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ECHOES

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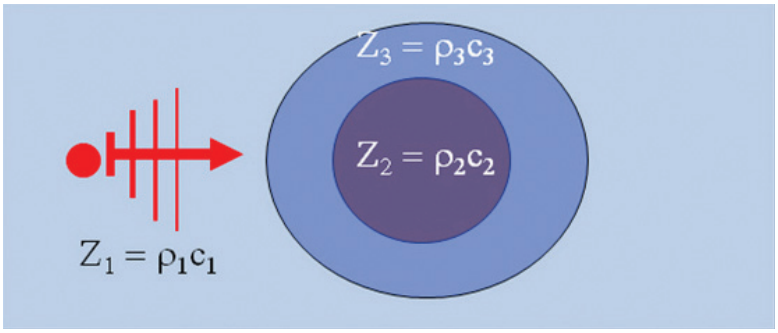
Acoustic Metamaterials

Thomas R. Howarth, Ph.D.

Acoustic metamaterials are one of the fastest areas of growth in the world of acoustics. At its roots, acoustic metamaterials are engineered materials designed to bend acoustic waves in a defined manner for specific acoustic applications. Metamaterials typically gain their material properties from structure rather than composition, using the inclusion of inhomogeneities to enact effective macroscopic acoustic wave propagation behaviors.



Acoustic Metamaterials Concept

As an acoustic wave propagates in a medium described by its acoustic impedance (Z_1), it typically spreads out in a spherical manner until it either decays or comes in contact with an object of a differing acoustic impedance (Z_2 or Z_3). The acoustic impedance in each medium is determined by its mass density (ρ) and speed of sound (c) where the speed of sound is related to the square root of the medium bulk modulus (K) divided by the mass density (ρ), hence, $c = \mathrm{SQRT}(K/\rho)$.

If the object of Z_3 has the same density ($\rho_1 = \rho_3$) and bulk modulus ($K_1 = K_3$) as the propagating medium of Z_1, then the acoustic wave continues into the Z_3 medium until it interacts upon the object described by the acoustic impedance of Z_2. If Z_2 and Z_3 differ, acoustic wave interaction occurs at the boundary.

The concept behind acoustic metamaterials is to manipulate the mass density and/or bulk modulus such that an acoustic wave propagating from the Z_1 medium into the Z_3 medium can bend or guide the incident Z_1 acoustic wave to: a) focus into the Z_2 object to form a defined acoustic interaction such as a superlens or b) to bend the acoustic wave while in the Z_3 medium to go around the Z_2 object without interaction.

This leads to the pursuit of developing materials that react with dynamic properties such that their mass density and/or bulk modulus appear to vary dynamically across a medium. The question now becomes, how can one alter the properties of a mediums mass density and/or bulk modulus to dynamically alter the propagation of acoustic waves in prescribed fashions?

Theoretical Approaches

A 2001 monograph chronicled the use of anisotropic layers in the design of "neutral inclusions" that resist detection (Ref. 1). The concept of pentamode materials (PM) was introduced as a class of acoustic metamaterials where mass densities are isotropic and bulk modulis are anisotropic.

The context of a double-negative (negative bulk modulus & negative mass density) was examined in a 2004 publication (Ref. 2). It was postured that an acoustic negative refractive index is possible as double negativity in acoustics can be derived from low-frequency single resonance structures.

Acoustic wave bending was examined by numerically deriving a general transformation for the density and the bulk modulus of a metafluid around a hard cylindrical scatterer (Ref. 3). The metafluid has an inhomogeneous bulk modulus coupled with an anisotropic and inhomogeneous mass density to transition an incident acoustic wave to bend around an object without interaction. This technique was later extended to 3D using coordinate transformations to obtain target values for either layered systems of fluids or fluids with theoretically continuously varying material properties featuring isotropic bulk moduli that are anisotropic in density (Ref. 4). This approach is known as 'inertial cloaks' (IC) to distinguish the anisotropic density nature of the metafluid. To create ICs, researchers are investigating multiple elastic layers (Ref. 5) and metafluids (Ref. 6).

Transformation techniques that mapped the scalar acoustic wave equation for pressure in an ideal fluid to a second scalar acoustic equation for acoustic pressure in a PM

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We hear that . . .

