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ECHOES

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Big Bang acoustics: Sound in the early universe

by Mark Whittle

Despite its title — "The Big Bang" — the modern scientific description of creation has, until recently, has been paradoxically lacking in any acoustic content. The original term was coined by Fred Hoyle in 1950 and refers to the "explosive" quality of the Universe's early expansion, rather than to sound itself. As the decades passed, many other qualities of creation have been studied, and even popular accounts now bring them to life — the enormously high temperature and density of the first moments; the sequence of eras — quark, hadron, lepton, radiation, matter — which track the changing content; moments of cathartic transition, as matter and antimatter annihilate, as thermonuclear fusion turns hydrogen into helium, as the Universe turns transparent. Creation, it turn out, is wild and wonderful, and the modern story is rich and fascinating. But the scenes described have all been silent ones.

Why has sound been such a latecomer to the story? Because sound involves *variations* in properties from place to place. As with many branches of physics, understanding average properties is much easier than understanding perturbations. But with the average properties now well understood, there is growing interest in perturbations, of which sound is a particular kind. Why are perturbations and their growth so important? Because they take an initially smooth Universe and turn it into the incredibly lumpy Universe of today, with its stars and galaxies dotted throughout an ocean of vacuum. Primordial sound, then, plays a crucial role in the origin of all *structure* — without it there would be no galaxies, stars, planets or people. The full story of the growth of perturbations is fascinating and complex, and too long a tale to tell here. But given the readership of *ECHOES*, let's zero in on some of the more overtly acoustic aspects of the story. A more complete account, which is aimed at a popular audience and which includes all the associated sounds, can be found on my website at http://www.astro.virginia.edu/~dmw8f.

First, the observations. The picture (minus the ear!) shows the full sky as seen by NASA'a microwave telescope, WMAP. These microwaves have been travelling for almost 14 billion years and they provide the most distant and ancient picture of the Universe we have — dating from 380,000 years after the Big Bang (for a human, that's just 12 hours after conception). The image is contrast stretched to show very slight patchiness in microwave brightness, which in turn traces variations in temperature and *pressure*. Hence, these patches are (mostly) peaks and troughs of *sound waves* moving through the hot glowing gas (the bright optical glow is converted into microwaves by the enormous redshift associated with Universe's expansion).

Choosing $\Delta p/p$ as our measure of loudness, the peak pressure variations are about 0.01% or roughly 110 dB — rock concert volume! Despite the relatively fine scale of the acoustic patchiness, the enormous distance to the microwave sky implies giant wavelengths — up to 200,000 light years. Thus, even with a very high sound speed (60% light speed, see below), the frequencies are incredibly low, about 10-12 Hz, and they only become audible to humans after an up-shift of about 50 octaves. This is as one might expect, an object as vast as the

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We hear that...

• **Gunnar Fant and Kenneth N. Stevens** received the 2004 IEEE James L. Flanagan Speech and Audio Processing Award "for fundamental contributions to the theory and practice of acoustic phonetics and speech perception." Fant is professor emeritus in the Department of Speech, Music and Hearing at the Royal Institute of Technology (KTH) in Stockholm, while Stevens is the Clarence J. LeBel Professor of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology. Stevens is a past president of ASA and also received the Gold Medal as well as the U.S. National Medal of Science. Fant received the ASA Silver Medal in Speech Communication.

• ASA member **Dahlia Sokolov** has been selected as AIP's Congressional Science Fellow in Washington DC for the coming academic year. She has been working as a postdoc in Radiation Oncology at NIH's National Cancer Institute.

• **Greg Swift**, Los Alamos National Laboratory, received the US Department of Energy's E. O. Lawrence Award for "developing the theory of thermoacoustic heat engines and for designing and building these engines and refrigerators that use the power of sound to operate at high efficienty with not moving parts." The Lawrence award includes a gold medal and $50,000. Swift is an ASA Fellow, and in 2000 he received the Silver Medal in Physical Acoustics.

• Part 3 of an historical reprint by Leo Beranek and John Kopec on Wallace C. Sabine, acoustical consultant" appears in the Winter issue of the National Council of Acoustical Consultants newsletter. The paper originally appeared in the January 1981 issue of JASA.

