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ECHOES

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Sound Propagation in Sand

by Sidney R. Nagel and Heinrich M. Jaeger

Tap a wine glass, a window pane, or any single piece of glass and they all respond with distinctive ringing sounds; tap a pile of glass beads and the response will be a dull thud. Why do containers filled with glass beads, sand, pharmaceutical pills, fertilizer or any other granular material have acoustical properties so different from those of the individual solids that these materials are made of? Sand fillings have long been used as highly effective sound proofing. But while granular materials may be ubiquitous and seemingly simple, detailed studies have shown a rich and complicated set of behaviors. In dry granular media without cohesive forces, pressure applied at point A is transmitted to point B via a disordered network of stress paths, or "force chains". These force fluctuations can be visualized and measured.[1,2] The force chain geometry depends on the local packing configuration of neighboring particles. Contact forces between solids are notoriously nonlinear, especially at small force levels. Because sound propagation depends crucially on the compression of these Hertzian contacts (the name given to contacts between smooth elastic surfaces) between the individual particles, the propagation of low amplitude vibrations through a granular medium exhibits a number of unusual effects.

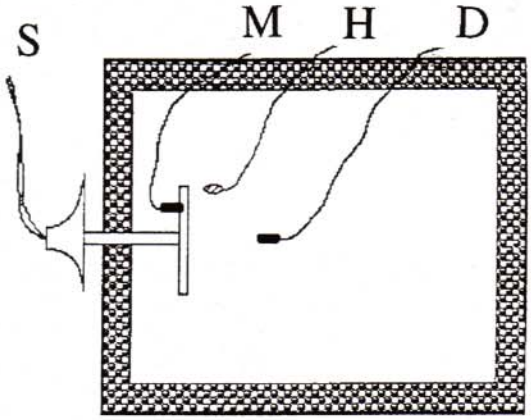

Figure 1. A schematic diagram of the sound propagation experiment. The source speaker S drives a metal plate at a fixed frequency. A monitoring accelerometer M ensures that the plate moves at a constant amplitude. The transmitted sound is detected by accelerometer D. A small resistive heater H is placed within the pile between the source and detector. The outside of the container is insulated against external vibrations and temperature fluctuations (from Ref. 5).

One of those phenomena concerns the dramatic time dependence of the amplitude of a transmitted sound wave through a granular medium.[3] A schematic of the experimental apparatus used to demonstrate this is shown in Fig. 1. The source speaker, marked S in the figure, is driven at a single fixed frequency, f, and is attached to a flat metal disk via a thin shaft. The vibrations are transmitted by this disk to the granular material which glass beads of a few millimeters diameter held inside an insulated box. In order to ensure that the vibration amplitude is constant, the acceleration of the disk is monitored with an accelerometer, marked M, and a feedback circuit kept the amplitude at the desired level. The transmitted signal is measured by a second accelerometer, marked D, situated in the pile a few centimeters in front of the vibrating plate. Remarkably, the fluctuations in the transmitted signal at D can be large – of the same magnitude as the average value of the signal itself. Power spectra reveal that these fluctuations extend over many orders of magnitude in frequency, down to 5 to 10 Hz, and indicate correlations that last for longer than a day. The sound vibrations cause the particles to shift their positions slowly over time so that the connections along the force chains are broken and reformed at different places leading to a non-linear response.[4] These minute motions produce the observed fluctuations in the transmission intensity. If one sweeps the frequency of the source, one finds that the transmission of the sound through the medium appears to be very "noisy" as shown in Fig. 2. This is not real noise since the measured response is completely reproducible if the measurement is repeated without disturbing the pile.[3,4] However, if the pile is disturbed even slightly, then subsequent frequency sweeps give rise to a new response pattern as shown in the lower panel of Fig. 3. Regardless of the details, all spectra share two characteristics: there are no isolated, clearly defined resonances as in ordinary solids, and the average signal absorption increases strongly with increasing frequency. Thus the "thud" when hitting a granular pile.

An even more spectacular demonstration of the way that fragile contacts between grains can affect sound propagation

continued on page 4

We hear that...

