Nearfield Acoustic Communication by Ants

Friday, January 29, 1999 4:00 p.m.

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and

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An analysis is presented of acoustic communication by ants, including a study of the black fire ant Solenopsis richteri. Generally, ants' stridulatory sounds are barely audible, but they pervade ant communities and appear to vary with the situation. Since ants are unresponsive to airborne sound on a human scale, it has been inferred that they can only communicate using vibrations through the soil substrate. However, from the structure of an ant's body and other evidence, the substrate-transmission theory appears unlikely. On the scale of an ant, a more likely explanation is that ants use nearfield airborne sound. The acoustic receptors are believed to be hair sensilla on the antennae. By detecting differences in sound displacement between the antennae, ants can communicate in the nearfield and yet remain insensitive to sound from the farfield. Additionally, differences in displacement can be used to determine the distance to a source the size of an ant. Acoustic communication by ants apparently has evolved to take advantage of nearfield sound. Also we have found that the tracheal air sacs of Solenopsis richteri expand to fill the anterior of the gaster. However, further research is needed to determine if this affects stridulation.

Why is the Auditory System so Complex?

Friday, February 5, 1999 4:00 p.m.

Professor George D. Pollak
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In this talk I will address the issue of why there are so many parallel pathways in the ascending auditory system and what functional role they may be playing in audition. The multiple pathways can be divided into 2 principal types: binaural pathways that merge information from the two ears and monaural pathways that segregate information from the two ears. There are several binaural and several monaural pathways but all of them converge upon a common target in the inferior colliculus, the principal auditory nucleus in the midbrain. I address the roles these pathways play by focusing on how these pathways

code for and represent interaural intensity disparities (IIDs), the cue that animals use to localize high frequency sounds. The main point of the talk is that the complexities of these pathways seem not to be required for encoding the cues that allow for the localization of a single sound source in space. Rather, I will present evidence to show that one function of the pathways is that they endow the higher regions of the auditory system with the ability to differentially encode the IIDs generated by multiple sound sources. Stated differently, the multiple pathways allow the system to suppress the directional information carried by echoes. Thus, the features that I will describe map closely onto a psychophysical phenomenon called the precedence effect. The precedence effect derives from human psychophysics and reflects the dominance of the directional cues of the first sound received over directional cues of following sounds for localization. The precedence effect, while important for architectural acoustics, is an auditory adaptation present in all animals and allows them to focus on one primary sound in the midst of many sounds.

Inspecting Industrial Components Using Magnetostrictive Sensors

Friday, February 12, 1999 4:00 p.m.

Dr. Yichi Lu
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San Antonio, Texas
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The topic of this seminar is Southwest Research Institute's research and development of magnetostrictive sensors (MsS) and their applications to ultrasonic inspection of industrial components. The MsS technology is a noncontact, inexpensive ultrasonic inspection tool. It generates and detects elastic waves in ferromagnetic materials utilizing the magnetostriction phenomenon. This technology has been used for inspecting bridge suspension cables, concrete reinforcement, oil/gas pipelines, and heat exchange tubes. We first discuss the physical principles of magnetostrictive generation and detection of ultrasound in ferromagnetic materials, and the physical configurations of the sensors developed in Southwest Research Institute. The MsS generates guided waves in the axial direction of cylindrical materials. The waves are highly dispersive, and several different modes of propagation can exist simultaneously, resulting in complicated frequency structure of the received signals. We will discuss the techniques used to process the received signals, and the frequency spectra of the signals generated in the cylindrical materials. Finally, we will give examples of the use of the MsS technology for inspecting steel strands, oil/gas pipelines, heat exchange tubes, and corrosion in reinforced concrete.

Laser-Generated Surface Acoustic Waves In Solids: Linear And Nonlinear Propagation, Anisotropy, And Dispersion

Friday, February 19, 1999 4:00 p.m.