Letters to the editor

Looking Back one more time

The 75th Anniversary party held in New York City is over. The meeting program with its 1200 abstracts, the 75th anniversary book, and DVD are now stored on our bookshelves. New visitors have come and gone from New York City since we were there. As the song goes, "The party's over, it's time to call it a day." But this doesn't preclude this writer to look back one more time to that wonderful week in May

75th Anniversary organizers get together in 2003

The theme of the meeting was "Glorious Past—Looking Forward." The Tuesday night ASA banquet was admittedly nostalgic—remembering how the founders celebrated their 25th anniversary in New York City in 1954 (those who missed it can buy the DVD). Remembering one's roots is what anniversaries are about. Going back in ASA time leaves us with no doubt about how dedicated our founders were in creating and sustaining the Acoustical Society of America.

The Wednesday morning event at City Center featured nine young professionals looking to the future of the Society for their specific technical field, packing a lot of good thoughts in short presentations. Added to their performances were some fine acceptance speeches for gold and silver medals, with Chester McKinney adding a standup comedian talent award to his gold medal. There were of course many other important events during the week, not to mention the fine technical program.

As I delete hundreds of once-important emails, it is interesting to see what remains in my memory. This is of course what events such as this are supposed to do. For me the lasting impression is a true admiration of ASA members—past and present—who volunteered their time and talents to make the Society what it is. I should have probably saved all of Leo Beranek's emails to exemplify the importance to details to planning meetings. And the split second coordination of all the presentations for the Wednesday event at City Center by the young professionals attest to Pat Kuhl's organization and love of working with younger members. She and Larry Crum also flew around the country to obtain the excellent interviews for the 75th anniversary DVD. These three past presidents kept contributing to the Society even though their terms are long over, worked side-by-side with the most recent president, Ilene Busch-Vishniac.

This special meeting had its beginnings years ago, and over that time, local committee Co-chair Damian Doria from Artec spent an uncountable number of volunteer hours making arrangements so everyone could enjoy themselves in New York City. There is not enough room in ECHOES to keep going here, but you get the gist. This is still primarily a volunteer society and we are all the better for it. Witness our fine anniversary party in May.

Charles Schmid

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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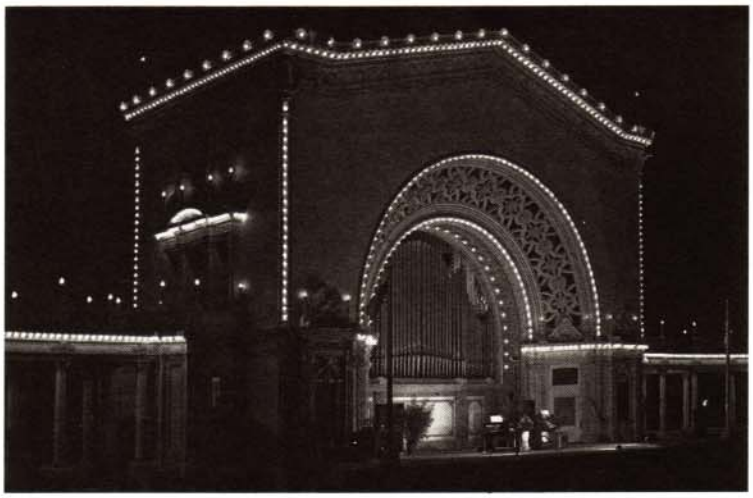
ASA returns to San Diego

Since 1969, ASA has met in sunny San Diego every 7 years, and this year is no exception. Besides 70 miles of picturesque coastline, San Diego offers Sea World, the San Diego Zoo, a wild animal park, Balboa Park with its many museums, Legoland, fine beaches, the Birch Aquarium, the University of California, and many other stellar attractions. The Town and Country Hotel in Mission Valley is adjacent to a 27-hole golf course and the Fashion Valley shopping mall, and has trolley service to downtown, the Gaslamp Quarter, Old Town, and Tijuana, Mexico.



Spreckels organ in Balboa Park

The technical program includes over 750 papers and 36 special sessions. Abstracts can be viewed online at http://asa.aip.org Two one-day colloquia and discussions will be held on "Ultrasound Characterization of Cancellous and Cortical Bone" and "Spatial and Binaural Evaluation of Performing Arts Spaces." A tutorial lecture on Ocean Noise and Marine Mammals will be given by Gerald D'Spain and Doug Wartzok on Monday evening, while a short course on Acoustical Oceanography by George Frisk, Grant Deane, James Preisig, and Dajun Tang will begin on Sunday afternoon. Awards will be presented at a plenary session on Wednesday afternoon. An instrument and equipment exposition will open with a reception on Monday evening and close on Wednesday afternoon. Technical tours include a visit to two outstanding pipe organs, including the Spreckels organ in Balboa Park and a 107-rank organ in the First Methodist Church.