• The third symposium on **acoustical communication by animals** will be held at Cornell University, August 1-5. Invited speakers will include Peter Narins, Whitlow Au, Robert Dooling, Richard Fay, David Mann, David Mellinger, and other ASA Fellows. Sponsors include the Office of Naval Research, the Acoustical Society of America, and Cornell University.

• **Noral D. Stewart** received the highest award given by ASTM International, the Award of Merit which carries with it the honorary title of Fellow of ASTM. The award was presented by the Chairman of the ASTM Board at the meeting of Committee E33 in St. Louis on May 18, 2010.

• **Fred Dylla**, Executive Director of AIP, reports that AIP displayed publications from member societies (including ASA) at two European trade fairs: the Frankfurt Book Fair and London Crossroads. AIP manages more than 2500 subscription contracts and more than 2/3 of the institutions are outside the US.

Letter from the Editor

This is Issue 1 of Volume 21 of *ECHOES*. In 1991 the Public Relations Committee requested funds to publish two issues on a trial basis, and Charles Schmid and Alice Suter agreed to serve as editors. Alice continued as editor until 1997, when I became the editor. (All 20 years of *ECHOES* can be found on the ASA website). I have thoroughly enjoyed my editorial duties for the past 14 years, and I thank the many members and friends of ASA who send me news items about ASA and acoustics and occasionally write a letter to the editor (of which I would like more!)

I think everyone who attended the joint meeting in Cancun agreed that it was a fine meeting. The weather was beautiful, the program was stimulating, and the beaches were every bit as inviting as advertised for the 860 registered attendees.

Special thanks are due to the co-chairs Segio Beristain, James West, and Samir Gerges and the other organizers, as well as the ASA staff at Melville. The exhibits added much to the meeting, and we specially thank the exhibitors who expended extra effort to transport materials overseas and guide them through customs. We regret that some international students had difficulty obtaining visas.

We hope the UN Framework Convention on Climate Change which followed us in Cancun by two weeks was just as successful as our meeting.

International meetings are especially enjoyable and valuable to the acoustics community but they require special effort on the part of the organizers. In May 2012 ASA will meet jointly with Wespac in Hong Kong, and in June 2013 we will combine with ICA in Montreal. We hope that by the times of these meetings, international travel will be easier for all.

Thomas Rossing
Stanford University

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.

Echoes Editor . . . . . .Thomas Rossing
ASA Editor-in-Chief . . . . . .Allan Pierce
Advisors . . . . . .Elaine Moran, Charles Schmid

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From the Student Council

Alex Sell

Hola from sunny Cancun! Student attendance at this meeting was excellent with approximately 75 attendees at the student icebreaker, 175 at the student reception, and 40 at the new student orientation session. The goals of these events are to make students aware of all the opportunities available at ASA meetings, connect with each other and mentors, and have an opportunity to voice their opinions to the Executive Council through the Student Forum.

The Student Council would also like to congratulate Dr. Christy Holland, from the University of Cincinnati, who received the 2010 ASA Student Council Mentoring Award at the Wednesday night student reception. Nominations for the next award, to be presented at the fall 2012 meeting in Kansas City, are due by July 15, 2011. All nomination forms can be found on the ASA student website at www.acosoc.org/student.

Looking ahead, the spring meeting in Seattle promises to be an exciting meeting for students. In addition to our regular student activities, the Student Council will be hosting a special session entitled, "Introduction to Technical Committee Research and Activities: Especially for Students and First-time Meeting Attendees," which will feature brief talks by a representatives from each of the 13 Technical Committees. Thanks to all who participated in student activities in Cancun, and we look forward to seeing you at the upcoming Seattle meeting!

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Acoustic Metamaterials

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material, without making an equivalent requirement on the displacements in each media, were introduced in 2008 (Ref. 7) and 2009 (Ref. 8) publications. The implication is the concept of isotropic density with anisotropic bulk modulus to bend acoustic waves in prescribed manners.

A comparison of IC, PM and PM-IC metafluids was published in 2010 (Ref. 9). The material properties of the metafluid layers were based upon realizable values specified by continuously varying properties. The analysis considered acoustic wave bending for an incident plane wave scattering from an acoustically hard sphere.