Virginia M. Richards received the Troland Research Award from the National Academy of Sciences at the NAS annual meeting in Washington, April 27. This award of $35,000 was given to her in recognition of "her contributions to auditory perception, especially to the understanding of the envelope and energy cures that contribute to detecting signals in noise." She is in the Department of Psychology, University of Pennsylvania.

Julia Royster received the National Hearing Conservation Association's Michael Beall Threadgill Outstanding Service Award at the NHCA annual conference in Albuquerque, Feb. 19-21.

Two book-signing parties took place at the Seattle ASA meeting. Springer-Verlag hosted a book-signing honoring **Neville Fletcher** and **Thomas Rossing**, authors of *The Physics of Musical Instruments*, 2nd edition. The National Council of Acoustical Consultants sponsored a book-signing for **Robert Apfel**, author of *Deaf Architects & Blind Acousticians?*

George C. Maling, Jr. has been elected to the National Academy of Engineering. George received the ASA's Silver Medal in Noise in 1992.

Nominations for Journal editor

Following more than a decade of exemplary service, Daniel Martin has asked to be succeeded as Editor-in-Chief of the Journal of the Acoustical Society of America. The President has appointed a Search Committee. According to the by-laws of the Society, "The Editor-in-Chief shall be responsible for the editorial management of all publications of the Society. He or she shall be assisted by such other editors and editorial boards as, upon his or her recommendation, are approved by the Executive Council." To be assured of consideration by the search committee, expressions of interest and nominations should be received no later than October 8, 1998. Contact Henry Bass, NCPA, University, MS 38677 or e-mail pabass@olemiss.edu.

ECHOES

Newsletter of the Acoustical Society of America
Provided as a benefit of membership to ASA members

The Acoustical Society of America was organized in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.

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ASA Foundation News

by Paul B. Ostergaard, Chair

There is exciting news from the Acoustical Society Foundation. First, two donors have established a scholarship fund named the Raymond H. Stetson Scholarship Fund that is to provide funds for students in speech. The fund will be managed by the Foundation and the selection of the recipient will be made by Special Fellowships Committee with the assistance of the Technical Committee on Speech Communication of the Acoustical Society. While the fund is small at this time it is hoped that it will grow with contributions so that it will be able to exist for many years. Under the rules of the Foundation the name of the fund can be retained with its present funding for ten years. If the fund has not reached $125 000 in contributions by the end of that time, the name will not be continued. If you want to donate to the fund, please send your contribution to the Foundation and designate your fully tax-deductible contribution for the fund.

Another exciting event is the establishment of the Acoustical Society Foundation Pooled Income Fund. This was made possible by the generous contribution of one person. But, you may ask, what is a Pooled Income Fund? Would you like to make a donation, receive income over your own lifetime and possibly that of your spouse, and receive a tax deduction for the donation which is based on your age (and that of the other beneficiary) at the time of the donation? This is a wonderful, perfectly legal way to give either cash or highly appreciated stock, which would then not be subject to capital gains tax, and have your donation based on the current market value of the stock. Upon the death of the beneficiaries, the money reverts to the Foundation for charitable purposes in supporting the Acoustical Society. The initial contribution must be at least $5000 and additional contributions of at least $1000 can be made anytime. This is a win-win situation for you, the Society and the Foundation! Should you want more information please contact the Foundation or talk The Foundation has recommended to the Executive Council of ASA a new General Secretary to succeed Bill Lang, the Treasurer of the Acoustical Society. Bill has been Acting General Secretary during the initial phases of starting the Foundation. Our sincere thanks go to him for all his efforts. More later on our new General Secretary, who is expected to take office on July 1.

To all those who contributed to the Foundation through the check-off and the dues bill, thank you. It has not been possible to recognize each of you individually, but your contributions have not gone unnoticed.

ISMA98 Proceedings Available

Proceedings of the International Conference on Musical Acoustics (ISMA98), held in Leavenworth, Washington, June 26-July 1, can be ordered from the ASA office ($40 for ASA members or $50 for nonmembers plus $5 shipping in the US, $7 by ground mail outside the US). The 395-page proceedings, edited by Douglas Keefe, Thomas Rossing, and Charles Schmid, include 64 papers on various topics in musical acoustics.

To the Editor:

It Was a Great Experience!

