

ECHOES

EXCERPTS FROM ECHOES

Scanning the Journals

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- Two papers presented at the 2005 **Australian Acoustical Society** conference are reprinted in the December issue of *Acoustics Australia*. A paper entitled “Learning Acoustics through the Boundary Element Method: An Inexpensive Graphical Interface and Associated Tutorials” was awarded the President’s Prize for the best technical paper. The Boundary Element Method (BEM), the paper points out, is particularly useful for analyzing sound radiation and acoustic scattering problems. The other paper “Acoustic Systems in Biology: From Insects to Elephants” discusses the physical principles in the sound production and hearing of a variety of creatures. The dominant frequencies used for communication by a large range of air-breathing animals is nearly proportional to the body mass raised to the -0.4 power.

- **Tunable nanoresonators** constructed from telescoping multiwalled carbon nanotubes (MWNTs) are described in the 2 June issue of *Physical Review Letters*. Such resonators, with their low masses, low force constants, and high resonant frequencies, are capable of weighing single bacteria, detecting single spins in magnetic resonance systems, and even probing quantum mechanics in macroscopic systems. In the device, a specially prepared MWNT is suspended between a stationary contact and a mobile piezo-controlled electrode. Varying the length of the nanotube beam through the controlled telescoping of the inner nanotube core from the outer nanotube shell tunes its resonant frequency.

- Higher sound clarity is obtained in **classrooms** when sound diffusers are applied to rear walls and ceilings rather than side walls, according to a paper in the *Proceedings of WESPAC IX*. However, absorbers increase sound clarity

even more effectively with smaller area in comparison with diffusers.

- A protein associated with a disorder that causes **deafness** and blindness may hold a key to one of the foremost mysteries of hearing, according to a paper in the June 28 issue of *Journal of Neuroscience*. Scientists have identified protocadherin-15 as a likely player in the conversion of sound into electrical signals. The findings will not only provide insight into how hearing takes place at the molecular level, but may also help us explain why some people temporarily lose their hearing after exposure to loud noise but regain it a day or two later. The protein is referred to as the “tip-link antigen” (TLA) because it induces the production of special antibodies which bind to the protein at the stereocilia tips in the cochlea. Using mass spectrometry, the researchers analyzed the makeup of the TLA and found two peptide sequences that match up to key segments of the protein protocadherin-15 in humans, mice and chickens.

- For any **touch, sound, or image** to be perceived, our senses have to activate neurons at the center of the brain, in the thalamus. According to a paper in the 16 June issue of *Science*, the weak neurons along the thalamocortical pathway may find strength through amplification within cortical layer 4. Researchers were able to measure excitatory electrical activity generated in a single cortical neuron in a mouse cortex by a single thalamic neuron.

- Several interesting effects are reported when **cavitation bubbles** are generated inside water drops in microgravity, according to a paper in the 1 September issue of *Physical Review Letters* (97, 094502). Toroidally collapsing bubbles generate two liquid jets escaping from the drop, and the

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“splash jet” discloses a remarkable broadening. Shock waves induce a strong form of secondary cavitation due to the particular shock wave confinement, which offers a way to estimate integral shock wave energies in isolated volumes. Bubble lifetimes in drops are shorter than in extended volumes in remarkable agreement with herein derived corrective terms for the Rayleigh-Plesset equation. These observations, made on board an aircraft flying in parabolic arcs to create near-weightless conditions, would be difficult, if not impossible, in normal gravity.

- A mathematical system for organizing the **12 tones of the Western scale** that makes use of a topological structure called an orbifold is described in the 7 July issue of *Science*. Chords are points in the topological space, and the segments connecting them indicate how chords progress. The work described in this paper is part of an ambitious project to characterize musical composition in great generality by means of mathematical music theory.

- **Language** is largely symbolic, but how we say something can be as important as what we say, according to an article in the 21 July issue of *Science Now Daily News*. Twenty four college students were asked to describe a dot moving across a screen. The students were told to use one of two sentences: “It is going up” or “It is going down.” The team found that when students described the dots going up, the pitch of their voice was, on average, 6 hertz higher than that of those describing the dot going down. The same thing happened when another 24 students read the sentences from a computer screen, indicating people change the sound of their voice according to directional information contained within words. Listeners readily caught these cues.