Demonstrations

Acoustic metamaterials were demonstrated in a 2000 publication (Ref. 10) when experimentalists fabricated rubber-silicon coated lead spheres crystals in a liquid. The sonic crystals design featured localized resonant structures that exhibit spectral gaps with a lattice constant considerably less than the incident acoustic wavelength. This demonstration showed that localized resonant structures can behave as a material with effective negative elastic constants. A 1D acoustic waveguide was designed in 2006 with a cascade of subwavelength Helmholtz resonators (Ref. 11). The result is an effective negative bulk modulus near the system resonance frequency. These two resonance approaches demonstrate the concept of negative moduli can be realized and thus provide an initial insight into acoustic negative refraction and superlensing below the diffraction limit.

In 2007 a metamaterial was reported which simultaneously possesses a negative bulk modulus and a negative mass density (Ref. 12). Negative bulk modulus is achieved through monopolar resonances of bubble-contained-water spheres while dipolar resonances of gold spheres in the same structure produce a negative mass density effect. This demonstration shows the possibility of acoustic metamaterials for creating effects such as negative refraction and an inverse Doppler effect.

A 2009 experimental demonstration considered an ultrasonic metamaterial lens (Ref. 13). Similar to the 1D acoustic waveguide featuring an arrangement of Helmholtz cavities to produce a negative dynamic modulus (Ref. 11), this effort focused ultrasound waves through a flat acoustic metamaterial lens composed of a planar network of Helmholtz resonators. The demonstration showed a tight focus of half-wavelength in-width at a 60.5 kHz resonance by imaging a point source and it also displayed a variable focal length at different frequencies. The lens is made of sub-wavelength elements and is therefore potentially more compact than phononic lenses that operate in the same frequency range. Although high-resolution acoustic imaging techniques are essential tools for nondestructive testing and medical screening, spatial resolution of conventional acoustic imaging methods is limited by the incident wavelength of ultrasound due to the quickly fading evanescent fields that carry sub-wavelength object features. Using negative dynamic modulus acoustic metamaterials, the evanescent waves instead of decaying, are enhanced through the metamaterial. This permits recovery of additional imaging features, theoretically making a perfect image without any deterioration and thus, renewed hopes of overcoming acoustic diffraction limits. This suggests the possibility of designing compact and light-weight ultrasound imaging elements with the potential to significantly advance underwater sonar sensing and ultrasonic imaging for medical diagnostics.

Summary

Acoustic metamaterials feature techniques for the alteration of bulk moduli and density. The field is rich with opportunities for basic theoretical and experimental efforts as the realization of acoustic metamaterials will result in the acoustical engineering of new products and devices that will allow the user to guide acoustic waves in prescribed manners according to the desired application.

So, stay tuned as the subject of acoustic metamaterials is in its infancy!

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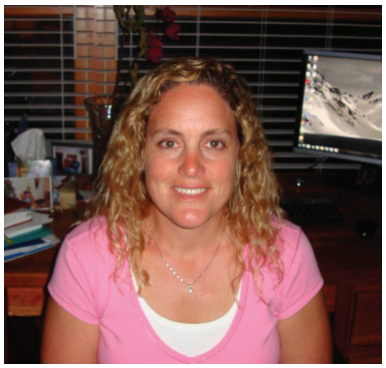
This article is based on paper 3pID3 at the 160th ASA meeting in Cancun. Dr. Thomas R. Howarth is the U.S. Navy's Senior Technologist for Acoustic Transduction. He is an ASA Fellow and former Chair of the Technical Committee on Engineering Acoustics.

Echoes from Cancun

Meet Wendy Adams, ASA's Education Coordinator



Wendy Adams (photo by son Alex).

Hello! I'm excited to have recently (Sept '10) become ASA's Education Coordinator. I was able to attend the meeting in Cancun where I met lots of really neat folks and was inundated with great ideas about education outreach projects that we can do together.

I am also in the Physics Department at the University of Northern Colorado in Greeley. I just finished teaching a capstone science course to pre-service elementary teachers. I live in Greeley (all my life) with my fiancé Bill Spencer and son Alex who has just turned 13. I began teaching at UNC in 1996 after receiving my masters in atomic physics at the University of Colorado (CU). After teaching intro physics courses for seven years, I discovered physics education research. I never imagined those three words would be spoken together! I went back to CU and got my PhD. in physics education research under the expert tutelage of Carl Wieman and stayed on after graduating to direct the PhET Interactive Simulations Project and serve as Director of Research for the Science Education Initiative. I missed teaching and I missed "doing" physics so here I am! I still visit the Carl Wieman - Science Education Initiative in British Columbia several times a year.

