Nonlinear Wave Phenomena in Resonant Gas Oscillations in Closed Tubes

Friday, January 25, 2002 4:00 p.m.

Professor Takeru Yano
Department of Mechanical Science
Hokkaido University, Japan
http://www.hokudai.ac.jp/bureau/e/index-e.html

The study of resonant gas oscillations in closed tubes is of basic importance in nonlinear acoustics. There appear various nonlinear phenomena such as shock waves, acoustic streaming, etc. In the weakly nonlinear case, the classical theory by Chester describes well the one-dimensional wave motion in the steady state oscillation in a straight tube. Even in the weakly nonlinear case, however, the initial transient phenomena have not been examined theoretically. Making use of the exact solution of the initial-boundary value problem of the linear wave equation, we shall demonstrate that there exists a modulation in the initial stage of nearly resonant oscillation. For the case of strong nonlinearity, the main thrust of the analysis is numerical computation. We shall clarify the wave motion in the strongly nonlinear case, when the acoustic Mach number at the sound source is of order unity, by solving the system of Navier -Stokes equations numerically. We also present numerical results for nonlinear phenomena in resonant oscillations in tubes with varying cross section. Furthermore, we shall discuss a bifurcation phenomenon associated with acoustic streaming at large Reynolds number in a resonator, identified via numerical analysis based on a model for incompressible flow.

The Ancient and Selective History of the Development of Short Range, High Resolution Active Sonars — Part 1

Friday, February 1, 2002 4:00 p.m.

Dr. Chester M. McKinney
Applied Research Laboratories
The University of Texas at Austin
http://www.arlut.utexas.edu

This is a brief history of the development of a broad class of active sonars which generally have most or all of these characteristics: relatively high operating frequency (35-1500 kHz), short range (a few meters to 1 km), high range resolution (1 mto a few cm), and high cross range resolution (a few degrees to 0.1 deg). Emphasis is on such sonars developed by several navies to find small objects such as naval seamines , although there are other important civilian applications. Beginning with the experimental work of Paul Langevin (France) in 1916-18, the development of three generic types of sonars is traced: ahead searching, multibeam , electronic scanning sonars; continuous transmission frequency-modulated sonars; and side-scanning sonars. Other types such as small boat sonars, sonars for manned and unmanned small submersibles, and 3D or camera type sonars are covered briefly. Basic research to support the development of all these sonars, primarily target strength, echo structure and bottom reverberation, is briefly discussed, as are other topics such as techniques for high cross-range resolution, target classification clues, and uses for wide bandwidth. Sonars proven to be historically significant are identified.

The Ancient and Selective History of the Development of Short Range , High Resolution Active Sonars — Part 2

Friday, February 8, 2002 4:00 p.m.

Dr. Chester M. McKinney
Applied Research Laboratories
The University of Texas at Austin
http://www.arlut.utexas.edu

This seminar concludes the history of active sonars begun in the previous seminar, given one week earlier. These sonars have most or all of the following characteristics: relatively high operating frequency (35-1500 kHz), short range (a few meters to 1 km), high range resolution (1 m to a few cm), and high cross range resolution (a few degrees to 0.1 deg). Emphasis is on such sonars developed by several navies to find small objects such as naval seamines, although there are other important civilian applications. Small boat sonars ,sonars for manned and unmanned small submersibles, and 3D or camera type sonars are discussed. Basic research to support the development of all these sonars , primarily target strength and echo structure and bottom reverberation, is also discussed, as are other topics such as techniques for high cross-range resolution, target classification clues, and uses for wide bandwidth.

Acoustic Modification of Sooting Combustion

Friday, February 15, 2002 4:00 p.m.

Karl Martin
Department of Mechanical Engineering
The University of Texas at Austin
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In order to understand the interaction of high intensity sound with sooting flames, an acetylene burner apparatus was developed in which a gaseous jet flame was exposed to acoustic fields with sound pressure levels above 140 dB. With proper frequency and amplitude, the acoustic field completely suppressed soot emissions from the flame. The acoustic field also changed the shape of the flame, creating a series of pulsations. High-speed video of the pulsations showed that the acoustic field imposes a dc velocity field on the flame, the magnitude of which is comparable and proportional to the acoustic particle velocity, and greater than the fuel jet velocity. Spectrometry measurements showed that the temperature of the flame increased with increasing sound pressure. Extinction measurements were used to reconstruct the radial distribution of soot in the flame. As with emitted soot, low sound power increased the in-flame soot concentration somewhat, but high sound power suppressed soot formation almost completely. The spectrometry and extinction measurements were also performed on partially premixed flames. The results from the two flames were quite similar, demonstrating that the primary effect of the acoustic field is to premix air into the flame. The available data indicate that sound generates a synthetic jet flow pattern, which draws air radially inward and premixes it with fuel in the fuel tube before the mixture burns.