A Fellowship Workshop on Wednesday evening, organized by the ASA Student Council, will provide information to help students and post-doctoral researchers obtain funding. The workshop will be followed by a reception for students.

A Fellows Hospitality Suite, with refreshments, will be open on Tuesday afternoon, and at the Fellows Luncheon on Thursday noon, Professor Walter Munk will speak on "IVY-MIKE: An account of the first thermonuclear explosion through the eyes of a participating Scripps oceanographer" at the Fellows Luncheon on Thursday noon. The Women in Acoustics luncheon will be held on Wednesday noon, and the ASA Foundation will host a dinner honoring Evelyn Young and other women in acoustics on Wednesday evening. Buffet socials will be held on Tuesday and Thursday evenings preceding the technical committee meetings.

Technical program organizing committee.

Balboa Park has many museums.

Exhibition at San Diego meeting

148th Meeting of the Acoustical Society of America
San Diego, California

EXHIBITOR PROGRAM

We invite all attendees of the 148th Meeting of the Acoustical Society of America to participate in the ASA Exhibition by visiting the exhibits. The exhibition will include computer-instrumentation, sound level meters, sound intensity systems, signal processing systems, devices for noise and vibration control and other exhibits on acoustics.

Town & Country Hotel
Atlas Ballroom
November 15-17, 2004

Monday, November 15 — 5 PM to 7 PM
Tuesday, November 16 — 9 AM to 5PM
Wednesday, November 17— 9 AM to 1 PM

Exhibition at San Diego meeting

Exhibition at San Diego meeting

Big Bang *continued from page 4*

spectrum is a featureless power law: $P(k) \propto k^n$ (k is the wave vector, n~1) which produces a formless "hiss." On reflection this is just as it should be, since no scale is yet preferred over any other, and so no "features" are introduced to the power spectrum. Furthermore, with an index n~1, this spectrum has the remarkable property of creating structures on *all* scales — from stars to galaxies. Even if it wasn't "music" to our ears, Nature certainly made an extremely wise and creative choice.

Let's end by looking at why Big Bang acoustics has received so much attention, quite apart from the fun of "listening" to creation. One hardly needs to mention to readers of *ECHOES* that the sound an object makes contains a massive amount of information about the nature of the object. So too with the Universe. Like a struck bell, the Universe was subject to an initial noise-like perturbation, to which it responded and continues to respond 14 billion years later. As with any material object, the response can be studied using power spectra which, in the case of the Universe, we can observe at two times: today in the cosmic tapestry of galaxies; and 380,000 years after the Big Bang, in the microwave sky (the latter is the richer source of information because all the oscillations are still linear and the physics of the fluid is well understood). Now, in close association with the observational developments, theorists have been constructing highly sophisticated computational models of the evolving perturbations which include most of the relevant physics. As in many sciences, one can study reality by matching model calculations to observations. In practice, cosmologists add three other data sets to the two acoustic ones, and from these they have been able to derive high precision (2-10% accuracy) measurements of such quantities as the Universe's age, geometry, expansion history, composition, and other, more abstract, properties. Impressive though this is, it is the basic agreement between the theoretical models and the observational data sets which provides such a powerful indication that the overall framework must be close to the truth.

Modern cosmology is in a golden era. Each decade sees great strides forward, in both observations and theoretical understanding. The most recent and exciting contribution has undoubtedly come from the power spectrum of the microwave sky. Remarkably, this yields to an *acoustic* analysis, which not only provides some of the most precise measurements of cosmic properties to date, but allows us to explore the deepest ancestry of *all* structure — from people to planets to stars to galaxies and beyond.

Mark Whittle is Professor of Astronomy at the University of Virginia. His research has included Seyfert galaxies and jets and Abell clusters.

Collecting data over the Internet

Collecting Data from Afar over the Internet

by Edward G. Pasanen and Dennis McFadden

Some readers of *ECHOES* may be interested in a procedure we have been using to collect data remotely over the internet.