As I'm on a half time appointment, I've whittled the list of projects down to what is hopefully a reasonable amount for this coming year. The posters and guidebooks are nearly completed. We're actively working with the Optical Society of America to get the www.exploresound.org website live with a respectable amount of content by the end of the year. We've also put together a committee to work on creating and distributing activity kits that can be mailed to teachers or student chapters for outreach. In addition, I'll be working on assembling a second, identical, demo kit or "traveling road show" as Preston Wilson likes to call it! This will allow ASA members to use the demos for outreach and we can continue to host demo shows for girl scouts and shows for the public in general. I'm coordinating ASA's new partnership with the Noisy Planet project and am gathering info about what sorts of acoustics education work is being done at various institutions in the U.S. Oh, and we're also updating the graduate (and undergraduate) programs in Acoustics data base and updating its web access.

One of the most important aspects of all this work will be testing it with students and making sure it fits into what is known about how students learn. There's not much point in going through all this effort if the materials are not effective teaching tools! Thanks again, and I'm looking forward to the year to come.

Best student paper awards (Cancun)

Animal Bioacoustics
Brendan Rideout, University of Victoria

Acoustical Oceanography
First: James Traer, University of California, San Diego,
Second: David Barclay, University of California, San Diego

Engineering Acoustics
First: Scott Porter, Pennsylvania State University
Second: Eric Dieckman, College of William and Mary

Musical Acoustics
First: Chao-Yu Perng, Stanford University
Second: Charalampos Saitis, McGill University

Noise
Alan Wall, Brigham Young University

Speech Communication
First: Nancy Ward, UCLA
Second: Melissa Baese-Burk, Northwestern University

Structural Acoustics and Vibration
First: Ashley Cannaday, Rollins College
Second: Christina Naify, University of Southern California

Mexican dancers at opening session (photo by Charles Schmid)

Miguel Zenker (left) and Tom Rossing (right) arranged a guitar concert by Juan Carlos Laguna (center)

Books + Committee

David Bradley and Charles Schmid

Members of the Books+ Committee

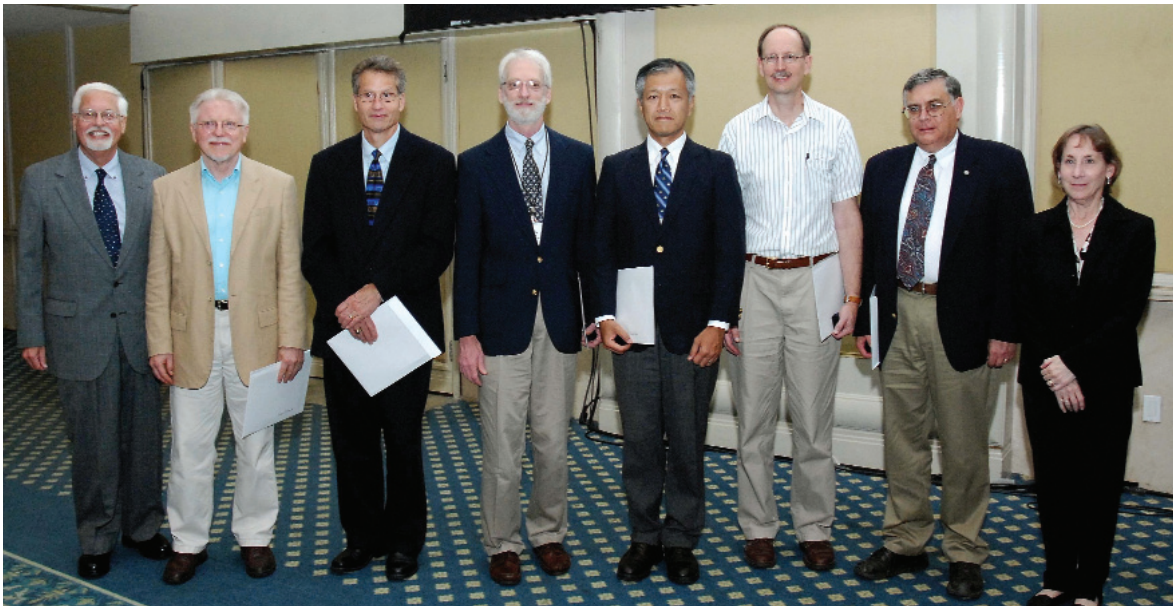
Front Row (L to R): James Candy, Richard Stern, Brandon Tinianov, David Bradley (Chair), Juan Arvelo Back Row: Philip Marston, Kenneth Foote, James Cottingham, Kim Benjamin, Jeffrey Nystuen, Allan Pierce, Michael Stinson (photo by Charles Schmid)