Source Directionality Issues in Anechoic Chamber Qualification

Friday, February 22, 2002 4:00 p.m.

William McKenna
Acoustic Systems
http://www.acousticsystems.com/

Source directionality is a growing concern in the qualification of precision grade anechoic measurement chambers. In such a qualification, one moves a microphone away from an omnidirectional point source and monitors the deviation from spherical spreading in free space propagation by observing fluctuations in the inverse-square law. Manufacturers of such precision grade chambers must perform this test frequently. The question thus arises: Where does one obtain one of these omnidirectional point sources? This presentation will discuss which virtues of source directionality are important for chamber qualifications, and it will examine the directionality of at least one of the currently more commonly used sources.

Traveling-Wave Thermoacoustic Engines: Some Theory and Applications

Friday, March 1, 2002 4:00 p.m.

Dr. Scott Backhaus
Condensed Matter and Thermal Physics Group
Los Alamos National Laboratory
http://www.lanl.gov/thermoacoustics

Thermoacoustic engines are a class of heat engines that convert high-temperature heat into acoustic power without the use of moving parts. Recent innovations in thermoacoustics now allow the use of Stirling-like thermodynamic cycles in thermoacoustic engines. The inherent high efficiency of the Stirling cycle has dramatically increased the thermal efficiency of these engines to 30% without compromising the simplicity and reliability of no-moving-parts thermoacoustics. The crucial acoustics and thermodynamics of these engines will be explained. The research into these engines will be motivated by describing potential applications such as the liquefaction of industrial gases and electric power generation aboard deep-space probes.

Micromachined Ultrasonic Sensors

Thursday, March 21, 2002 4:00 p.m.

Professor Pierre Khuri-Yakub
E.L. Ginzton Laboratory
Stanford University
http://www.stanford.edu/group/ginzton
http://www.stanford.edu

With the advent of silicon micromachining, it is now possible to make capacitors with very thin gaps that sustain electric fields of the order of 109 V/ mor more. These capacitors can be made into transducers of ultrasound in gases, liquids and solids. This presentation will show how such transducers can be made to outperform traditional piezoelectric transducers in many applications such as nondestructive evaluation, underwater camera, and medical ultrasound imaging.

Acoustics Research at the Air Force Research Laboratory

Friday, March 22, 2002 4:00 p.m.

Dr. Douglas S. Brungart
Air Force Research Laboratory
Wright Patterson Air Force Base
http://www.wpafb.af.mil

The mission of the Aural Displays and Bioacoustics branch of the Air Force Research Laboratory (AFRL/HECB) is to enhance the performance and safety of Air Force personnel by conducting research in advanced audio interfaces and by mitigating the adverse effects of noise and vibration. In this presentation we provide an overview of some current research projects at AFRL/HECB. In the area of bioacoustic protection, these projects include the measurement of environmental noise on the flight decks of U.S. Navy Aircraft Carriers, the development of advanced hearing protectors for 150 dB noise environments, and the study of the effects of bone conduction on auditory localization with double hearing protection. In audio displays, these projects include the development of speech-based audio distance cues and the implementation of audio navigational aids for dismounted security personnel. Results are also presented for a basic research project examining the effects of audio interference on performance in a speech reading task.

New Approaches to Beam Aberration Correction in Medical Acoustics

Monday, April 1, 2002 4:00 p.m.

Professor Paul Carson
Department of Biomedical Engineering and Department of Radiology
University of Michigan
www.bme.umich.edu
www.rad.med.umich.edu

An acoustic beam focused in homogeneous media for interrogation or intervention will be defocused when portions of the beam travel through materials with differing speeds of sound. In echo-location imaging, such as medical ultrasound imaging, useful corrections for many aberrations can be made if there are adequate numbers and locations of elements in the imaging transducer array and if an appropriate model exists for the imaged scattering targets. In medical ultrasound, 2D transducer arrays are required. Using a homogeneous scatterer model, corrections can be made for the main body wall aberrations near the transducer. Time delay and amplitude corrections can be made rapidly at each transducer element. Corrections for more extreme pulse waveform distortions can be made with techniques such as phase conjugation if known point targets exist in the imaging region of interest. Remote production of point targets in vivo for medical ultrasound image aberration correction by acoustic droplet vaporization (ADV) is now technically possible. The main question is whether ADV will be prohibited in most desired applications by bioeffects concerns. At the other extreme from coherent point targets, incoherent fusion of image volumes acquired from different views in space or time can be performed with new, nonlinear image registration algorithms. Very few restrictions are placed on the scattering targets employed in this registration. This allows for a robust, if not precise, correction of part of the wave propagation differences between the different views.