Dr. Al. A. Kolomenskii
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A survey of recent studies of the excitation and propagation of surface acoustic waves in solids will be presented. With increasing amplitude, the waveform experiences nonlinear evolution during propagation. Experimental observation and theoretical description of this effect will be considered. Laser methods that provide the necessary high amplitudes will be discussed. Special features of propagation in anisotropic solids will be described, including the angular redistribution of energy in the acoustic field (i.e., the phonon focusing effect), formation of field caustics, cuspidal structures with self-intersections of the wavefront, and “multiplication” of pulse arrivals. Measurements showing strongly anisotropic behavior of surface acoustic wave pulses in Si, Ge, and GaAs single crystals will be presented. The propagation of surface waves in a more complex system, consisting of a half-space covered by a layer, will be considered in connection with studies of the elastic and mechanical properties of thin solid films.

Micromachined Ultrasonic Transducers

Friday, February 26, 1999 4:00 p.m.

Dr. F. Levent Degertekin
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Micromachined ultrasonic transducers (MUTs) have become an alternative to piezoelectric transducers in the last few years. They offer solutions to the problems of high frequency medical ultrasonic imaging, which is currently limited by the piezoelectric transducer array fabrication and cabling technology. They are also suitable for airborne ultrasonic applications requiring efficient transducers with high dynamic range. Capacitive MUTs consist of many surface micromachined, small metallized membranes which are separated from the silicon substrate by a thin (0.1-1 micron) vacuum-sealed gap. This parallel plate capacitor structure enables one to generate electric fields in the order of 10 8V/m in the gap with reasonable DC bias voltages. In the transmit mode, an AC signal is applied on top of the DC bias to generate sound in the medium. In the receiver mode, the capacitance change is measured. The basic advantages of capacitive MUTs are their simple fabrication process, low cost, and the possibility of integration with the driving and detection electronics. It is possible to fabricate MUTs to form 1-D and 2-D transducer arrays by properly patterning thousands of membrane cells using a simple micromachining process. In this talk, the capacitive transducer concept is described and its characteristics in air and immersion are analyzed with the help of an electrical equivalent circuit. A quantitative comparison of MUTs with piezoelectric transducers is presented for the case of a 2-D array underwater camera operating at 3 MHz. A brief description of the MUT fabrication process is given. The results obtained from ultrasonic imaging experiments using 1-D arrays in immersion are presented along with non-destructive testing measurements in air at 2.3 MHz. Several approaches to electronics integration, bandwidth and resolution improvement in air, and future applications of MUTs, are also discussed.

Seismic Piezoelectric Accelerometer

Friday, March 5, 1999 4:00 p.m.

Fernando Garcia Osuna
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The key component of any seismic monitoring system is the analog sensor, or transducer. The sensor transforms both strong and weak ground motions into electrical signals, while the remainder of the system is devoted to calibration, data acquisition, and application of statistical distributions to estimate the energy radiated by the seismic event. Most seismic events have energy in a low frequency band extending from 20 Hz down to the millihertz region. With this in mind we discuss the design, model equations, implementation, and testing of a seismic accelerometer. The sensing element used in our device is known as a Bimorph, a pair of piezoelectric ceramics sandwiched together and cantilevered to produce maximum sensitivity to flexural deformation. Larger displacements may be measured with the Bimorph than with conventional sensing elements based on the motion of single plates. The Bimorph possesses high electromechanical coupling at low frequencies without sacrificing sensitivity in the frequency range of interest. However, at very high amplitudes the nonlinear response of the cantilever beam lowers the resonance frequency. The electromechanical parameters responsible for controlling the characteristics of the device are discussed and used to obtain analytical and experimental models. Calibration of the accelerometer was carried out with a sinusoidal shaker. Experimental results show that this device provides a good alternative to existing seismic monitoring networks.

Macrosonic Standing Waves in Oscillating Cavities

Monday, March 29, 1999 4:00 p.m.

Dr. Bart Lipkens
Macrosonix
Richmond, Virginia
http://www.macrosonix.com

A new technology called Resonant Macrosonic Synthesis (RMS) has been developed. RMS allows the creation of high amplitude shock-free standing waves in oscillating closed cavities that are driven by a linear motor. Measurements in cavities designed with RMS show standing wave overpressures in excess of 340% of ambient pressure. In contrast, maximum overpressures in cylindrical cavities are about 17%. Ratios of peak-to-minimum pressure of 27 were observed. Since practical compressors for air, refrigerants, and other gases require pressure ratios of 3 or more, the RMS technology can be used in a wide range of applications. A theoretical investigation of high amplitude standing waves in an acoustical resonator is presented. A one-dimensional model equation for the velocity potential is derived from the fundamental gas dynamic equations for an ideal gas. Since the energy losses in the resonator occur in the acoustic boundary layer, we modified the model equation to include the boundary layer. A second modification is the addition of a turbulence model to account for turbulence dissipation. Both hardening and softening behavior is observed and shown to be geometry dependent. Hysteresis effects are present in the frequency response curves. Comparison between measurements and calculations are shown for waveforms and power dissipation. In both cases a good agreement is obtained.