The Books+ Committee is charged with reviewing proposals for the reprinting of out-of-print books on acoustical topics as well as other types of publications including DVDs, CDs, and videos (hence the + sign). ASA has also published English translations of books originally published in other languages as well as collections of articles reprinted from a variety of prior publications. The Committee itself is composed of the Chair and other members appointed by the President, with the Editor-in-Chief as an ex-officio member.

A list of over 40 printed books, four e-books, and books and demonstrations in other media can be found at the ASA Store at http://asa.aip.org.

Proposals for the publication of out-of-print books by ASA are submitted to the Books+ Committee which evaluates the market for each book. If the reprinting appears to be worthwhile, the status of the copyright is first checked. If a copyright exists and is still in force, it must either be transferred to ASA or permission to reprint the book must be obtained from the copyright holder in order to go forward with the project. Fortunately many of the authors who hold and grant copyrights to these reprints are ASA members. Those books that are published for the first time require a review for technical accuracy before publication to insure a high standard. Again ASA is fortunate that authors of such books have prepared the material for publication on a voluntary basis. Other books, especially in the field of architectural acoustics, are based upon material which originated at special sessions held at ASA meetings, with the most recent example being *Acoustical Design of Theatres for Drama Performance*.

Once a book or other publication is approved by the Committee, it is submitted to the Executive Council via the External Affairs Council for final approval. If you have a favorite out-of-print book which you would like to see in print again, please contact the ASA [asa@aip.org] to obtain a book proposal form. The ASA makes every effort to publish high-quality publications and offer them at reasonable prices. The Society also has a strong desire to be a leader in the dynamic field of publication. If you have suggestions as to the use of other media or methods to insure that acoustical science and technology topics are publicized and made available to the general population, the Books+ Committee will be most pleased to consider your ideas.



Fellows: George Frisk (ASA President), William Brownell, R. Lee Culver, Timothy Duda, Toshio Irino, Bruce Newhall, Noral Stewart, Judy Dubno (ASA Vice President). Other new Fellows (whose names were read) are: H. Timothy Bunnell, Emily Buss, Cathy Ann Clark, Bertrand Delgutte, Donald Eddington, James Jenkins, Charlotte Reed, Mark Schaffer, and Mario Zampolli

Scanning the journals

Thomas D. Rossing

• Great concern has been voiced for at least 30 years about the sad state of U.S. primary and secondary **education in mathematics, science, engineering, and technology**, an editorial in the 28 May issue of *Science* reminds us. Potential remedies are a need for much better prepared math and science teachers and a clear statement of learnings goals that are the same across the United States. A unique time has arrived for achieving common, state-level science education standards in the United States, and the scientific community should step up as a vocal energetic advocate for common standards.

• Applications of the **Mortar finite element method in vibroacoustics and flow induced noise computations** are discussed in a paper in the May/June issue of *Acta Acustica/Acustica*. Mortar methods are discretization methods for partial differrential equations which use separate finite element discretization on non-overlapping subdomains and allow the coupling of two or more subdomains with quite different mesh sizes.

• "**Digitizing Sound: How Can Sound Waves be Turned into Ones and Zeros**" is the title of an article in the October issue of *The Physics Teacher*. An activity used in an applied physics class in high school includes recording their own voice, digitizing them in 8-bit coding, and creating a poster showing how a CD would record their voices as a pattern of bumps and pits.