Active Termination of Impedance for Broadband Signals in a Circular Solid

Friday, April 19, 2002 4:00 p.m.

Guillermo Aldana
Department of Electrical and Computer Engineering
The University of Texas at Austin
http://www.ece.utexas.edu

Real time data collection in down-hole environments has long been a goal of the drilling and oil industries. Information such as pressure, deviation from vertical, and temperature near the drill bit is used for decision making by the operator. Currently, the rate of transmission (using choked mud pulses) is on the order of 10-14 bits/second. Acoustic telemetry (which uses the drill string as the information carrier) has the potential to significantly increase the rate of data transmission, by perhaps two orders of magnitude. However, acoustic telemetry must overcome the dispersive, filtering and attenuating mechanism inherent to the drill string and drilling operations. The design and numerical simulations of a directional array for the generation of transient waves in a uniform, isotropic solid waveguide are presented. The directional array serves the purpose of a repeater and a terminating impedance, both of which may aid in increasing the transmission rate of information from the drill bit to the operator. Numerical simulations show that the proposed design is capable of rebroadcasting and canceling transient signals emerging from a (scaled)

model of a drill string by 14 dB. The basis of the algorithm lies in exploiting the low frequency behavior of PZT transducers and using a modified Fourier series expansion, along with properly spaced and phased sources embedded in the waveguide. The design proposed is robust to drill string geometry, drilling depth, and frequency content of the incoming signal.

Applications of the Kramers-Kronig Dispersion Relations to Ultrasonic Propagation

Friday, September 13, 2002 4:00 p.m.

Dr. Kendall Waters
Laboratory For Ultrasonics
Washington University in Saint Louis
http://www.wustl.edu

The Kramers-Kronig (K-K) dispersion relations are based upon the fundamental notions of linearity and causality. The relations provide a criterion for the causal consistency of a given measurement or model of the propagation mechanisms of a medium. We review briefly the development of the K-K relations with particular attention paid to the acoustic forms. We develop dispersion relations for media with attenuation obeying a frequency power law and compare to experimental measurements of plastic materials and liquids. Although the standard forms of the K-K relations are integral in nature, we demonstrate that a differential dispersion relation is also available for these types of media. Lastly, we consider finite bandwidth forms of the integral K-K relations applied to resonant systems: a suspension of an ultrasonic contrast agent and a suspension of plastic microspheres.

Ultrasound Elasticity Microscope for Guiding Femtosecond Laser Eye Surgery

Friday, September 20, 2002 4:00 p.m.

Assistant Professor Stanislav Y. Emelianov
Department of Biomedical Engineering
The University of Texas at Austin
http://www.bme.utexas.edu

Ultra-short pulse (femtosecond) laser technology is evolving into a novel clinical tool capable of performing high precision surgery of transparent (i.e., cornea) or translucent (i.e., sclera) eye tissue. However, patient specific guidance and optimization of femtosecond laser surgery and treatment is required for clinical application. Ultrasound biomicroscopy is a natural tool for guiding laser-based surgery because various tissue types, including optically opaque tissues and structures, can be imaged at sufficient depths. In addition, quantitative evaluation of tissue parameters (e.g., elasticity, structural integrity, flow velocity, volume, etc.) is possible with high frequency, high resolution ultrasound. Quantitative knowledge of these parameters can guide and monitor refractive surgery and therapeutic procedures in the eye. An ultrasound elasticity microscope based on a 50-MHz, single-element, focused transducer will be described. The results of laboratory studies of quantitative ultrasound and elasticity imaging will be presented and discussed for two applications: (1) corneal surgery for transplantation and refractive error correction and (2) scleral surgery for glaucoma treatment. Finally, advanced developments

and future directions in ultrasound biomicroscopy will be addressed.

Physiological Correlates of Temporal Resolution in Hearing

Friday, October 4, 2002 4:00 p.m.