I just got my Spring issue of *Echoes*. I have a similarly woeful story about Chain Reaction, although not nearly as amusing as Larry's. I was contacted by the production designer, since the movie was about SL (sonoluminescence) fusion, and that's the research that I am doing. The first thing I was told was that there would be no pay, no movie credit, no nothing. I said, sure, OK, this should be fun anyway. We talked about SL and what a "large system" might look like for about 45 minutes. I answered his questions as well as I could. The next day, I followed up our conversation with a short memo. I think the designer listened to some of the things that I told him (the movie had some elements of what we discussed), but of course, he had his own agenda, technical and financial constraints, etc. It's Hollywood–they spend more on one lunch for their stars and crew than they do on a technical consultant.

When I didn't even get a thank-you for my time, I was kind of annoyed. I called Fox and spoke to the publicist for the movie. I told her that courtesy was the issue here. So...she apologized and I received

-A Newtonian Demonstrator, that has "Chain Reaction" printed on it (It doesn't work)

-A couple of large posters from the movie

-A small pin with the picture from the poster on it and.....

-8 free tickets to the opening followed by

-unending harassment and ribbing during/after the movie from my wife and complaints from my kids asking why daddy was punishing them by making them watch the movie.

It was a great experience!!!!!

William Moss, P.O.Box 808, Livermore, CA 94551

Underwater Sound Transmissions and SI Units

I believe it is time for us, the underwater sound community, to change our habits. Many underwater sound scientists were at a meeting at University of California, La Jolla, in the fall of 1994. During our discussion on the public's perception of the meaning of source levels in decibels (dB), Walter Munk and I proposed the following guidelines for underwater sound:[1]

1. Always report sound pressure measurements in pascals (Pa);
2. Always report radiated acoustic power in watts.

These units are SI and follow common geophysical practice.

A brief note in an issue of *Echoes* 8, No. 2, Spring 1998, p 8, demonstrates a reason for not using decibels (dB) in underwater sound publications. It quotes a source level 195-dB, without qualifications, in an ATOC experiment. Readers familiar with acoustics and hearing know that there are physiological reasons for using the logarithmic dB. The threshold of hearing is at the sound pressure of 20 micropascals and this was chosento be the reference pressure for decibel calculations. Thus the threshold of hearing is about 0-dB and the threshold of pain is about 130-dB at 1000 Hz. The reference pressure and the meaning of 0-dB have been the same since the 1920's. To them, a 195-dB level sounds very painful for animals near the source. In fact, my calculation for a 195-'underwater-dB' omnidirectional source shows that the ATOC source was radiating less than 260 watts into the ocean.[2] Many music amplifiers and public address systems radiate more power.

An explanation follows. Air acousticians and the underwater sound community use different reference dBs. Underwater acousticians, engineers, and geophysicists have to pay attention to the reference pressures because three different underwater-dBs have been used since the 1940's. These reference sound pressures are 20 micropascal (same as in air), 0.1 pascal (the 1950-1960s), and 1 micropascal (the current choice).

My proposal is not radical. We continue to use our linear sound transmission equations. We measure the farfield pressure field of our transducers and compute the source power. We continue to measure the sound pressures at our hydrophones. Filter operations and signal processing are the same. Let us abandon the unnecessary dB confusions and use SI units to describe the source inputs and results of measurements.

1] Acoustic Techniques for Measuring Ocean Variables: A review of existing and emerging opportunities. Editors, Capt. Bob Smart and Dr. AlexanderVoronovich. The cover sheet says that copies are available from Capt.Smart, NOAA/OAR1315 East-West Highway Room, 11508 Silver Spring, MD 20910-3282 [bsmart@rdc.noaa.gov and A.Vronovich@tl.noaa.gov]

2] C. S. Clay and H. Medwin, Acoustical Oceanography, John Wiley and Sons (1977), Sec. 3.2; H. Medwin and C. S. Clay, Fundamentals of Acoustical Oceanography, Academic Press, Boston (1998) Sec. 3.1.4 and 3.4.6.