The background is this: For some time we have been studying otoacoustic emissions (OAEs), which are weak sounds produced by the inner ear that escape back out of the cochlea into the middle- and outer-ear canals where they can be recorded and measured. A number of our studies of OAEs in humans suggested that prenatal hormonal exposure can affect the strength of OAEs, but there was no way for us to perform a direct experimental test of that possibility in humans. Through a stroke of extraordinary good luck, we met Professor Kim Wallen of Emory University and the Yerkes National Primate Research Center outside Atlanta, Georgia, who has been studying a group of rhesus (macaque) monkeys, some of which had been treated hormonally during prenatal development. Dr. Wallen generously invited us to obtain OAE measurements on his colony of animals, but as eager as we were to make those measurements, we quickly realized that going to Atlanta to test as many as 60 animals, several times per animal, was going to be inconvenient, expensive of both money and effort, potentially highly inefficient, and possibly a serious intrusion on the shared facilities and personnel at the Yerkes Field Station.

Experience in telecommuting suggested that the job might be done more efficiently by controlling the data-collection process remotely. For some time we had been using the software application Timbuktu to control one computer remotely from another via Ethernet for email and other everyday purposes. When a control session is established, the remote computer's display appears in a window on the local computer, and the local keyboard and mouse can control the remote machine. The question was how well this arrangement would work for data collection. We outfitted a desktop computer in Atlanta with our custom-written LabView software used to collect the OAE data, with a National Instruments audio data-acquisition board, and with Timbuktu. Then, on a visit to the Yerkes Field Station, we instructed the staff on the set-up of the OAE measurement apparatus and the placement of the microphone in the external ear canal of a rhesus monkey. With this knowledge, and their existing knowledge about handling the animals, and administering and monitoring the anesthetic, the Atlanta team was fully capable of preparing an animal for an OAE measurement session.

Upon our return to Austin, we established that we were in fact able to control the computer in Atlanta using the Timbuktu interconnection. Thus, an experimenter in Austin with considerable experience collecting OAE data was in control of the collection and initial evaluation of the OAE data being obtained from the rhesus monkeys in Atlanta.

Note that in an actual data-collection session, the experimenters in Atlanta behaved as if all aspects of the test session were to be controlled on-site. Only when data collection was ready to begin was control of the local computer, and thus the experiment itself, relinquished to the experimenter in Austin.

Timbuktu also provides an intercom-like link running in parallel with the control connection, which permits continuous voice contact between the experimenters in the two locations. This provided the experimenter in Austin an easy way to communicate to the experimenter in Atlanta when the microphone needed to be repositioned or additional anesthetic administered. Upon completion of an OAE-measurement session, copies of the data files were transferred via the same internet connection to Austin for analysis.

Establishing this internet arrangement clearly led to considerable savings in costs and effort, and it also allowed flexibility in scheduling measurement sessions; this often was helpful because Dr. Wallen's team shares some of the test facilities at the Field Station with other investigators. Another advantage of this remote-control setup is that the actual data collection is performed entirely by the system located in the field, and is not strictly dependent on the speed and reliability of the Ethernet link. We occasionally experienced network problems, but they did not interfere with the time-critical aspects of data collection. In the rare episodes of brief network interruption, contact was maintained by telephone (a quaint 19th century device). In our case, both computers were Macintosh, but one or both could have been IBM-compatibles.

Later, a similar set-up was implemented with the University of California, Berkeley, in order to collect OAE data from spotted hyenas, a species of considerable interest hormonally. Our collaborators there were Drs. Ned Place and Stephen Glickman.

By the way, the data collected so far are excellent from both sites. Preliminary reports of this research were presented at the ASA meeting in Austin, November 2003.

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The Summer newsletter of the APS Forum on Education has articles on education and outreach from the following AIP member societies: Acoustical Society of America (by Thomas Rossing and Uwe Hansen), American Astronomical Society, American Geophysical Union, and Optical Society of America as well as an article on how AIP supports education.

