

ECHOES

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Probing for an ocean on Jupiter's moon Europa with natural sound sources

Will the acoustic techniques we use to probe our own oceans on Earth one day be used to probe oceans on another world? I sometimes wondered this, but never thought I would live to see the day that it may happen. Well, I still may not live to see that day, but the odds are very high that my students will! All bets are on that these techniques will be used on Jupiter's moon Europa in the next couple of decades. It is equally fantastic that work done in a particularly specialized and environmentally extreme area of acoustics, known as arctic acoustics, now provides a vital link to the search for extraterrestrial life.

Europa is one of four Jovian moons. It was discovered by Galileo in one of his first uses of the telescope in 1610. Europa is roughly the size of earth's moon but is much brighter since, with its albedo of about 0.64, it scatters more than half the light it intercepts. Its brightness stems from the fact that its surface is completely covered with frozen water. What is remarkable about Europa is that below this ice sheet may lie a dark ocean of salty water that exceeds the volume of all terrestrial oceans combined. This makes Europa probably the most likely world outside of our own for life to exist as we know it.

What are the current hypotheses about Europa's interior composition? Europa is covered with a layer of ice and possibly liquid water that is roughly 100-200 km thick above a silicate and iron core. Its radius is roughly 1500 km, about 1/4 that of the Earth. Most planetary scientists agree that the outermost surface of Europa is a brittle ice sheet that is roughly 5 km thick.

What stimulates most of the debate is what lies beneath this layer. At one extreme is a thin shelled model and at the other is a soft convective ice model. Proponents of the former argue that a liquid ocean at least 100 km deep lies directly below the brittle ice. Those in favor of the latter argue that there is no liquid ocean below but only mushy ice that extends to the moon's core. The middle ground, which seems to be

most popular, is taken by those who believe that about 40 km of soft convective ice lies below the brittle surface and beneath this is an ocean of liquid water that extends for 5 to 100 km to the moon's core [1].

What evidence is there for an ocean on Europa? Perhaps the strongest evidence for a liquid ocean on Europa comes from magnetometer data collected during the Galileo probe's orbit [2]. Apparently Europa's magnetic pole flips direction like a big compass as the moon orbits around Jupiter's immense magnetic field. The magnitude of this field change indicates that the surface of Europa has a conducting layer that is at least 6 km thick. A salty ocean would fit the bill but warm slushy ice would probably not.

Other evidence comes from optical images of Europa from the orbiting Voyager probe of the early 1970s and the Galileo probe of the mid 1990s. These revealed a large number of surface cracks and craters on Europa's surface, some extending for thousands of kilometers, that have apparently been healed by liquid water or soft ice oozing up from below.

How does acoustics come into the picture? Electromagnetic waves are quickly attenuated in water, so the primary tool for probing the depth and structure of our terrestrial oceans is with sound. At low frequency, sound waves can propagate thousands of kilometers across an ocean. For example, humpback whales vocalizing as far away as Greenland have been readily tracked using acoustic listening stations in Bermuda.

Ice-penetrating radar has been used to determine the thickness of glaciers on Earth. Our expectation, however, is that such radar waves will be scattered away long before they reach a potential ice-ocean interface on Europa. This is because the radar wavelengths are on the order of one meter while the scale of surface and subsurface fractures and anomalies is on the order of at least 100 meters.

Our plan is to use both acoustic echo-sounding and tomographic techniques to probe Europa's interior. Echo-sounding

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We hear that...

● **ACTIVE 2002**, an international symposium on Active Control of Sound and Vibration will be organized by the Institute of Sound and Vibration Research (ISVR) and held at Southampton University, July 15–17, 2002. General chair for the symposium is Professor Stephen J. Elliott of the ISVR Signal Processing and Control Group. The format of the meeting will follow previous ACTIVE symposia with full-length papers being available to delegates at final registration. The Call for Papers is available at <www.isvr.soton.ac.uk/ACTIVE2002>.

Student News

by Micheal L. Dent

The student council is in the process of implementing a number of additional benefits for students involved in the ASA. These include a student website, mentoring awards, cheap travel options to ASA meetings for students, and career information. Some of these benefits are already available to students—if you know where to look. Travel subsidies are easy to apply for and cheaper hotel information is available about a month before the meeting by contacting Elaine Moran. Many of the technical committees have already added student sections and student news to their own web pages. At the next meeting, a handout will be given to all students with information about events and activities that students should attend to get the most out of their meeting experience.