Clarence S. Clay, Jr., 5033 St. Cyr Rd., Middleton, WI 53562

Musical Acoustics Research Library

A new internet-based reference library is now available to the acoustics community. The Musical Acoustics Research Library (MARL) is a collection of independent archives or libraries assembled by distinguished groups or individuals in the field of musical acoustics research. Currently, MARL is comprised of the Catgut Acoustical Society Library, the Arthur H. Benade Archive, the John Backus Archive, and the John W. Coltman Archive. MARL is directed by representatives of each member collection, in conjunction with the Center for Computer Research in Music and Acoustics (CCRMA) at Stanford University, which maintains the contents of each library. The archives of three prominent wind instrument acousticians, together with the extensive string instrument resources of the Catgut Acoustical Society Library, position MARL as a primary musical acoustics reference source.

You are encouraged to visit the MARL website at http://www-ccrma.stanford.edu/CCRMA/Collections/MARL/. If you find references in the WWW pages to items of interest, you may email Gary P. Scavone at gary@ccrma.stanford.edu to request that these items be scanned, converted to PDF documents, and made available over the internet. Also, you may schedule an on-site visit if you wish to peruse the contents of MARL in person.

Acoustophoresis

Todd L. Brooks and Robert E. Apfel

Separation is an integral part of many industries, with a prominent role in everything from the manufacture of chemicals, metals, plastics, pharmaceuticals, fossil fuels, and paper, to key roles in the treatment of waste, recycling, food processing, and biotechnology. A separation process sorts materials based on differences in one or more physical properties. For example, centrifugation is commonly used to separate blood based on differences in density, while filtration is used to separate particles by size. Other common methods of separation include distillation, evaporation, and electrophoresis (separation based on electric charge differences).

Acoustophoresis is the separation of particles using high intensity sound waves. It has long been known that high intensity standing waves of sound can exert forces on particles. A standing wave has a pressure profile which appears to "stand" still in time. The pressure profile in a standing wave varies from areas of high pressure to areas of low pressure. Standing waves are produced in acoustic resonators. Common examples of acoustic resonators include many musical wind instruments such as organ pipes, flutes, clarinets, and horns.

The force exerted on a particle by the standing wave depends partly on the strength and frequency of the acoustic wave, as well as the size of the particle. Furthermore, the force depends on the relative elastic and inertial properties of the particle and the liquid in the resonator. For example, consider a liquid containing particles which are more "compressible" than the liquid, such as an oil drop in water. When the sound field is turned on, the particles will experience a force which tends to push them to the nearest acoustic pressure maximum. If the particles were less compressible than the fluid, they would migrate towards the nearest acoustic pressure minimum.

The particles will form "bands" and may begin to precipitate out of the liquid as the particles clump together. There are commercially available devices used in bioreactors which combine an acoustic resonator with a steady flow of liquid through the cell. The viable cells become trapped by the acoustic field and are retained in the reactor while smaller parts of cell residue are convected out of the reactor.

This example illustrates how particles can be separated from a liquid, but it is also possible to separate two or more different types of solid particles based on differences is their compressibilities and densities. Say, for example, that we have a liquid containing two types of particles which differ in elastic properties. One type of particle is more compressible than the liquid, while the other type is less compressible. When the liquid in the resonator is subjected to a strong acoustic standing wave, the forces on the two types of particles will be in opposite directions, causing them to separate and migrate towards distinct positions in the standing wave.

Because acoustophoresis separates particles based on differences in elastic properties, it is useful in separating particles similar in size, charge, and density which can not be distinguished by other processes. In optimizing a system for separating different types of particles, there are several considerations:

1. The fluid exerts a drag force on particles opposing their motion in the fluid. This drag force (related to the viscosity of the fluid) limits the speed at which particles can be separated by the acoustic field. The force of gravity on the particles should be considered, though it plays a small role if the particles and liquid have similar densities. The density and elastic properties of the host fluid can be modified somewhat to enhance the separation process.