National noise control efforts: Future challenge

by Henning von Gierke

Professional Societies like the ASA, American Speech Hearing-Language Association (ASHA), Institute of Noise Control Engineers (INCE) and the ICBEN (International Committee on the Biological Effects of Noise) do their best to support national and global noise control issues. But this effort is difficult today, as the USA lacks a unified national noise policy or any centralized agency responsible for noise policy. Needless to say that fact puts American industries at a potential economic disadvantage in competition with many other countries, especially those in Europe and with Japan, which have clearer, more uniform noise policies. In addition American citizens do not know where to turn when excess noise pollution threatens their neighborhoods due to the fact that the U.S. Environmental Protection Agency (EPA) eliminated its noise pollution office in 1981. In the past, when the Acoustical Society sensed there were societal problems involving acoustics such as noise control, we would form groups to study the issues and decide how to be proactive. In the year I was elected ASA president (1978) we organized a session with invited speakers on noise control, including as keynote speaker Dr. N. Golovin from the Office of Science and Technology (OST) of the Executive Office of the President of the US. It is a sad reflection on our nation to note that I wouldn't even know who in a high level policy position would be willing and able to talk about the US Noise Policy today.

I was first introduced to these problems as a newcomer to the USA in the early 1950s when I had the good fortune to contribute to the Benox (Biological Effects of Noise Exploratory) Project under Hallowell Davis. I recall my admiration for Hal Davis for his dedication to this voluntary job. I was also impressed that a distinguished world-renowned scientist felt a responsibility to see ivory-tower science applied to practical and societal problems of national significance. The 1953 Benox report[1], recommended research approaches for what we predicted would be the effects on man from jet aircraft noise over the coming 20 years. This report was followed just about 10 years later, in 1965, by the Jet Aircraft Noise Panel convened by Dr. Hornig, the director of the OST of the President's Executive Office, to make recommendations for overall jet aircraft noise alleviation. Bill Galloway and I, along with K. Kryter and H. Hubbard, were among the 27 technical, economic and legal experts invited to participate in this effort. The following year the National Sonic Boom Evaluation Program grew out of this collaboration. The Panel made important recommendations[2], including the need for nationally and internationally accepted Noise Standards. This in turn led to a growing recognition by the ASA that creating standards was an important responsibility for a leading scientific, technical society such as ASA, and we began to develop and publish ASA-ANSI (American National Standards Institute) standards in 1975, including standards on noise. Since then ASA has published about 120 ASA-ANSI standards.

The Noise Control Act of 1972 was passed with the assistance of a number of ASA members, directed the EPA to protect the public health and welfare against the harmful effects of noise and to identify the critical "levels of cumulative noise exposure." This led to creating several task forces and working groups consisting of members from interested professional organizations, industries, workers organizations and local, state, and Federal governments. As one of the senior advisors to EPA, I had the privilege (and headache!) to chair this effort to achieve consensus among this group, and after two years of hard deliberations the "Levels Document"[3] was published. It spelled out the A-weighted sound level, the time-averaged sound level Leq, and the day-night weighted level Ldn as the primary descriptors for environmental noise, workplace noise, and leisure time noise. Also the document defined criteria for judging annoyance effects, speech interference, sleep interference and the probability of noise-induced hearing loss. Many ASA experts, especially Bill Galloway, Ken Eldred and Daniel Johnson, were immensely helpful in the adoption of these uniform descriptors. To be sure, these might be revised as time goes by and new studies are done, but these original standards gave government agencies a quantitative basis for their decisions.

The implementation of the Noise Control Act proceeded successfully until 1981, when EPA's noise control effort was suddenly terminated by the Reagan administration.[4] Up to this point the Levels Document and the global initiatives for government sponsored noise control were guidelines for the whole world. After 1981 this leadership was abdicated. The noise control program in the U.S. remains without direction, coordination or funding. Individual agencies like the United States Department of Transportation (particularly the FAA), NIOSH, OSHA, DOI, DOD, NASA continue their programs independently mostly along the original EPA guidelines, but now without overall oversight or united advancement in noise control.[5]

Our Society's goal, in coordination with other organizations, must be clear: we need to renew U.S. efforts to help national and international noise control activities to regain their proper position to advance a quieter, healthier environment for our citizens and industries.

1.BENOX Report. An exploratory study of the Biological Effects of Noise, The University of Chicago, 1 Dec 1953.

2."Alleviation of Jet Aircraft Noise Near Airports" A report of the Jet Aircraft Noise Panel. March 1966. Office of Science and Technology, Executive Office of the President.