• The prevalence of **hearing loss in teenagers** rose by nearly one-third in recent years compared with the rate in the early 1990s, according to a report in the August 18 issue of the *Journal of the American Medical Association*. The portion of U.S. adolescents aged 12 to 19 with hearing loss rose from 14.9 percent to 19.5 percent in 2005 and 2006.

• People who **sleep best through disruptive noises** produce brainwaves in their thalamus with the most spindles, according to a paper in the August 10 issue of *Current Biology*. Apparently the thalamus regulates sensory input to the cerebral cortex, so spindles may represent a dirct cause of oblivious deep sleep or at least they may help to guide treatments to the sleep-deprived.

• School is not where most **people learn most of their science**, according to an article in the November/December issue of *American Scientist*. Although it is important to improve and maintain the quality of science teaching in the schools, the average Americans spend less than 5 percent of their time in classrooms, and most science is learned outside of school. We are fortunate to enjoy a landscape filled with digital resources, educational television and radio, science museums, zoos, aquariumms , national parks, and community activities which make "free-choice" science learning available to young and old alike. Steadily accumulating research shows that out-of-school complementary learning opportunities are major predictors of children's development, learning, and educational achievement. The research also indicates that economically and otherwise disadvantaged children are less likely to have access to these opportunities. Children with parents who support learning at home do better than children with parents who do not.

• The principle of active noise cancellation, used in **noise cancelling headphones**, is being applied in sensitive detectors for gravity waves, according to a paper in *Physical Review Letters* **105**, 123601. The system uses coupling of mechanical and optical degrees of freedom in an optomechanical system of very high sensitivity.

• The 14 October issue of *Nature* has a special feature entitled **Science Masterclass** which questions and answers posed to 10 Nobel laureates including George Smoot (physics Nobel 2006) whose photo with acoustician Elizabeth Cohen appeared in the Spring 2007 issue of *ECHOES* and Peter Agre (chemistry Nobel 2003) who grew up next door to the Rossing family in Northfield, Minnesota. Questions were selected from those submitted by the public to a special nature website ranging from scientific questions about current research and theories to more general considerations about life, politics, funding, inspiration, and ephitaphs. Many laureates compared science—especially the peer review system with democracy: The system may have problems but no one has come up with a better way to do science.

• The **intensity of the earthquake that shook Haiti was amplified** along a narrow ridge of hard rock south of the central city according to a paper in *Nature Geoscience* posted online on October 17. Topographic amplification can occur due to constructive interference of waves within the wedgelike geometric structure of the ridge, combining to produce higher peak forces. The findings should help scientists and planners to map areas of the city at risk in future earthquakes and to develop microzonation maps.

• **Thin sheets of carbon nanotubes can generate sound under water** 100 times more efficiently than predicted theoretically, according to a letter in *Nano Letters* **10**, 2317 (May 27, 2010). Such sheets can generate sound in air when an electric current is applied by heating up and creating pressure waves in the surrounding air. When such a nanotube-based device is placed in water, a thin layer of air surrounds the hydrophobe sheets, providing a barrier against the water. This enhances the acoustic vibration and also prevents the water from degrading the nanotubes. The sound projection efficiency of nanotube sheets substantially exceeds that of much heavier and thicker ferroelectric acoustic projectors below 5 kHz.

• A **loudspeaker design for sound image localization** on a large flat screen is described in the July issue of *Acoustics Science and Technology*. In spite of its simplicity, a preliminary validation shows that the design effectively alters the radiated sound field so as to expand the listening area.

• "**The anti-science strain pervaiding the right wing in the United States is the last thing the country needs in a time of economic challenge**," reads an editorial in the 9 September issue of *Nature*. Rush Limbaugh, for instance, has told his viewers on Fox News that "science has become a home for displaced socialists and communists." US citizens face economic problems that are all too real, and the country's future crucially depends on education, science and technology as it faces increasing competition from China and other emerging science powers.

• Inaudible **infrasonic sounds generated by wind turbines** could influence the function of the ear, according to a review paper in the 1 September issue of *Hearing Research*. Although the sensory stereocilia on the inner hair cells (IHC) are "fluid coupled" to mechanical stimuli, so their responses depend on stimulus velocity, outer hair cells (OHC) are directly coupled to mechanical stimuli, so their input is

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Scanning the journals

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greater than the IHC at low frequencies. At very low frequencies the OHC are stimulated by sounds at levels below those that are heard. This raises the possibility that exposure to the infrasound component of wind turbine noise could influence the physiology of the ear.

