Schoppe
Applied Research Laboratories

Ambient noise recorded at a deep ocean site in the Pacific Ocean was analyzed to determine wind speed dependence. The OUTPOST SUNRISE experiment was conducted to measure low frequency ambient noise in a high bottom loss area using a bottom-located, vertical hydrophone array. Wind speeds, which varied from 2 to 23 knots, were recorded concurrently with ambient noise. At wind speeds less than 9 knots, the water column was dominated by distant noise. At wind speeds greater than 9 knots, omnidirectional levels depended on receiver depth and frequency of the data. Correlation of beam levels at 65 and 130 Hz with wind speed depended on beam angle. Horizontally, the field was dominated by

distant noise. Beam levels at beam angles greater than 20° above the horizontal correlated well with wind speed. Ambient noise source levels were estimated using source directionalities of a dipole and plane of monopoles.

Faculty Introductions and Overviews of Current Research Projects

Friday, September 9, 1994 4:00 p.m.

Members of the Acoustics Faculty
Departments of Mechanical Engineering and Electrical Engineering
The University of Texas at Austin

The purpose of this seminar is to introduce members of the acoustics faculty and their research associates to anyone who is either new at UT or simply curious. Overviews of current projects will be provided by David Blackstock, Ilene Busch Vishniac, Mark Hamilton, Elmer Hixson, and anyone else who feels inclined to describe his/her activities.

An Update on the Effects on Humans of Low Frequency Acoustics

Friday, September 16, 1994 4:00 p.m.

Dr. Michael F. Pestorius
Director, Applied Research Laboratories

The Navy is developing a long range, low frequency active (LFA) sonar. With the demise of the Soviet submarine force, the deep water threat has diminished and the Navy is interested in using LFA in shallow water where exposure of swimmers and divers will occur. Thus, a study is underway to determine the effects on humans during exposure to high intensity, low frequency (several hundred Hertz) sound. The effects being studied include: auditory, vibrotactile, cardiac, pulmonary, performance, and rectified diffusion. Previous tests have shown that auditory, vibrotactile, and rectified diffusion effects will not be the limiting responses below a sound pressure level of 160 dB//1 μPa. I reviewed the progress of this investigation for this audience on April 29th 1994. Since then, significant new data have been obtained in the Ocean Simulation Facility at Panama City, Florida. The background of the study and the progress to date will be review in this talk.

An Investigation into the Use of Ultrasonics as a Production Logging Tool

Friday, 23 September 1994 4:00 p.m.

Tom Maher
Department of Petroleum Engineering
The University of Texas at Austin

Production logging can be defined as any operation that answers the question “How much of which fluid is coming from where?” The fundamental problem is to measure flow rates of different phases in multiphase flow, which means determining the average velocity and volume fraction of each phase. The behavior of acoustic waves in random media indicates that determining velocities from Doppler shifts and

concentration of scatterers from the attenuation of the signal is possible. Theory predicts an exponential decay in signal intensity with increasing volume fraction of gas bubbles and this has been verified in experiments. The bubble size distribution is a primary factor in the rate of decay, and an independent method of determining this distribution in our experiments has been developed and verified with experimental data. Results and future work will be discussed.

Characterizing Fluid Flow Through a Perforation Using Ultrasonic Doppler Velocimetry

Friday, 23 September 1994 4:30 p.m.

Muhammad Razi
Department of Petroleum Engineering
The University of Texas at Austin

The objective of this experimental study is to develop an ultrasonic measurement technique to determine the velocity of fluid flow from a perforation in a petroleum well. The measurement will be made from inside the well. Preliminary work in this study has been done using continuous and pulsed ultrasonic waves of 2.25 MHz. Results derived from the work done so far are very encouraging. Further studies, both theoretical and practical, are in progress.

Experimental and Theoretical Study of the Acoustitron

Friday, September 30, 1994 4:00 p.m.