3."Information of Levels of Environmental Noise Requisite protect the Public Health and Welfare with an Adequate margin of Safety." US EPA Report No. 550/9-74-004 (March 1974)
also: "Noise-How much is too much?" Henning von Gierke, Noise Control Engineering (24-34) July-August 1975

4.Administrative Conference of the United States "The Dormant Noise Control Act and Options to Abate Noise Pollution" Sidney A. Shapiro (November 1991)

5."Noise Control- Where do we stand today" Henning E. von Gierke, Daniel L. Johnson, Guest Editors, ASA, INCE, Noise Control Engineering Journal, Vol. 44 (3) pp.107-160, May-June 1996

Henning von Gierke served as the Society's 41st president (1979-80) and as its first Standards Director (1978-79). He is the recipient of the Distinguished Service Citation (1978), the Silver Medal in Noise (1981) and the Gold Medal of the Society (1999).

Scanning the journals

by Thomas D. Rossing

• Blind people are known to be better than sighted people at orientating themselves by sound, but a brief communication in the 15 July issue of *Nature* indicated that the **early blind** are better at judging pitch as well. The younger the onset of blindness, the better is the performance in judging rapid pitch change, which is in line with cerebral plasticity being optimal during the early years. Early-blind subjects were better than both late-blind and sighted subjects at determining the direction of pitch change for different temporal as well as spectral levels.

• The April issue of *Acoustics Australia* features five papers on **vibration** presented at the 10th Asia Pacific Vibration Conference (APVC 2003) held in Australia Nov. 12-14, 2003. The papers deal with fault diagnosis, stiffness of bridge structures, crack detection, passenger car power trains, and pump vibrations.

• Atomic force microscopes (AFMs), using a sharp scanning tip mounted on a sensitive cantilever, are widely used to explore structure on the scale of single atoms. A new record in spatial resolution, reported in the 16 July issue of *Science* depends upon detecting **high harmonics** in the vibrational motion of the cantilever as the tip moves across a sample. A comment on this paper in the same journal suggests that since the auditory system is so good at analyzing sounds, downshifting the high harmonics into the audible range might allow the ear to detect subtle changes in the "sound" of the cantilever as it scans the sample.

• The July/August issue of *Acta Acustica/Acustica* includes eight papers on **musical acoustics** written by the authors of invited papers at the Stockholm Music Acoustics Conference (SMAC 03). The papers, which are expanded versions of the original papers, have been peer reviewed and deal with bowed strings, brass instruments, physics-based modeling of musical instruments, optical methods for visualizing sound fields, speaking and singing.

• The acoustical conductance and Q values were calculated for three **Helmholtz resonators** and compared to measured values in a paper in the August issue of the *American Journal of Physics*. Theoretical Q values tended to be a little larger than measured values, probably due to the inability to calculate small wall losses in the flaring region beyond the neck. In a resonator with more than one aperture, the total conductance is the sum of the individual conductances provided that the apertures are acoustically independent.

• Physicists at King's College, London have applied wave mechanics to reproduce the formants of the human vocal tract, according to a paper in the 30 July issue of *Physical Review Letters* (**93**, 54301). The researchers model **wave dispersion** in a simple organ pipe to show how changing the pipe cross-section alters the kinetic and potential energy densities. Rayleigh showed that constricting an organ pipe at an antinode raised its resonance frequency while expanding the pipe lowered it. The authors of this paper have added dispersion by examining how changing pipe cross section alters the potential energy density.

• Ground squirrels have been found to use 50-kHz **ultrasound** to warn each other of danger, according to a story in the 29 July issue of *Nature*. At ultrasonic frequencies sound can be very directional, allowing a squirrel to disguise its presence from a predator yet still warn other squirrels. It is thought to be the first time that any animal has been found to use ultrasound for an alarm call, although ultrasound is widely used by bats for navigation.

• During mating season, male midshipman fish migrate to their nesting territory and begin to hum, a sound that females find irresistible. A paper in the 16 July issue of *Science* reports that the **acoustic sensitivity** of the inner ear in females is adjusted to better match the frequencies put out by the mating hum in response to seasonal changes in circulating steroid hormones. Thus, the effectiveness of the male's song is enhanced by seasonally tuned hearing in females.