Algorithm For The Design Of Broadband, Constant-Beamwidth, Point-Element Linear Arrays With Constant Sidelobe Level

Friday, April 9, 1999 4:00 p.m.

Joseph B. Gaalaas
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An algorithm has been designed that allows one to calculate the individual element weights, as a function of frequency, required to achieve specified values of sidelobe level and half-power beamwidth. The arrays considered have linear geometry and an odd number of evenly spaced, point-elements. The input parameters are the sidelobe level, half-power beamwidth, and the number of elements. For different values of the input parameters, the bandwidth that produced realizable solutions was determined numerically. Upon choosing values for the input parameters that yield realizable solutions, the weighting functions for each element are determined by an explicit calculation. An array may be combined with a scaled version of itself to increase the bandwidth. The element weights for an octave bandwidth broadside array were calculated using this algorithm and this array was combined with a scaled version of itself to extend the bandwidth to two octaves. Arrays based on these calculated weights were implemented with a digital signal processor. Some initial measurements of the directivity patterns in an anechoic room will be presented to assess the design procedure.

Speech Synthesis Using Reduced-Complexity Modeling of Aeroacoustic Sources

Friday, April 23, 1999 4:00 p.m.

Dr. Michael H. Krane
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Progress in speech synthesis is limited in part due to a lack of information concerning the fundamental physics underlying the production of speech sounds. The goal of this work is to apply knowledge from the fields of aeroacoustics and internal flow aerodynamics to produce a model for aerodynamically-produced speech sounds. Because speech synthesis applications put a premium on computational speed, a particular focus has been to produce a reduced model of both the flow and the resulting sound field. Such a speech synthesizer has been implemented as a combination of a transmission-line representation of the acoustic field, a model prescribing the formation and evolution of vorticity in the vocal system airflow, and an aeroacoustic source. The aeroacoustic source strength was expressed in terms of the unsteady

vorticity field and the shape of the vocal tract. Initial evaluations of this model will be presented. The first case simulated the sound produced by airflow in a pipe with a flow passage shape which mimics the generic features of speech sound production. The pipe geometry and jet speed were matched to those of an experimental realization. Given the simplicity of the jet model, the computed and measured pressure spectra at the pipe exit compared surprisingly well. The second validation case consisted of synthesizing consonant speech sounds, both in isolation and in vowel-consonant-vowel sequences. These results show the strong potential for this approach to improve the quality of speech synthesis. Furthermore, the fact that good agreement between the reduced-complexity model and experiment suggests that a high-fidelity computation of the vorticity field may not always be necessary for accurate prediction of the sound field arising from unsteady fluid flows.

Magnetostrictive Sensors and Their Applications

Monday, May 17, 1999 4:00 p.m.

Dr. Yichi Lu
Southwest Texas Research Institute
San Antonio, Texas

The magnetostrictive sensor is a non-contact, nondestructive inspection technology that is suitable for inspecting ferromagnetic components. Progress has been made in recent years in order to use magnetostrictive sensors for long range pipeline corrosion inspection, suspension bridge cable inspection, and concrete curing monitoring. Since magnetostrictive sensor techniques rely upon magnetic fields to generate and detect ultrasound, the relationship between the acoustic signal and magnetic field is highly nonlinear. The inevitable hysteresis loss and eddy-current loss also limit the energy conversion efficiency at high frequencies. Since magnetostrictive sensors employ guided elastic waves for ultrasonic inspection, effective use of the technology also requires a clear understanding of the waveguide modes used and the strain fields associated with these modes. The following topics shall be addressed in this talk: (1) Interpretation of the nonlinear relationship between the applied magnetic field and the observed ultrasonic signal amplitude based upon the dynamic magnetostrictive hysteresis loop; (2) Discussion of the characteristics of the longitudinal waveguide modes and associated strain fields generated by the magnetostrictive sensors, and their impact on ultrasonic testing; (3) Use of magnetostrictive sensors for long distance crack depth sizing in pipelines; (4) Use of embedded magnetostrictive sensors for concrete curing monitoring.