- The **hydromonochord**, an interesting way to demonstrate string vibrations by water swirls, is described in a paper in the September issue of *The Physics Teacher*. The horizontal vibrating string just makes contact with the surface of a water bath so that the vibrational motion of the string sets up a pattern of swirls on the surface of the water. The water bath has two slits the width of the string on opposite ends so that they function as fixed bridges.
- The July/August issue of *Acta Acustica/Acustica* includes a special section on "**Natural and Virtual Instruments: Control, Gesture and Player Interaction**." In many bowed strings, brasses, reeds, and flutes, two feedback loops exist: the first allows for sound production and second its (real time) control by the player. Advances in acoustics have allowed deeper studies of the gestures used by instrument players.
- **Audio watermarking** refers to embedding extra data into an audio signal, generally for copyright protection. A paper in the September issue of *Acoustical Science and Technology* describes audio watermarking based on subband amplitude modulation at relatively low frequency. Detecting the existence of the watermark is difficult without knowing the key used in the encoding process, but yet the sound quality of watermarked music is comparable to MP3-encoded music.
- While **Wallace Clement Sabine** (1868-1919) is best remembered for his pioneering work in architectural acoustics, an article in the December issue of *The Physics Teacher* points out that he also was very much involved in the undergraduate laboratory teaching program at Harvard, and he was responsible for "Physics C," a Harvard laboratory course that was taken by high school teachers in the early 1890s. He published a manual with notes for 72 experiments, including one on the torsional pendulum. The catalog of the L.E.Knott Apparatus Co. of Boston lists a "Sabine's Torsion Pendulum for determining the torsional moment of a wire and the moment of inertia of a ring."
- Assassin bugs hunt spiders by **plucking the threads of spiderwebs** to draw the arachnids closer, according to a paper in *Proceedings of the Royal Society B* published online 27 October 2010. The vibrations mimic those generated by insects trapped in the webs, and are even at specific frequencies to avoid eliciting an aggressive response. The assassin bugs avoid producing higher frequency vibrations that could trigger a high-speed approach from the spider.

Acoustics in the News

- Quieter echolocation in some bats allows closer approach to eared moths according to a report in the September 11 issue of *Science News*. Western barbastelle bats in Europe typically ping out echolocation calls softly enough (about 94 dB) to locate a moth before the moth hears the predators coming. This bat version of whispering corresponds to a tenth to a hundredth the amplitude of echolocation calls of typical aerial-hunting bats.
- Researchers at Loughborough University in England reported that they have developed an electronic system that can warn of an impending landslide according to a story in the December issue of *IEEE Spectrum*. The system picks up the telltale sounds of shifting earth, barely perceptible movement at the underground plane known as the shear surface. It is possible to predict a landslide by checking for sounds made by particles rubbing against one another at the shear surface. Hollow pipe inserted in a hole deep enough to reach the shear plane serves as a waveguide. Besides acting as an early warning system, the device can be used to measure the effectiveness of efforts to stabilize soil, such as draining or regrading.
- A professor of science broadcast journalism in Canada attacks the information policies of Conservative Prime Minister Stephen Harper in an editorial in the 30 September issue of *Nature*. A policy enacted in March stipulates that all federal scientists must get pre-approval from their minister's office before speaking to journalists who represent national or international media. Researchers have been prevented from sharing their work at conferences, giving interviews to journalists, and even talking about research that has aready been published.
- Observing baryon acoustic oscillations is one technique that astronomers have used to distinguish between competing ideas about the nature of dark energy according to a news note in the 30 September issue of *Nature*. In the early Universe, sound waves traveled through space, leaving behind patterns in the large-scale arrangement of baryons (protons and neutrons). These patterns can be used as a sort of cosmic ruler to estimate how dark energy has stretched the Universe over time.
- The Obama Adminisstration received reports from two presidentially appointed bodies on how to improve math and science education in U.S. elementary and secondary schools, according to a story in the 24 September issue of *Science*. The President's Council of Advisors on Science and Technology (http://bit.ly/pcast-on-stem) report offers vision of how to accomplish Obama's goal to lift U.S. students from the middle to the top of the pack by the end of the decade. The other report (http://bit.ly/nsb-on-innovators) by the policymaking body for the National Science Foundation, says the country needs to be more concerned about the high end of the student population, namely those most likely "to become leading STEM professionals."
- The U.S. Senate confirmed Subra Suresh as direcctor of the National Science Foundation. Suresh, who served as Dean of Engineering at the Massachusetts Institute of Technology, replaces nuclear engineer Arden Bement.
- Using a laser turntable manufactured by ELP in Japan, old LPs can sound as good as new, even when cracked in half, according to an article in the March issue of *IEEE Spectrum*. The turntable uses five lasers instead of a physical tone arm and stylus. Proponents claim that these devices, which cost $10,000 to $15,000, can capture the warmth of vinyl while still hitting the frequency response of modern CDs.
- Sculptor Conrad Shawcross's musical sculpture "Fraction