• Long-lived **acoustic vibrational modes** of an embedded nanoparticle are discussed in the 30 July issue of *Physical Review Letters* (**95**, 55506). Nearly spherical clusters of atoms a few nanometers in size have mechanical vibrations which can be initiated through sudden thermal excitation with a brief laser pulse. Subsequent evolution of the vibration can be followed by observing the light absorption of a probe pulse which follows the pump pulse. Particular combinations of material, such as gold nanoparticles imbedded in TiO2, give rise to very low damping of the fundamental "breathing" mode even though the longitudinal plane wave acoustic impedances in the two materials are the same.

• A **traveling-wave thermoacoustic electric generator** that is especially suited for space probes is described in the 9 August issue of *Applied Physics Letters* (**85**, 1085-1087). The core of the device uses a thermoacoustic Stirling heat engine (TASHE) coupled to a linear alternator to produce 60 watts of electrical power. The piston is filled with helium at high pressure (55 bar). In the alternator, a coil of copper wire is attached to the piston and oscillates with it, so that the linear piston motion is transformed into electricity.

• Interaural time difference (ITD) is a major cue for determining **sound source location**, and this ITD should be coded with maximal accuracy. According to a paper in the 5 August issue of *Nature*, the optimal coding depends on head size and sound frequency. For humans, the optimal strategy depends on frequency: above 400 Hz a homogeneous distribution is optimal, while below 400 Hz distinct sub-populations are optimal.

• The Berlin Phonogramm-Archiv, one of the world's most comprehensive collections of traditional music, is described in a tutorial in the July issue of *Acoustical Science & Technology*. The Archive was established by Professor Carl Stumpf of the Institute of Psychology at Berlin University in 1900. In 1944, 90% of the collection was evacuated to mines in Silesia and later taken to Leningrad. At the end of the 1950s the holdings were handed over to authorities in East Berlin, partly exchanged with the West. After reunification, the historical collections were returned to the Museum für Völkerkunde in 1991. The extensive

wax cylinder recordings, dating from 1893, has been entered into the UNESCO register "Memory of the World."

• Some deaf people are questioning **cochlear implants**, according to an article in the 28 August issue of *New Scientist*. Many people who have been profoundly deaf from an early age immerse themselves in the deaf community, where sign language is the primary communication tool. Some members of this community reject the popular notion that they are "disabled," arguing that they are simply a minority with their own rich culture and language. They question whether it is ethically defensible to restore, or refuse, hearing to a deaf child too young to decide for themselves. At a conference on cochlear implants in Manchester, UK a couple of years ago, members of a group called the Deaf Liberation Front staged a protest with banners saying "Better deaf than dead."

• A phononic crystal consisting of stacked beads of tungsten carbide 0.8 mm in diameter will block sound waves at 1 MHz, where the wavelength is close to the diameter. However ultrasound just slightly lower in frequency can be focussed by the array, according to a paper in *Physical Review Letters* **93**, 024301 (9 July). This effect, termed **negative refraction** because the wave is bent in the "wrong" direction, arises from the same kind of interference process that creates a band gap at lower frequencies. Destructive interference occurs for waves travelling in most directions but not for those heading toward the focal point. The interference pattern changes dramatically for a small change in frequency. Phononic crystals may offer improved image resolution close to the wavelength of the ultrasound oscillations where conventional ultrasound imaging begins to fail.

• The recognition and localization of sound signals is fundamental to acoustic communication. According to a letter in the 12 August issue of *Nature*, **sound localization in female crickets** is achieved by comparing the output of the left and right recognition networks. Auditory orientation emerges from reactive motor responses to individual sound pulses.

• The evolutionary changes that took place in the sound transmission mechanism of the outer and middle ear in **early whales** is documented in a letter in the 12 August issue of *Nature*. The fossil record indicates that this evolutionary transition took less than 15 million years. Sound transmission mechanisms passed through a stage in which hearing in both air and water was unsophisticated, but this intermediate stage was replaced by a sound transmission mechanism similar to that in modern toothed whales.

• **Left and right ears** process sound differently. The right ear responds more to speech, while the left ear is more attuned to music, according to a paper in the September 10 issue of *Science*. It is known that speech is processed primarily in the left hemisphere of the brain while music is handled largely by the right, but until now it was assumed that the two ears are essentially interchangeable. In other studies, researchers have found that children with hearing loss in the right ear tend to have more problems in school than children who are deaf in the left ear, suggesting that the right ear is critical for learning situations.