Michael Bailey
Department of Mechanical Engineering
The University of Austin

Work has just begun on the experimental and theoretical investigation of sound propagation in a toroidal waveguide – an acoustitron. Since the acoustitron is a waveguide in the form of a closed loop, a traveling time harmonic wave within the acoustitron sees no termination. Instead the wave goes round and round, passing the sources on every lap. Whether the sources cancel or amplify the wave depends on frequency. In the amplified wave, finite amplitude effects continuously push energy into higher frequencies, although the wave is only periodically replenished at the primary frequency. A one dimensional model of the acoustitron (a straight tube with periodic sources) has been solved numerically and, in some cases, analytically. Construction of an experimental acoustitron is in progress. A possible application of the acoustitron is the investigation of acoustic coagulation of smoke particles by traveling waves.

Airport Noise

Monday, October 17, 1994 4:00 p.m.

Michael T. McNerney
Center for Transportation Research
Department of Civil Engineering
The University of Texas at Austin

This seminar is designed to provide a better understanding of the airport noise problem, which is one of the most demanding problems facing our nation's airports today. The lecture will describe the aircraft operational effects on noise and FAA noise certification of aircraft. An overview of the FAA Part 150 Noise Compatibility Program and an example of implementation at Dallas Fort Worth Airport will be discussed. Calculation of noise contours using the FAA Integrated Noise Model Version 4.11 will be explained. Discussion of planned future enhancements to the Integrated Noise Model and the potential for integration with Geographical Information Systems (GIS) will be conducted.

Characterizing Fluid Flow Through a Perforation Using Ultrasonic Doppler Velocimetry

Friday, October 21, 1994 4:00 p.m.

Muhammad Razi
Department of Petroleum Engineering
The University of Texas at Austin

The objective of this experimental study is to develop an ultrasonic measurement technique to determine the velocity of fluid flow from a perforation in a petroleum well. The measurement will be made from inside the well. Preliminary work in this study has been done using continuous and pulsed ultrasonic waves of 2.25 MHz. Results derived from the work done so far are very encouraging. Further studies, both theoretical and practical, are in progress.

Acoustic-Aerosol Interactions in a Three Dimensional Standing Wave Chamber

Friday, October 28, 1994 4:00 p.m.

Professor Ofodike Ezekoye
Department of Mechanical Engineering
The University of Texas at Austin

A range of applications (from environmental to materials processing) rely on technological and scientific developments related to aerosol dynamics. A particularly underutilized but potentially significant approach to controlling the aerosol size distribution for a variety of applications is the use of acoustic/sonic aerosol agglomeration.

In this project, we examine the hydrodynamics of aerosol distributions as related to the acoustic agglomeration phenomena within a laboratory-scale flow field and measure the particulate size distribution as a function of aerosol type, aerosol loading and acoustic field specification. At the same time, computational models are being developed and evaluated to aid in clarifying the dominant physical processes promoting the experimentally observed results. Based on the results from both the experiments and computations, fundamental information on the dominant processes driving acoustic agglomeration are determined.

In this seminar, the theoretical basis for acoustic agglomeration will be presented, as well as preliminary experimental and computational results from our project.

Finite-Amplitude Surface Waves: Theory and Experiments

Friday, November 4, 1994 4:00 p.m.

Douglas Meegan
Department of Physics
The University of Texas at Austin

A surface wave is a wave that is confined to propagate along a two-dimensional surface of discontinuity in a three-dimensional elastic medium. This most basic characteristic of surface waves led to several practical applications that are in use today in the areas of ultrasonic measurement and seismology. Presently, there is an interest in studying the propagation of finite-amplitude surface waves and using this information to describe the nonlinear elastic properties of materials. A generalized model for nonlinear surface wave propagation at a planar interface will be described and presented. The model is a generalization of an existing model for nonlinear Rayleigh waves that was developed by Zabolotskaya with the use of Hamiltonian formalism. Experiments that are in progress to test these models will also be discussed.