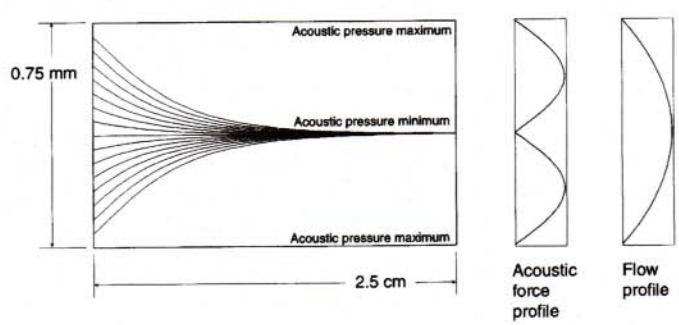
2. The acoustic force on particles can be increased by using higher frequencies. Typically, biomedical ultrasound frequencies are used (millions of cycles per second). The wavelength at these frequencies is on the order of millimeters, so the resonating cells must be built quite small.

3. The force on the particles can be increased by increasing the strength of the sound field. The acoustic pressure cannot be increased without limit since high acoustic pressures can cause damage to biological cells.

4. The net motion of the particles is a combination of the motion in the direction of the flow, and the motion perpendicular to the flow due to the acoustic force. Typically, the fluid flow through the resonator is not uniform so that different acoustic field/ fluid flow configurations lead to different particle trajectories.

At the Yale Acoustics Laboratory, we are currently exploring several cell configurations in order to determine the optimal conditions for separation for a given application.

Todd Brooks and Robert Apfel are in the Department of Mechanical Engineering at Yale University. Apfel served as President of ASA.



Calculated particle trajectories in a half-wavelength resonator with parallel walls. Fluid flow is from left to right and the acoustic standing wave propagates in the vertical direction. Lines represent the trajectories of 20 micron plastic spheres. The cell is tuned to 1 million Hertz, and the acoustic pressure amplitude is 1 atmosphere. Fluid flow rate is 6.76×10^{-6} m^2/s.

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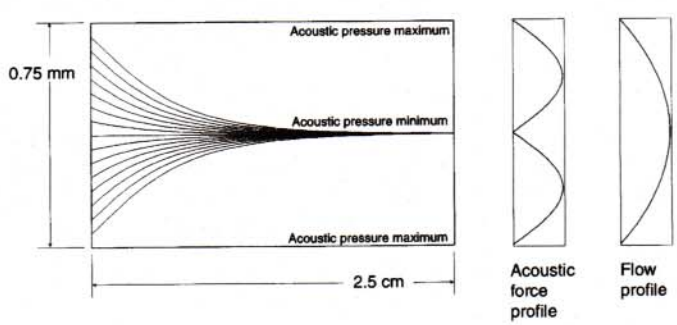

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Echoes From Seattle

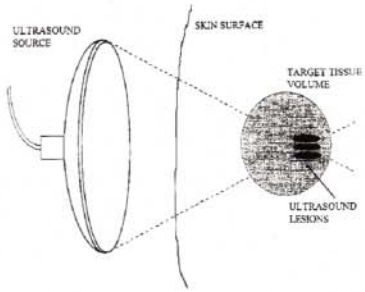
Can Ultrasound Replace Conventional Surgery?

by Gail ter Haar

An exciting application of medical ultrasound coming to the fore again, is that of high intensity focused ultrasound, sometimes referred to as HIFU or FUS (focused ultrasound surgery). In the medical frequency range (0.5 – 15 MHz) ultrasound has wavelengths of 0.1 – 3 mm in human soft tissues, and energy from an external source can be brought to a tight focus at depth within the body. If the energy concentration at the focus is sufficiently high, cells within the focal volume are killed, while other cells lying in the beam path are spared. This therefore opens up the possibility of targeting tissue volumes through the intact skin, with the aim of their selective destruction.

This technique was first developed in the 1940's and 50's. A research group led by W.J and F.J Fry in Champaign-Urbana, Illinois were pioneers in developing high intensity beams for the selective destruction of brain tissue for neurobehavioural studies, and for the treatment of conditions such as Parkinson's disease. This group was able to demonstrate considerable success in producing highly localized damage, but were hampered by the lack of sophisticated imaging techniques to target, monitor and follow up their treatments. In addition, the drug treatment, L-dopa, was developed at this time and proved to be a popular and successful competing treatment for Parkinsonism. There was a resurgence of interest in HIFU in the 1960's when New York scientists headed by Dr. F. Lizzi and ophthalmologist Dr. J. Coleman investigated the use of high intensity focused ultrasound for treatment of glaucoma in the eye. Again, the timing was wrong as this coincided with the development of laser techniques.