Piezoelectric PZT Films for Electromechanical Applications

Thursday, June 17, 1999 4:00 p.m.

Dr. Qing-Ming Wang
Lexmark International, Inc.
Lexington, Kentucky
http://www.lexmark.com

The development of piezoelectric Pb(Ti 0.52 Zr 0.48) O 3(PZT) thin films toward device miniaturization for microelectromechanical system (MEMS) applications depends largely on the processing capability of PZT film on silicon substrate, since the combination of PZT thin film with silicon allows for the integration of the active sensing or actuator elements directly with on-chip driving or receiving circuits, and also allows for the fabrication of a variety of micro-mechanical structures using micromachining technology. The fabrication of PZT films (1 mm to 12 mm thick) through a multilayer sol-gel spin-on coating route provides a significant breakthrough in the development of piezoelectric micro-devices. The electromechanical properties of PZT films compare favorably with values for PZT bulk ceramics. Two micro-patterning techniques have been used for PZT film patterning, i.e., micro-contact printing and two-step wet chemical etching. The micro-contact printing can be used for patterning of PZT films less than 1 mm thick, while the two-step chemical etching method is applicable for PZT film with thickness above 1 mm. Two application examples will be presented: micromachined monomorph sonar transducers using PZT film on Si (100) substrate as an active layer for high-resolution acoustic imaging systems; and a high density, fast speed piezo-printhead using PZT film elements on Si (110) substrate as actuator arrays for ink jet printing.

Plasma Sound Source: Research Efforts at ARL:UT and Recent Developments

Friday, September 17, 1999 4:00 p.m.

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

This talk is an overview of the efforts at ARL:UT to develop and improve the plasma sound source, also known as a spark source. Spark sources, or plasma sources, have been used for the creation of impulsive sound for shallow marine seismic exploration since the 1950s. Sound is produced by breaking down the liquid water and discharging a large electrical current across an electrode, creating an arc and subsequently a bubble. The acoustic radiation from the bubble produces a sound pulse that resembles a 1.5 cycle sine wave pulse. Because there is no residual gas, the bubble has only one principle collapse. Although the plasma sound source is potentially a controllable source with a wide bandwidth, it has not been widely used. Its application has been limited because of the issues of efficiency and durability. However, the plasma sound source is still attractive because of the relatively small size of the electrodes and because of the characteristics of the acoustic pulse it produces. In the late 1980s ARL:UT began a research effort to make the plasma sound source more practical and improve its efficiency and reliability. The poorly understood subject of dielectric breakdown of water was investigated. The use of arrays of electrodes/bubbles to increase the effective radiated energy (source level) has proven to be successful. Bubble interaction effects are discussed in this talk, along with important characteristics of the electrical system. Experimental and computational results for arrays of various sizes, including comparison of the acoustic pulses from multiple electrode/bubble arrays with that from a single electrode/ bubble, are presented.

A Reduced-Noise Gas Flow Design Guide for NASA Glenn Research Center

Friday, September 24, 1999 4:00 p.m.

David A. Nelson
Nelson Acoustical Engineering, Inc.

A “Reduced-Noise Gas Flow Design Guide” has recently been developed for NASA’s John H.Glenn Research Center (GRC) at Lewis Field, Ohio. The purpose of the Guide is to allow GRC engineers and designers to address hearing conservation and community noise issues at the design stage using readily available system parameters. The Guide has two parts, a written Manual and a Microsoft Excel-compatible Workbook. The Manual explains prudent design practices, describes methods of estimating noise emission, and explains the practical use of common noise-reducing elements. The Workbook consists of sixteen spreadsheets that implement the noise emission and noise reduction estimates, two spreadsheets that perform computations for an elementary gas flow system, and a handy gas flow parameter calculator spreadsheet. Noise estimation methods and special issues in noise emission from piping systems are the focus of this presentation, along with a demonstration of the software.