- To a person who suffers from **hyperacusis**, even the sound of their own voice can be intolerable, according to an article in the 15 July issue of *New Scientist*. Nobody knows exactly what causes hyperacusis, but it can be brought on by head injuries, exposure to extremely loud sounds, Lyme disease or autism. It has also been linked with tinnitus. The main question puzzling researchers is whether it results from structural damage to the ear or flaws in the way the brain interprets sound signals.

The most successful treatment is a therapy using gradual desensitization with “pink noise,” sound in which the amplitude decreases with increasing frequency.

- Two-way communication over gas pipelines using multi-carrier **modulated sound waves** is the topic of a paper in the July issue of *Acoustical Science and Technology*. Conventional acoustic communication technology is limited by the effect of reverberant signals, but the use of multi-carrier frequencies which change cyclically avoids this. Using this method, a transmission rate of 3840 bps was achieved.

- A portable navigational aid for the blind transmits soft, **low-pitched beeps** directly to the inner ear, according to an article in the 19 August issue of *New Scientist*. The system

guides users with beeps that appear to come from whatever direction the person needs to head in. The user simply walks towards the sound. The device uses a processor in a backpack to combine GPS location readings with data from cameras and motion sensors attached to a headband or helmet. This information is fed into a virtual 3D model of the streetscape or building the person is navigating to calculate which direction the person should walk. To make the beeps appear to come from a particular direction, the system varies the timing and intensity of the vibrations transmitted to each earpiece to vibrate the skull.

- The pattern of the **sound waves** viewed by the Wilkinson Microwave Anisotropy Probe satellite, which show the abundance of hydrogen and helium in the universe, are another evidence for the large amount of dark matter in the universe according to an article in the August 29 *Scientific American Newsletter* online. These measurements are in agreement with other measurements which show that at most, 5 percent of the mass-energy density of the universe is in the form of atoms. Many physicists and astronomers think dark matter is probably a new particle that so far has eluded detection during particle accelerator experiments or discovery among cosmic rays. In order to behave as dark matter, it must be heavy and weakly interacting with normal matter.

- The April issue of *Acoustics Australia* is a special issue on **Mechanisms of Hearing Damage**. The articles are presented in a “top down” order beginning with the psychoacoustics of sound localization using head-related transfer functions. Another article reviews neural organization with particular emphasis on the signals which descend to the cochlea to either control the processing of sound via the outer hair cells or the excitability of primary neurons carrying the frequency analysis upward. Two papers deal with the genetics of hearing loss. The special issue attempts to draw attention to the cross-fertilization between psychoacoustics and physiological acoustics.

- Taiwan’s high-speed train, scheduled to open in October, has raised new questions about the level of **noise and vibration**, according to a story in the August issue of *IEEE Spectrum*. The latest twist in this tale began three years ago, when the government solicited design concepts for reducing vibration from passing bullet trains. Taipei-based Sheus Technologies Corp. proposed to stiffen the rail bed’s foundation and install barrier walls containing elastic rubber pellets. However, the design is not predicted to meet the National Science Council’s goal, which reportedly was to limit noise from a train passing 200 meters from the track at 300 kilometers per hour to 48 decibels. Some observers fear that semiconductor manufacturing in Tainan Industrial Park may be affected by the vibrations.

- “Our atmosphere is filled with sounds that we cannot hear,” begins an article on **infrasound** in the August issue of *Physics World*. “From listening in on volcanoes to detecting nuclear explosions, a global network of infrasound

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detectors is allowing researchers to tune in to our atmosphere.” Infrasound has been a hot topic in ASA recently, as readers of *JASA*, *Acoustics Today*, and *ECHOES* are well aware. “Infrasound” was the lead article in the January 2006 issue of *Acoustics Today*, as it was in the Fall 2001 and Fall 2005 issues of *ECHOES*. Although much of the same material is covered in this article, two items that caught my eye were the “mystery of the Earth’s low-frequency hum,” due to standing Rayleigh waves driven by atmospheric turbulence; and the new optical fiber infrasound sensors that get around the use of mechanical filters to reduce background noise. Unlike audible sound, infrasound can travel thousands of kilometers through the atmosphere and is used by some animals as a form of communication.