Professor Craig Champlin
Department of Communication Sciences and Disorders
The University of Texas at Austin
http://csd.utexas.edu

Human communication signals vary jointly in frequency and amplitude as a function of time. Frequency analysis is accomplished primarily in the cochlea via mechanical filtering. Time analysis, on the other hand, occurs within the central auditory nervous system. Likely, the latter form of encoding is based on neural synchronization brought about by fluctuations in the acoustic signal. The focus of this presentation is on temporal resolution, defined as the ability to monitor rapid changes in the envelope of the stimulus. Temporal resolution has been assessed with various types of signals. One common procedure employs tones that have been amplitude-modulated with a sinusoid. By measuring the listener’s sensitivity to modulation across a range of carrier frequencies, it is possible to derive a temporal modulation transfer function (TMTF). The TMTF has a low-pass characteristic, and the time constant of the filter provides an estimate of temporal resolution. We have obtained TMTFs both psychophysically (behaviorally) and physiologically in the same listeners. The physiological method is based on scalp recordings of bioelectrical responses from the brain. This technique may be potentially useful for evaluating persons whose temporal resolution is compromised because of trauma or disease.

Cochlear Implants: History and Technology

Friday, October 18, 2002 4:00 p.m.

Assistant Professor Jan Moore
Department of Communication Sciences and Disorders
The University of Texas at Austin
http://csd.utexas.edu

The introduction of cochlear implants has been the most important advance in the history of rehabilitation for people with profound sensorineural hearing loss. This technology has been commercially available to children and adults for the last twenty years. The implant technology has changed radically during this time, as well as the speech, language, and reading outcomes of children receiving the device. This seminar will review the past and current implant technology and speech processing strategies and the impact the technology has had on patients receiving the device.

Ultrasonic Wave Phase Conjugation with Applications in Nonlinear Acoustic Imaging

Wednesday, October 23, 2002 4:00 p.m.

Professor Philippe Pernod
Institut d'Electronique et de Micro-electronique du Nord Ecole Centrale de Lille
Villeneuve d'Acsq, France

Wave phase conjugation (WPC) is a means of performing time reversal, i.e., producing a conjugate wave, which propagates backward toward the original source or scattering site as though a movie of the wave field were suddenly played in reverse. We perform WPC by exploiting parametric interaction in magnetostrictive ferrites. When an ultrasound wave of frequency f enters the ferrite rod, a strong magnetic field of frequency 2f is applied, causing the acoustic wave of frequency f to reverse direction and exit the rod in the direction from which it arrived. This method so amplifies the conjugate wave that its propagation can be highly nonlinear. In this talk the use of parametric WPC for compensation of phase distortion in inhomogeneous media is demonstrated first for linear acoustic imaging applications. Applications in nonlinear acoustics are considered next. Generally speaking, nonlinearity breaks time reversal invariance of a wave field. Nevertheless, WPC provides high quality refocusing of nonlinear acoustic beams even under conditions of strong phase distortions introduced by inhomogeneous media. Compensation of phase distortions by WPC is demonstrated for second-harmonic imaging using nonlinear conjugate beams, and also for WPC of selected harmonics of the nonlinear incident beam.

Experiments in Low Frequency Acoustic Agglomeration

Friday, November 1, 2002 4:00 p.m.

Stephen M. Burcsak
Applied Research Laboratories
The University of Texas at Austin
http://www.arlut.utexas.edu

In 1997 the Clean Air Act was revised to include a new standard for particulate in the diameter range 0-2.5 micron-meter. Currently used industrial pollution control devices, such as electrostatic precipitators and cyclone separators, are ineffective at removing particulate of diameter less than about 5 micron-meter. One method that can be used to increase the efficiency of current pollution control devices is acoustic agglomeration, a process in which sound causes smaller particles to gather to form a larger particle or attach to existing larger particles. The larger particles are then effectively collected by existing devices. Low frequency agglomeration, which is the focus of this talk, has a number of advantages. Although the mechanism responsible for low frequency agglomeration is not fully understood, our experimental results prove its existence. It is hoped that the data reported will provide a basis for continued experiments and for developing theoretical models for the phenomenon.

Elastography: Imaging the Elastic Attributes of Soft Tissues

Monday, November 4, 2002 4:00 p.m.