Recent Efforts on the Plasma Sound Source

Friday, November 11, 1994 4:00 p.m.

Dr. Robert L. Rogers
Applied Research Laboratories

The plasma sound source, also known as the spark source, has been in use in various niches in geophysical research and in biomedical applications for a number of years. Even with these applications, very little work has been done regarding the engineering, modeling, and design of spark sources. Consequently, the spark sources built have suffered from low electrical-to-acoustic transduction efficiency. The acoustic output of a given spark source is usually determined empirically after the device has been built. Recently developed models show good agreement with measured acoustic signatures over a wide range of energies and hydrostatic pressures. The investigations at ARL:UT, which focus on understanding and modeling the fundamental processes associated with this source, will be discussed.

Presentations for the 128th Meeting of the Acoustical Society of America, Part 1

Friday, November 18, 1994 4:00 p.m.

Katya Knight
“Extensions of the theory for nonlinear Rayleigh waves”

Katya Knight
“Pulsed nonlinear Rayleigh waves”

Zhenya Zabolotskaya
“Evolution equations for nonlinear Rayleigh wave propagation”

Doug Meegan
“Theoretical model for nonlinear Stoneley and Scholte waves”

Lectures in Nonlinear Acoustics

Saturday and Sunday, November 19-20, 1994

Professor Oleg V. Rudenko
Chair, Acoustics Faculty
Department of Physics, Moscow State University

The two lectures on Saturday will be an introductory short course on the general properties and special features of nonlinear acoustic wave interactions in media with weak and strong dispersion. Both spectral and temporal analyses will be described. Specific topics include interaction and self-action phenomena in weakly dispersive media (e.g., Riemann waves, sawtooth and shock waves, intense noise waves). Computer visualizations will accompany the short course. The lectures on Sunday will cover two special topics. The first lecture is on exact solutions of model equations in nonlinear acoustics, including new developments in the analysis of cubic nonlinear media encountered in optics. The second is on the physics of sawtooth-like waves, including the use of kinetic theory to describe the statistics and relative motions of colliding shock waves. Lecture notes will be provided to participants who request them in advance. Professor Rudenko is known internationally for his many papers and textbooks in the field of nonlinear wave physics.

Lecture 1: Saturday, 10:00 a.m. to 12:00 p.m.
Lecture 2: Saturday, 1:30 p.m. to 3:30 p.m.
Lecture 3: Sunday, 10:00 a.m. to 12:00 p.m.
Lecture 4: Sunday, 1:30 p.m. to 3:30 p.m.

Presentations for the 128th Meeting of the Acoustical Society of America, Part 2

Monday, November 21, 1994 3:30 p.m.

Mike Bailey
“Bioeffects of positive and negative pulses in vivo”

Robin Cleveland
“Sonic Boom Risetime”

Mark Hamilton
“Transient axial solution for the reflection of a spherical wave from a paraboloidal mirror”

Larry Gelin
“Experimental study of reflection of airborn, spark-produced N waves by a paraboloidal dish”

Tom Kite
“The improvement of low frequency driver performance using an amplifier with negative output resistance”

Presentations for the 128th Meeting of the Acoustical Society of America, Part 3

Wednesday, November 23, 1994 3:30 p.m.

Wonkyu Moon
“Thermodynamic property considerations for modeling piezoelectric ceramic vibrators including thermal effects”

Wonkyu Moon
“Bond graph model for one-dimensional heat conduction for modeling of piezoelectric ceramic vibrators including thermal effects”

Oleg Rudenko
“Analytical method for describing the paraxial region of finite amplitude sound beams”

Vera Khokhlova
“Modification of the spectral method for describing nonlinear acoustic waves containing shocks”

B.J. Landsberger
“Transmitted beam distortion and rotation due to mode conversion between acoustic and shear waves at liquid-solid interfaces”

Jinlong Wu
“Propagation of sound in a lined circular duct with sheared mean flow”