- According to a paper entitled “The failure of the Tacoma Bridge: A physical model” in the August issue of the *American Journal of Physics*, “one of the most surprising of physical phenomena is the conversion of a steady state condition into oscillations.” Other examples of **self-excited oscillations** include the blowing of air through the reed of a clarinet, the flow of air over the embouchure hole of a flute, and the conversion of the steady pull of a violin bow into oscillation of the string. The paper addresses historical misconceptions of the 1941 Tacoma Narrows Bridge collapse, a computational model of vortex behavior, and evidence for the correctness of this model. Fluid mechanics has typically been the domain of experimentalists because the governing equations are difficult to solve. Only now, they point out, is computer power becoming equal to the task.

- “Zap-while-you-scan therapies set sights on cancer” is the title of an article in the August 12 issue of *New Scientist* describing the use of **high-intensity ultrasound** to kill tumors. The idea is to use magnetic resonance imaging (MRI) or computed tomography (CT) to create three-dimensional images precise enough to guide a tumor-zapping beam of ultrasound to its target. Surgeons can be confident they have hit all of the tumor and spared the surrounding tissue according to surgeons at the Ontario Cancer Institute in Toronto. The scanner can also measure real-time tissue temperature, so the doctor knows exactly when the target has received a sufficient dose.

- “Hearing colours, **seeing sounds**” in the 3 August issue of *Nature* is a commentary on Kandinsky’s synaesthetic paintings. Reacting to a performance of Wagner’s opera “Lohengrin,” the Russian painter conceived a kind of painting that might aspire to the abstract condition of music. Attempts to devise color notations for music date back to the sixteenth century, and the earliest attempt to construct a color organ was made as long ago as the early eighteenth century. Kandinsky considered color as the “keyboard, the eyes are the hammers, the soul is the piano with many strings.” In 1914 he painted “Fugue,” whose interwoven sequences of colored patterns are explicit representations of musical motifs.

- Physicists in the US and Japan have found strong evidence that **phonons** play a key role in high-temperature superconductivity, according to a letter in the 3 August issue of *Nature*. The phonons allow electrons with opposite spins to pair up, which is widely believed to be what happens in conventional low-temperature superconductors, but until now no boson-mediated electron pairing has been observed in high-temperature superconductors. The paired electrons form bosons as they collapse into a single quantum state via a process called Bose-Einstein condensation. By placing the tiny metal tip of a scanning tunneling microscope above the surface of a bismuth strontium calcium copper-oxide (BSCCO) sample, the researchers measured the energy states in the superconductor on an atomic scale. Changes in current as the tip moved just a few nanometers across the sample indicate that the electron-pairing mechanism varies on these tiny scales, and that there is interplay between the paired up electrons and the crystal lattice.

- A discussion of **vibration isolation** of precision objects appears in the July issue of *Sound and Vibration*. The use of “smart” constant natural frequency (CNF) isolators substantially widens the application range of inexpensive passive isolators, which are generally less expensive than active isolation systems. CNF isolators have their stiffness proportional to the applied weight load in order to automatically satisfy decoupling conditions.

- According to an article in the September-October issue of *American Scientist*, some tadpoles hatch prematurely upon sensing a predator’s **vibrations**. The red-eyed tree frog, an inhabitant of Central American tropical forests, lays clutches of eggs on leaves overhanging ponds, so that when the tadpoles hatch they drop into the water. The usual gestation period is six to eight days, but after four days of gestation the tadpoles will start to hatch if the clutch is attacked by a predator. The eggs apparently sense vibrations as a snake or other predator tears into the clutch. In the laboratory, the highest rate of hatching was induced by signals that had a half-second duration and intervals of 1.5 to 2.5 seconds, which are consistent with snake attacks.