A phase I clinical trial is being conducted by members of the Physics Department at the Royal Marsden Hospital: Institute of Cancer Research, London, UK, into the feasibility of using high intensity focused ultrasound in the treatment of cancer. The aim of this phase of the trial is solely to assess the safety of such a treatment and to determine whether there are any adverse side effects. For this study, a 10 cm diameter, focused ceramic (PZT4) bowl with focal length 15 cm is used as the source of 1.7 MHz ultrasound. The ellipsoidal focal volume has dimensions 15 mm in the long axis, and 1.5 mm in diameter. Peak intensities of the order of $1 kWcm^{-2}$ are used for exposure times lasting 1-3 seconds to induce temperatures in the range 60 - 90°C. Electron microscopy of tissue after it has been subjected to this type of exposure level reveals that the volume of damaged tissue follows the focal dimensions very closely, and that the boundary between normal, undamaged, cells and dead cells is 5-6 cells wide. For most medical applications, this volume of tissue damage is too small to be useful, and so methods are needed for moving the focal zone within tissue in order to "paint out" clinically useful volumes. This may be done by mechanical movement of the transducer or by electronic beam steering using phased array systems.



The principle of focused ultrasound surgery technique. A High-intensity sound beam is brought to a tight focus within the tissue volume to be destroyed. Only the cells within the focal zone are killed; all other cells are spared.

A technique such as this that gives very high precision of spatial damage can only be used to its full advantage if the target site can be accurately located, and if the damage induced can be monitored both at the time of creation, and during the subsequent follow-up period. For these purposes both diagnostic ultrasound and magnetic resonance imaging have been employed. Temperature-sensitive pulse sequences allow the position of the focal zone to be visualized dynamically on a magnetic resonance scan. Necrosed tissue can also be seen using MR images. However, undertaking high intensity ultrasound treatments in the core of a magnet is a non-trivial problem, and the technique will see much wider application if ultrasound imaging methods can be found for treatment monitoring and follow-up. An ultrasonic lesion that is purely thermal in origin is not visible on a conventional B-mode image. If it contains cavitation or vapor bubbles it shows up as a hyperechoic region. In general, such "bubbly" lesions are not sought as they are unpredictable in shape and size. Parametric imaging techniques are being sought for imaging the clinically useful thermal lesions.

The phase I trial being undertaken at the Royal Marsden Hospital is designed to study the potential of focused ultrasound surgery in the treatment of soft tissue tumors. Tumors that can be visualised on a diagnostic ultrasound scan and that lie 4 -12 cm below the skin surface are targeted. Patients do not receive anaesthetic, and are fully conscious throughout the treatment. As yet, no attempt at tumor cure has been made, but the procedure has been well tolerated by patients, with no side effects and with good indications that the part of the tumor that has been targeted has been killed. Tumor sites in the liver, kidney and prostate have been chosen for this phase I study. The next stage of the trial (phase II) will be to target tumors in the liver and prostate.

High-intensity focused ultrasound also has a role to play in the stopping of blood flow. The group at the Applied Physics Laboratory in Seattle under the guidance of Dr. L. Crum are investigating the potential of high-intensity focused ultrasound beams to seal bleeding blood vessels. They have shown that bleeding may be stopped in a matter of seconds. This has potential uses during surgery, and for the treatment of trauma victims. Another application is being studied at the Institute of Cancer Research in London in collaboration with the fetal medicine department of Queen Charlotte's Hospital, London. The potential of ultrasound to occlude a blood vessel may be useful in shutting off the shunt vessels responsible for feto-fetal transfusion syndrome, a common problem that occurs in identical twin pregnancies.

Minimally invasive surgery is a rapidly expanding field of medicine. Focused ultrasound fits well into this category, and has the potential of offering truly non-invasive, bloodless treatments in a number of benign and malignant conditions. In contrast to the early work in this field, the current availability of sophisticated diagnostic imaging techniques now makes this a feasible treatment for a large number of applications. It seems probable that HIFU will become an accepted treatment modality in a number of fields over the next few years.