Acoustic Emission Testing of Process Industry Equipment

Friday, October 1, 1999 4:00 p.m.

Professor Timothy Fowler
Department of Civil Engineering
The University of Texas at Austin
http://www.ce.utexas.edu

Acoustic emission serves an important function in the process industries. It is a global nondestructive examination technique which provides a measure of the structural severity of a defect. As such, it is complementary to other NDE methods such as radiography, ultrasonics, and visual, which are used for examination of local areas. Extensive field test experience has led to codes and standards and to development of improved test procedures and load schedules. The lecture will review the principles of acoustic emission, and its application to metal and fiber reinforced plastic, tanks, pressure vessels, and railroad tank cars. The unique capabilities of the technology will be discussed, together with evaluation criteria and modern methods of analyzing and filtering test data.

Designing Asphalt Pavement for Improved Acoustical Performance

Friday, October 8, 1999 4:00 p.m.

Jeff DeMoss
Center for Transportation Research
The University of Texas at Austin
http://www.utexas.edu/research/ctr

Pavement type and surface configuration are known to have a significant effect on traffic noise. Studies of different roadway surfaces have shown that more-porous pavement designs perform better acoustically. However, pavements are currently designed for durability and safety, not for their acoustical characteristics. Reported here is a study to develop a design criterion for improved acoustical performance of asphalt pavement. Previous work shows that existing porous media theory may be used to predict the acoustical absorption coefficient for porous asphalt pavement. A two-microphone impedance tube and a reverberation chamber were employed to determine the acoustical absorption coefficient of pavement samples. Different pavement mixtures were considered in an attempt to identify combinations with high absorption. Existing porous media theory was used to design double-layer pavement surfaces for improved acoustical absorption. Measurements of absorption for both single-layer and double-layer samples were compared with the theoretical predictions. Good agreement was observed with respect to the frequency of the peak absorption.

Acoustical Measurements While Drilling

Friday, October 15, 1999 4:00 p.m.

Dr. Jean-Pierre Masson
and
Dr. Kai Hsu
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We present an overview of acoustical measurements while drilling, ranging from low frequency seismic to ultrasonic pulse-echo measurements. The main topic is the development of an acoustical logging-while-drilling (LWD) tool in the kilohertz range. This tool provides compressional measurements of rock in real time and recorded modes. It operates on the same principles as modern wireline acoustical tools. As the drilling operation progresses, the transmitter is fired and acoustic waves propagating through the mud and formation are detected by the receiver array. Microprocessors in the tool are used to extract compressional slowness of the formation from the waveforms. The data is transmitted uphole in real time via mud telemetry. The compressional and porosity logs that are generated provide input for lithology identification and overpressure determination. The compressional log is also used to generate synthetic seismograms for correlation with surface seismic section and to upgrade the seismic map. Log examples with wireline comparisons and applications are presented for a variety of lithologies and downhole conditions.

Automotive Acoustics Applications and Overview with Ford Motor Company

Friday, October 22, 1999 4:00 p.m.

Mike Stoeckle
Ford Motor Company
http://www.ford.com

Acoustical considerations play an important role in the design and development of an automobile. The purpose of this discussion is to inform students interested in acoustics of practical applications and the design process in the automotive industry. Emphasis will be on acoustical aspects of the design process. Customer perceptions and input are gathered and translated into engineering metrics, the components are designed and assembled, and then the design is verified against the metrics. The verification methods used at both a vehicle level and system levels will also be discussed. Included are the following: sound quality techniques; analytical (or CAE) methods, both from structure borne and airborne perspectives and with respect to various frequency ranges; and test methods both in the lab and on the road, including subsystems and full vehicles. The talk seeks to provide a better appreciation of both acoustical characteristics from a customer's perspective and the way Ford engineers specific acoustic properties into its vehicles.

Modern Audio and Acoustic Test and Measurement

Friday, November 12, 1999 4:00 p.m.