- At terahertz frequencies, light couples with periodic lattice distortions resulting in **phonon-polaritons**, according to a letter in the 10 August issue of *Nature*. Polaritons are electro-mechanical excitations in condensed matter that describe light propagation near resonances. In ferroelectric materials, terahertz radiation propagates by driving infrared-active lattice vibrations, resulting in phonon-polariton waves. The resulting fast motion of these charges has been observed by using femtosecond X-ray diffraction.

- An **ultrasonic device** could help athletes who have had their teeth broken while playing high impact sports, according to a note in the 8 July issue of *New Scientist*. A piezoelectric crystal generates low-power ultrasound at about 20 kHz applied to a tooth brace attached to the damaged tooth.

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- Researchers at the University of Illinois and the University of Missouri-Rolla have built an ultrasound version of a laser, according to a story in the June 12 issue of *NASA Tech Briefs*. Called a uaser (pronounced WAY-ser for ultrasound amplification by stimulated emission of radiation), the instrument produces ultrasonic waves that are coherent and of one frequency. The device consists of piezoelectric auto-oscillators mounted on a block of aluminum, which serves as an elastic acoustic resonator. When an external acoustic source is applied, the oscillators synchronize to the frequency of the source. The device demonstrates, according to the inventors, that “the essential nature of a laser can be mimicked by classical mechanics—not quantum mechanics—in sound instead of light.”

- It is now possible to hear what the voice of the Mona Lisa would have sounded like, according to a story in *CNN.com* dated June 2. The chart of any individual’s voice, known as a voice print, is unique to that person, and a Japanese researcher believes he has achieved 90 percent accuracy in recreating the quality of the enigmatic woman’s speaking tone. In the Mona Lisa’s case, the lower part of her face is quite wide (which suggests a low voice) and her chin is pointed (which adds tones in mid-frequency).

- When it came out in December, the high-frequency sound of a device called Mosquito was supposed to be the sonic equivalent of a “no loitering” sign (see Acoustics in the News in the summer issue of *ECHOES*). Its annoying sound, which many adults can’t hear but most young people can, would act as a teen repellent. Now, according to a story in the June 14 issue of *The Washington Post*, teens are getting back at adults. Downloading the sound, or another ring tone in the same frequency range (around 17 kHz), allows them to hear their cellphones ring when their parents and teachers cannot. Traffic at one website which markets the tone, spiked as 100,000 kids tried to download the sound.

- “Balancing the art and science of sound” is the title of an article in the advertising supplement to the June 14 edition of *International Herald Tribune* that deals with opera houses. “It’s a myth that there’s a perfect acoustics” is a statement by an opera conductor with which many acousticians would agree. However, the definition of acoustics as “basically air vibrating in a cavity” is one with which there would be less agreement.

- Last year, according to the 11 July issue of the *Institute*, more than 1500 people joined the IEEE Women in Engineering (WIE) group, the largest annual growth in its history, bringing the total number of WIE members to about 12 000. Last year also saw the formation of 43 WIE Affinity Groups and Student Affinity Groups, the most ever established in one year, for a total of 103. Student IEEE membership increased by more than 8% last year, while membership in regular grades increased only 0.5%.

- Scientists at the University of Tromsø in Norway are investigating the “strange musical sounds” practiced by violinist

Mari Kimura, according to a story in the 6 July issue of the *World Science* home page. ASA members may recall that Roger Hanson and Fred Halgedahl explained these “anomalous low frequency” (ALF) violin sounds some 15 years ago, and Mari demonstrated them at an ASA meeting.

- A \$30 million Air Force memorial just west of the Pentagon which reaches 300 feet into the air required a special vibration damper, according to a story in the 17 July issue of the *Washington Post*. Early in the design process, wind-tunnel tests revealed that the wind could send the silver spires into a series of oscillations that could lead to catastrophic failure. The solution involved an exotic trick of physics. Hidden high inside the elegant metallic spires designed by James Ingo Freed, who also designed Washington’s Holocaust Museum, are 13 steel boxes, a stack of six in the tallest spire, four in the next and three in the last, which, although it is the shortest, still rises 201 feet above the ground. The boxes are about 2 1/2 feet on each side, and each contains a single, free-rolling, metal ball that is 20 inches in diameter and weighs nearly a ton. Those balls in boxes provide a unique energy-damping system that, although invisible to visitors, promises to keep the monument’s swaying within tolerable limits well into the 22nd century.