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Acoustics in the News

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(9:8)" is reviewed by art professor Martin Kemp in the 14 October issue of *Nature*. The sculpture follows the tradition of Pythagoras (who believed that everything was governed by numbers), the plates of Chladni, and the harmonograph of Scottish mathematician Hugh Blackburn (which has two adjustable pendulums swinging at right angles to one another). Shawcross's sculpture, which hangs in the Oxford Science Park, was "designed" by using a harmonograph with the pendulums adjusted to a frequency ratio of 9:8, corresponding to a musical interval of a major second.

• Complaints about noise are becoming a growing problem for advocates of wind turbines, according to a story in the 13 August issue of *Science*. Wind developers in the United States, the United Kingdom, Canada, and New Zealand have all faced vehement local opposition due to noise. Turbine blades that spin faster make more energy more efficiently, but they also make more noise, so there's always a tradeoff between efficiency and noise. There is some evidence, however, that people tend to accept wind farms over time; the older a project is, the more the turbines are accepted.

• Daily sessions of whole body vibration in 18-month old male mice (which are equivalent to humans of age 55 to 65) appear to forestall loss of bone mass that can result in fractures, disability, and death. According to a report in the October 25 issue (online) of *Science Daily*. To see if these findings translate to the trauma clinic, researchers are evaluating vibration tolerance in patients with lower–limb fractures. While vibration lacks the cardiovascular benefit of exercise, animal and human studies have shown that it can improve muscle strength and weight loss.

• Two scientists, who won Nobel prizes in physics and later turned their attention to science education, are honored in the 29 October issue of *Science.* Born in Poland, Georges Charpack lived most of his life in Paris where he launched a program called "La main a la pate" (hands in the dough) that involved teaching so that children learned by doing. Carl Wieman, who received the 2001 Nobel prize for creating the first Bose-Einstein condensates, has spent more than a decade understanding how students learn. He began his work on improving undergraduate science instruction at the University of Colorado, and later at the University of British Columbia. In Septembeer he was appointed associate director for science in the White House Office of Science and Technology Policy.

• The micronium, tiny musical instrument is made up of springs that are only a tenth of the thickness of a human hair, played a leading role at the opening of a two-day scientific conference on micromechanics in the Atak music venue in Enschede, The Netherlands on September 27, according to a story in *Science Daily* (online) for Sept. 29. A composition has been specially written for the instrument: "Impromptu No. 1 for Micronium" by Arvid Jense, who is studying MediaMusic at the conservatorium in Enschede.

• New technology developed in Norway makes it possible to zoom in on sound in much the same way that photographers can zoom in on an image according to a story in *Science Daily* (online) Oct. 5. by adapting a well-known marine sonar technology physicists have developed an intelligent, sharply focused directional microphone system that enables TV producers to zoom their audio reception, much like they can zoom their camera lenses for close-ups. The microphone system is ideal for use during conferences and video conferences, since it identifies the source of the sound, then isolates the speaker's voice. When a speaker moves about the stage while communicating to the audience, for example, the microphone tracks him.

• China now has the world's fastest computer, according to a story in the 18 November issue of *Nature*. The Tianhe-1A computer, housed in the National Supeercomputer Center in Tianjin, achieved 2.57 petaflops (2.57s1015 floating point operations per second, eclipsing the US Department of Energy's Jaguar system at the Oak RidgeNational Laboratory.