Dr. Tom Kite
Audio Precision
Beaverton, Oregon
http://audioprecision.com

This talk will describe techniques used to measure performance parameters of both analog and digital audio equipment. Particular attention will be given to methods that are also appropriate to acoustic measurements, such as the use of maximum-length sequences (MLS) for pseudo-anechoic frequency response determination. In addition, measurement modes unique to Audio Precision's test equipment will be described. The aim of the talk is to introduce an acoustically- minded audience to the methods used to characterize familiar equipment such as amplifiers, CD players, effects processors, and loudspeakers.

Harmonic generation by Rayleigh–Lamb Waves in Isotropic Elastic Plates

Friday, November 19, 1999 4:00 p.m.

Washington De Lima
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Harmonic generation by Rayleigh–Lamb waves of finite amplitude in homogeneous, isotropic, stress-free elastic plates is investigated theoretically. A bifrequency primary wave field is considered, in which the two waves propagate in single yet arbitrary Rayleigh–Lamb modes. Solutions for the second-harmonic and difference-frequency components are obtained via modal decomposition and use of reciprocity relations. Two conditions are required for generation and resonant amplification of these spectral components, power flow, and phase matching. Second-harmonic generation is considered first. Although phase matching is possible between a primary wave in the first symmetric mode and its second harmonic in the second asymmetric mode, the power flow is found to be zero. However, with one primary wave in each of the first symmetric and asymmetric modes, both phase matching and power flow may be achieved with the difference-frequency wave generated in the first asymmetric mode. In particular, resonant parametric amplification of the difference-frequency wave can be achieved under conditions where dispersion prevents efficient coupling from occurring between the primary waves and other frequency components. Explicit analytic solutions are presented and discussed. [Work supported by the Brazilian Ministry of Science and Technology, and the National Science Foundation.]

Nonlinear Surface Acoustic Waves in Cubic Crystals

Tuesday, November 23, 1999 4:00 p.m.

Ronald E. Kumon
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The University of Texas at Austin
http://www.ph.utexas.edu

Both the linear and nonlinear properties of surface waves in crystals are significantly different from those in isotropic media. Recently developed model equations are employed to perform theoretical and numerical studies of nonlinear surface acoustic waves in nonpiezoelectric, cubic crystals. The model possesses a nonlinearity matrix that describes the coupling strength of the harmonic interactions. This matrix is shown to provide a powerful tool for characterizing waveform distortion. Selected numerical results are presented for propagation of initially monofrequency surface waves in various surface cuts and directions. When the nonlinearity matrix is real-valued, compression shocks form in some directions, whereas rarefaction shocks form in others. In certain particular directions, generation of one or more harmonics may be suppressed, and shock formation postponed. In still other cases, energy may be transferred rapidly to the highest harmonics, and shock formation enhanced. When the nonlinearity matrix is complex-valued, the velocity waveforms may exhibit asymmetric distortion and low frequency oscillations near peaks and shocks. Measurements of pulsed waveforms in crystalline silicon obtained by colleagues at the University of Heidelberg are shown to be quantitatively reproduced by calculated results.

The Ocarina: From Pre-Columbian Times to the Legend of Zelda

Friday, December 3, 1999 4:00 p.m.

Professor David Peterson
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http://www.uca.edu

For thousands of years Indian cultures in the Western hemisphere have produced whistling vessels and musical instruments, ocarinas, from clay. Ocarinas are found in wide array of morphological forms – vegetables, animals, demons, etc. – being as much art as music. Typically single chambered, they were tuned to a non-western pentatonic scale and used in solo and ensemble playing for ritual or pleasure. Ocarinas were brought to Europe after the Spanish conquest and eventually “modernized” to play a diatonic scale in Italy in the 1800’s. The American folk music revival in the 1960's and 70’s rediscovered the instrument and it was used as a lead by the Troggs (Wild Thing) and the Mamas and the Papas (California Dreaming). Its return to popular culture was assured when the ocarina became the mystical instrument of choice in the Nintendo games, The Legend of Zelda, with some 250 million copies sold. The instrument is really just a Helmholtz resonator. Although several investigators/builders have claimed to have discovered a mathematical method for making a 4 hole diatonic instrument using cross fingering, a basic physical model shows that this is impossible without significant mistunings. Of course, as in other instruments, talented players can overcome this in various ways. The lecture will include demonstrations on various instruments and short selections of ocarinas as used in popular music.