Professor Jonathan Ophir
Department of Radiology
The University of Texas Medical School at Houston
http://www.uth.tmc.edu/radiology
http://www.uth.tmc.edu

The mechanical attributes of soft tissues depend on their molecular building blocks (fat, collagen, etc.), on the microscopic and macroscopic structural organization of these blocks, and on the boundary conditions involved. In the normal breast, for example, the glandular structure may be firmer than the surrounding fibrous connective tissue, which in turn is firmer than the subcutaneous adipose tissue. Pathological changes are generally correlated with changes in tissue stiffness as well. Many cancers, such as scirrhous carcinomas of the breast, appear much stiffer and less mobile than benign (fibroadenoma) tumors. In many cases, despite the difference in stiffness or mobility, the small size of a pathological lesion and/or its location deep in the body impede its detection and/or evaluation by palpation. In general, the lesion may or may not possess echogenic attributes that would make it ultrasonically detectable. For example, tumors of the prostate or the breast may be invisible or barely visible in standard ultrasound examinations, yet be much stiffer than the embedding tissue. Since the echogenicity and the mechanical attributes of tissue are generally uncorrelated, it is expected that imaging some of the latter will provide new information that is related to tissue structure and/or pathology. The clear understanding of tissue stress/strain relationships is necessary for the interpretation of any of these imaged mechanical attributes. Recent work in the field has shown significant differences in elastic behavior between normal and abnormal tissues, and notably, also between some normal tissue components inside organs such as kidney and prostate. We describe the work in our laboratory over the past 12 years to develop elastographic methods for the visualization of the elastic behavior of normal and pathological tissues at high resolutions. We show theoretical developments, simulation results, and tissue results in vitro and in vivo.

Broadband Source Localization in the Presence of Interferers

Friday, November 8, 2002 4:00 p.m.

Ethan P.Honda
Applied Research Laboratories
The University of Texas at Austin
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Using passive sonar to localize quiet submerged acoustic sources in the presence of strong interferers has been a challenging task for much of the last century. This seminar will present a new model based spatial filter that helps localize such sources. The filter consists of three matrix multiplications: a transformation from element-level data to bearing space, a frequency dependent windowing matrix that effectively “bandpass filters” the bearing space data, and a transformation back to element-level data. Problems with invertibility of the transformation to bearing space are discussed and an alternate method using unitary matrices obtained from the polar decomposition of the model matrix is presented. The effectiveness of the filter is shown by using the filtered data in a broadband cost function that is able to localize a submerged target in the presence of a surface interferer.

Gerrymander: An Interactive Musical Composition for Clarinet and Computer

Friday, November 15, 2002 4:00 p.m.

Russell F.Pinkston
Professor of Composition and Director of the The University of Texas at Austin Electronic Music Studios
http://ems.music.utexas.edu

While compositions involving traditional musical instruments and pre-recorded electronic sounds have been around since the 1960’s, it is only recently that the technology has advanced sufficiently to allow such sounds to be generated in real-time and under the direct control of the performing musician. Gerrymander is a composition for solo clarinet and computer in which the computer processes and manipulates the sound of clarinet in real-time to generate a dynamic musical accompaniment to the live performer. The performer is also able to interact with the computer to control various aspects of the accompaniment, including the timing of passages played by the computer and the overall pacing of the composition. The computer accompaniment is controlled primarily by tracking the fundamental pitch of the incoming audio signal and using it to follow a pre-recorded musical score. However, the performer can also directly trigger events and capture audio segments using MIDI foot pedals. Granular synthesizers, pitch shifting delays, and contrapuntal harmonization algorithms, as well as a polyphonic sampler and all the necessary mixing and control logic were implemented in MAX/MSP on a Macintosh G4 powerbook equipped with a firewire-based external audio interface and a MIDI pedal board. The paper will consist of a demo performance of the composition using a pre-recorded clarinet part, followed by a detailed description of the software using a video projector. It will conclude with a short tour of the UT Electronic Music Studios.

Tour of Acoustic Systems

Friday, November 22, 2002 4:00 p.m.

Bill McKenna
Acoustic Systems
http://www.acousticsystems.com

This tour is a class field trip for Engineering Acoustics (ME 379N, EE 363N), but it is open to the public. Acoustic Systems, located in Austin, Texas, has been designing, manufacturing, and installing acoustical products since 1971. While Acoustic Systems does offer standard products, our focus is on custom designs, manufactured per customer specifications. Acoustic Systems is staffed by highly qualified sales professionals who work in tandem with a team of talented designers to provide responsive customer support throughout the design, manufacture and installation phases of every project. The company operates a state-of-the-art manufacturing facility and a NVLAP (National Voluntary Laboratory Accreditation Program) certified laboratory for the measurement of acoustic transmission loss, absorption and noise reduction. The test facility is used for ongoing analysis and improvements to Acoustic Systems’ products as well as independent testing for companies throughout the United States.