• The September-October issue of *American Scientist* has a very interesting and enlightening review article on "The Design and Function of **Cochlear Implants**." Cochlear implants have a 40-year history, culminating in the current generation of high-performance devices, which have restored speech communication to a large number of deaf people. A cochlear implant has five main components, only two of which are inside the body. An external microphone picks up sounds and directs them to a sound processor which sits inside a case behind the ear. The processed signals are conveyed to a radio transmitter which transmits information to a receiver, implanted in the bone above the ear, from which signals pass to an array of electrodes inside the cochlea. One type of implant uses a continuous interleaved sampling (CIS) strategy to convert acoustic signals into a code for stimulating the auditory nerve. An advance that will be seen shortly is the combination of electric and acoustic stimulation, which combines residual low-frequency hearing with electrical stimulation of the cochlea at high frequency.

ASA Student Design Competition

The 2004 Student Design Competition, sponsored by the Technical Committee on Architectural Acoustics (TCAA) and the Newman Student Award Fund, was judged at the 147th ASA Meeting in New York. The project involved preparing the schematic design for a music pavilion to serve as a city orchestra's summer home and assorted support spaces. There were 16 entries submitted from 7 different schools. The panel of judges included: Joshua Dachs (Fisher Dachs Associates), Byron Harrison (The Talaske Group), Tony Hoover (Cavanaugh Tocci Associates), Dana Hougland (Shen Milsom Wilke), Joseph Myers (Kirkegaard Associates), and Mark Reber (Jaffe Holden Acoustics). The Wenger Foundation funds these awards annually in memory of the firm's founder, Harry Wenger, who was a long-time friend of education in music and architectural acoustics. Images of the winning posters can be viewed at www.newmanfund.org.

Six prizes were awarded, including one First Honors ($1000 Wenger Prize) and five Commendations ($500 Wenger Prizes):

First honors: Molly Norris, Julie Byrne, and Rebecca Simkins, Rensselaer Polytechnic Institute

Commendations: Michael Bono and Michael Colburn, University of Kansas; Erica Bowden and David Bradley, University of Nebraska; Kevin Kudwig, Sebastian Otero and Evelyn Way, Rensselaer Polytechnic Institute; Jacob Mueller, Jonah Sacks and Andrew Eckel, Rensselaer Polytechnic Institute; Michael Vigeant, University of Nebraska.

The 2005 student design competition will be judged at the 149th meeting of ASA in Vancouver. Information will soon be available at www.newmanfund.org.

Acoustics in the news

• Using optical metrology and digital image processing methods to recover the sound of old recordings is the subject of a story in the July 12 issue of the *San Francisco Chronicle*. The authors, from the Lawrence Berkeley National Laboratory (see paper 2pMU4 at the 147th ASA meeting in New York), developed the system for particle physics research. They have applied it to tin and wax cylinders as well as 78-rpm shellac disc recordings. One of their most impressive feats so far was to extract high-quality sound from a worn wax cylinder with a 1912 recording of a barbershop quartet singing a sentimental tune "Just Before the Battle, Mother." The great thing about the technique is that it's noninvasive, as compared with the original phonograph which would wear down the grooves with each playing. The oldest known surviving recording is of a talking clock recorded in 1878, which can be heard at http://tinfoil.com. The Berkeley scientists' sound reproduction site is www-cdf.lbl.gov/~av. They also have a lay-language version of their ASA paper at http://www.acoustics.org/press/147th/haber.html.

• "Another black hole is singing" according to a story in the August 3 issue of *New York Times*. Last year astronomers discovered that outbursts from a giant black hole in the Perseus cluster of galaxies were sending pressure waves with a frequency of about 57 octaves below middle C (see the Fall 2003 issue of *ECHOES*). Now another group of astronomers has discovered waves from another black hole in a galaxy known as M87. The sound waves in M87 are spaced about four million years apart.

• Yet another analysis of the sounds recorded at the assassination of John F. Kennedy is being made at the Lawrence Berkeley Laboratory, according to a story in the August 3 issue of the *New York Times*. This analysis will make use of a digital scanning apparatus (see first story in this section) to examine the Dictaphone belt which recorded sounds from an open microphone on a police motorcycle during the shooting in Dallas, Nov. 22, 1963.

• The 14 September issue of the *New York Times* reports on the paper in *Science* (see last item in "Scanning the Journals," this issue) reporting that left and right ears process sound differently. From birth, the right ear responds more to speech, while the left ear is more attuned to music.

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