- Although the world seems to get noisier all the time, the hearing of Americans is not worse today than it was 35 years ago, according to a government study reported in the 30 June issue of *Science*. The study of some 5000 subjects reports that blacks have better hearing than whites, and women hear better than men.

- A dark horse has jumped into the race to solve the mystery of dark energy, according to a story in the August 12 issue of *New Scientist*. NASA has decided to fund the ADEPT probe, which will probe this unknown force by looking for the imprint of primordial sound waves. Until now, the front runners were missions that planned to study dark energy by looking for ancient supernovae, which is hardly surprising, since it was the study of supernovae in the 1990s that led to the discovery of dark energy. The ADEPT (Advanced Dark Energy Physics Telescope) probe, however, will look for sound waves that permeated the infant cosmos and helped to trigger the formation of galaxies. Astronomers have noted a repeating pattern of slight excesses of galaxies in the cosmos having a wavelength of a few 100 million light years.

- It’s a myth that there is a perfect acoustic,” Kent Nagano, the new music director at Munich’s Bayerische Staatsoper, is quoted as saying in the June 14 issue of the *International Herald Tribune*. Nagano, who succeeded Zubin Mehta, considers the Munich opera house to be “fantastic” for opera but not for symphonic concerts. When the orchestra leaves the pit to go onstage a specially designed acoustic shell is employed. Nagano says that the only way to know what the audience hears is by going into the seats oneself.

- Wavelets are being used to transform the haunting calls of whales into movies, according to a story in the August 1

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issue of *The New York Times*. According to engineer Mark Fischer, who learned about acoustics by developing software for Navy sonar, the images capture intricate details in the whale sounds that are not easily heard. Wavelets are capable of picking up auditory fingerprints that are unique to different species and even individuals within a group (see article on whale vocalization in the Summer 2006 issue of *ECHOES*). Some of the whale images can be viewed at <http://www.neoimages.net/artistportfolio.aspx?pid=1270>.

- The builders of the new organ in the Kimmel Center in Philadelphia call it the largest pipe organ in any concert hall in the United States, according to a story in the May 15 issue of *The New York Times*. The organ, built by Dobson Pipe Organ Builders of Lake City, Iowa, has 125 ranks with 6,938 pipes, some more than 40 feet in length. Oliver Latry, the organist at Notre Dame in Paris, who performed during the two-week opening festival, described the organ as “wonderfully versatile.”

- Flying mosquitoes may change the whining tone created by their wings to match those of potential mates, according to a note in the July issue of *Current Biology*. Researchers recorded the wingbeat frequencies of pairs of tethered tropical mosquitoes and found that both mosquitoes in an opposite-sex pair alter their wingbeat patterns until their flight tones are the same. By contrast, the noises made by same-sex pairs diverge in frequency. Males, who have more sensitive antennae, make wingbeat adjustments more quickly than female mosquitoes.

- Particle physicists have come up with a novel way to promote free, immediate access to journal articles, according to a note in the 1 September issue of *Science*. Led by CERN, the giant lab near Geneva, Switzerland, they propose to raise at least \$6 million a year to buy open access to all published papers in their field. Recently, the American Physical Society announced that a \$975 to \$1300 payment to its two main journals would make an article available to all readers. Elsevier, the other major particle physics publisher, announced an open-access option for \$3000. Nearly all particle physicists already share preprints of their articles on free servers such as arXiv.org at Cornell University, but the final article is still what academia values most.

- While most members of Congress are back home campaigning for reelection, according to a story in the 18 August issue of *Science*, a small group of staffers is at work in Washington on legislation that could influence science spending for years to come. Their goal is to craft a broad bill aimed at bolstering U.S. competitiveness that Congress could pass before the November election. The legislation draws upon several reports published over the past year, including the National Academies' *Rising Above the Gathering Storm*. Unlike appropriation bills, which determine how much each federal agency can spend in a given year, these bills set desired funding levels over several years and attempt to draw political support for ongoing spending increases.



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