Gail ter Haar is head of Therapeutic Ultrasound in the Joint Physics department, Institute of Cancer Research, Royal Marsden Hospital, Surrey, UK. Her research interests lie in the safety of diagnostic ultrasound, the bio-effects of ultrasound and the use of ultrasound in therapy. This article is based on her plenary lecture at ICA/ASA in Seattle (session 2aPLa).

Echoes From Seattle

Largest Acoustics Meeting Ever!

The joint ICA/ASA meeting in Seattle, with over 2000 registrants, was generally acknowledged to be the largest acoustics meeting ever held. Thanks to an army of volunteers headed by meeting chairman, Larry Crum, the busy meeting ran smoothly. The technical program included 1504 papers arranged into 170 sessions by the Scientific Program Committee, chaired by Pat Kuhl. Sixteen plenary speakers, representing different areas of acoustics, were scheduled at the two meeting hotels.

The opening ceremony, in the historic 5th Avenue Theatre, highlighted the Pacific Northwest's rich Native American heritage, jazz, and gospel music. Ralph Bennett, a Haida Indian, called on the winds to be favorable to our Congress, after which we were welcomed by Lawrence Crum, President of ASA and Tor Kihlman, Chair of the ICA.

Social events included a welcome reception at the Pacific Science Center, a cruise and salmon dinner at Tillicum Village on Blake Island, a buffet social, student receptions, a banquet, and various tours and excursions. All registrants received a copy of the Proceedings on CD-ROM, and many participants elected to purchase the 4-volume printed proceedings as well. (These may also be ordered from ASA as long as the supply lasts). Lay-language versions of many papers are still available through the ASA World Wide Press Room at: www.acoustics.org/lay_lang.html.

Two satellite symposia followed the ICA/ASA: ISMA98, a symposium on musical acoustics at the Sleeping Lady Conference Center in Leavenworth, Washington; and IPS-98, a conference on phonetic sciences at Western Washington University in Bellingham.

Opera Houses and Concert Halls

Several interesting sessions at Seattle were concerned with the acoustics of opera houses, concert halls, and other performance halls. No less than 7 sessions on opera house acoustics included discussions of sound fields for the singer and orchestra as well as for the audience. The Vern Knudsen lecture by John Bradley gave an overview of concert hall research, especially the balance between complexity and practicality. At a session arranged by Leo Beranek, speakers described the acoustics of several performance halls at the new Tokyo Performing Arts Center, which opened in 1997, and which includes the New National Theatre and Tokyo Opera City. Tours of Benaroya Hall, the new home of the Seattle Symphony Orchestra in the final stages of construction, were led by Cyril Harris, acoustical consultant for the hall, and by George Wilson.

Distortion, Dolphy, and Hendrix

Distortion isn't always a thing to be avoided, as pointed out by speakers at "The Purposeful Use of Nonlinear Distortion in Musical Performance: The Eric Dolphy/Jimi Hendrix Celebratory Session" in Seattle. Originally, distortion occurred as musicians tried to coax more sound out of their amplifiers than they were designed to deliver; then guitarists, such as Hendrix, discovered that distortion, if handled properly, gave their instruments an expressive, harmonically rich voice. Dolphy, a virtuoso performer on the alto saxophone, bass clarinet, and flute, learned how to artistically handle distortion in woodwind multiphonics. These artists had strong ties to Seattle, and the Experience Music Project, an interactive music museum scheduled to open in 1999, will showcase their contributions to jazz and rock music.

Dolphy/Hendrix Memorial Jam session

Acoustics in the News

• A new type of sonar developed by John Potter and his colleagues at the University of Singapore detects how an object distorts the ocean's natural background din of breaking waves, rain, or passing ships, according to a note in the May issue of *Discover*. This is somewhat akin to viewing objects in ambient light on land; the natural analogue to light in the atmosphere is acoustics in the ocean because light doesn't travel very far in the ocean and sound does. Assuming that dolphins and other marine mammals can detect ambient noise at least as well as electronic instruments, do they have an imaging method that no one yet knows about? Computer simulations by Potter and his colleagues suggest that dolphins should be able to see ambient noise images from at least 25 feet away. The next step is to test real dolphins to learn whether they do indeed use background noise to detect objects.

• Bioengineers Mostafa Fatemi and James Greenleaf at the Mayo Clinic have invented a new type of ultrasound probe that jostles tissue or other material then listens for sounds generated by the movement, according to a story in the April 3 issue of *Science NOW*, the online version of *Science*. They take ultrasound pictures by focusing two ultrasonic beams with slightly different frequencies on an object. Interference

effects between the beams vibrate the target which emits low-frequency sound, in contrast to high-frequency ultrasound used in traditional imaging.

• Although the energy of the sound emitted when a glass breaks makes up only about 5% of the energy released, this sound can strongly influence the way in which a crack propagates, according to a paper by Jean-Francois Boudet and Sergio Ciliberto in *Physical Review Letters* **80**, 341. Although the macroscopic behavior of the material can be well described by linear elasticity theory, the response of the material at the tip of the propagating crack is almost certainly nonlinear, the authors point out, because the crack magnifies the applied load and leads to high stresses in the space around its tip. In this context, even a small perturbation can significantly alter the behavior of an unstable nonlinear system.

The dynamics of fast fracture has been studied for many years, and Ben Freund of Brown University developed an elegant theory to describe fracture behavior outside of a small nonlinear zone around the crack tip. Freund's theory suggests that the velocity of a moving crack increases with its length. Experiments on fast fracture have indicated that cracks traveling faster than a critical speed (about one-third the speed of the Rayleigh sound waves in the material) emit high-frequency sound waves. Boudet and Ciliberto showed that it is these high-frequency emissions that alter the crack's motion. When they generated artificial high-frequency sound pulses, they found that cracks moving slower than the critical velocity sped up, but the pulses had little effect on fast cracks, since these had already been influenced by their own acoustic emissions.

• When Yasunobu Inoue at Nagaoka University of Technology discovered that a chemical reaction could be made two thousand times faster by bouncing sound waves from a catalyst made from a thin film of palladium, fellow chemists greeted his findings with skepticism. Sven Kelling and David King discuss this effect and their attempts to study similar effects in other catalysts under various conditions in an article entitled "The Really Fast Show" in the May 16 issue of *New Scientist*. Meanwhile Inoue is aiming for a million-fold enhancement in the reaction rate.

• According to a story by Anthony Tommasini in the December 8 *New York Times*, two demonstrations of a Steinway grand piano with a lid-like reflector beneath the piano, were inconclusive. The story attributed the idea to Daniel Revenaugh, pianist, conductor and inventor in Berkeley, California, although ASA members will recall an inclined lower "lid" for a grand piano was described by Harold Conklin, Jr. in 1979 (paper BB7 at the 50th Anniversary meeting in 1979). In one of the recent demonstrations the piano was played by a computerized mechanism. "Up close to the stage, you could definitely hear a difference," commented Ronald Coners, chief concert technician at Steinway. "Further back, it did not seem to have that much effect."

In November 1996, Peter Serkin rehearsed on a piano with the lower lid and decided to use it for the performance. However, Carnegie Hall officials would not allow it. What the officials seem to fear, Revenaugh contends, is anything that will give the impression that the sound of a piano at Carnegie Hall needs enhancing.

• Detlef Lohse compares 5 different bubble-collapse phenomena in a news note "Lasers blow a bigger bubble" in the March 5 issue of *Nature*. Common to all 5 phenomena (raindrops falling on the sea, single-cavitation bubble luminescence (SCBL), hydrodynamical cavitation, mutli-bubble sonoluminescence (MBSL), and single-bubble sonoluminescence (SBSL)) is the formation of a geometric singularity at the center when the bubble collapses. If one could nucleate a bubble using a strong laser pulse in the pressure antinode of an oscillating sound field, thus combining the methods employed in SBSL and SCBL, the temperatures and pressures inside the bubble could be pushed even further into the region of extreme states of matter.

• Human subjects are known to adapt their motor behavior to a shift of the visual field brought about by wearing prism glasses. The analog of this phenomenon in the speech domain is a device that can feed back transformed speech signals in real time. By means of such a device, according to a report by John F. Houde and Michael I. Jordan in the 20 February issue of *Science,* subjects were exposed to phonetically sensible, online perturbations of their own speech patterns.

It was found that speakers learn to adjust their production of a vowel to compensate for feedback alternations that change the vowel's perceived phonetic identity.

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