Student attendance at the last meeting was high—approximately 26% of all meeting attendees in Chicago were students, while only 12% of the ASA membership body consists of students. The Best Student Paper competitions are heating up—many committees report increased submissions. The winners of the competitions at the Chicago meeting are listed below, congratulations to all (as of press time, some committees had not yet reported winners). I again urge all students to enter the next competition—it is not often that you can make several hundred dollars for fifteen minutes of work in this field!

AO: Kyle Becker (1st Place) from the Woods Hole Oceanographic Institute; BU/BV: Oliver Kripfgans (1st Place) from Univ. of Michigan, Sandy Polaichik (2nd Place) from U. Wash/APL, Mark Haun (3rd Place) Univ. of Illinois; MU: Daniel Ludwigsen (1st Place) from Brigham Young Univ.; PA: Mark Marr-Lyon (1st Place) from Washington State Univ., Ray Scott Wakeland (2nd Place) from Penn State Univ.; SP (Young Investigator Award): Patrick Wolfe (1st Place tie) from Cambridge Univ., Corey Cheng (1st Place tie) from Univ. of Michigan; SC: Om Deshmukh (1st Place) from Boston Univ.; SAV: Paulo Alves (1st Place) from State Univ. of Campinas in Brazil, Sondipon Adhikari (2nd Place) from Cambridge Univ.; UW: Karim Sabra (1st Place) from Univ. of Michigan, Luc Lenain (2nd Place) from Univ. of Delaware, Preston Wilson (3rd Place) from Boston University.

Micheal Dent is the Animal Bioacoustics representative to the Student Council, and a Ph.D., student at the University of Maryland.

To the Editor

Special issues of *Applied Acoustics*

I note that in *ECHOES* you highlighted the recent Special Issue of *Acustica*. Please note that *Applied Acoustics* (Elsevier) has been contributing Special Issues since 1989. Neville Fletcher edited one on Musical Instrument Acoustics in 1996. Recent ones are: Sound Intensity Measurement—Feb. 1997, Insect Acoustics—April 1997, Underwater Ambient Noise—July 1997, Building Acoustics—Dec. 1997, Aircraft Noise—Oct. 1998, Military Acoustics—Feb. 2000, Surface Diffusion in Room Acoustics—June 2000, Automotive Noise and Control—Aug. 2000, Mechanical Source Identification—Nov 2000, and Spatial Impression—Feb. 2001.

*Keith Attenborough
Editor-in-Chief, Applied Acoustics
Department of Engineering, The University of Hull*



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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Student Design Competition

by Lily Wang

The Acoustical Society of America Technical Committee on Architectural Acoustics and the National Council of Acoustical Consultants sponsored a student design competition, judged at the 141st ASA meeting in Chicago, June 2001. The project involved the preparation of a schematic design for a college performing arts center with emphasis on room acoustics and noise control. There were 17 posters submitted from 10 different schools. This year's panel of judges included: Mark Holden (Jaffe Holden Acoustics), Gary Madaras (The Talaske Group), Ron McKay (McKay Conant Brook), Dawn Schuette (Kirkegaard Associates), and Leslie Ventsch (Skidmore Owings & Merrill).

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Probing for an Ocean...

(continued from page 1)

reveals the depth and composition of the seafloor and sub-bottom layers by analysis of the arrival time and amplitude of acoustic reflections from these interfaces. Tomography reveals the temperature structure of the ocean by the way sound waves are perturbed along forward propagation paths. Multiple sources and receivers are typically required to probe a large volume of ocean by tomography. On Europa, our goal is to use echo-sounding to determine the thickness of the ice layer and the depth of the potential ocean. We also hope to use tomography to invert data for the temperature structure of Europa's ice or water layers since this temperature information holds vital clues for the existence of life as we know it.

We plan to exploit natural cracking events on Europa's surfaces as sound sources of opportunity. Recent work in the planetary science community shows that cycloidal cracks on the surface of Europa likely form on a daily basis [3] due to stresses induced by Europa's eccentric orbit which has a period of roughly 3.5 days. The resulting tide is expected to have an immense amplitude of roughly 30 meters leading to tensile stresses on the order of 40 kPa, equivalent to the kind of pressure experienced at roughly 400 meters below a terrestrial ocean's surface. These cracks typically have arcs that extend for hundreds of kilometers and probably propagate at a rate of about 3.5 km/hour. We estimate that along a given active cycloidal feature, cracks will form about every 30 seconds and will extend about 100 meters in depth. We also estimate that the acoustic waves radiated from these cracks will be in the 0.1-100 Hz range with typical wavelengths exceeding 1 km. In contrast to ice-penetrating radar, inhomogeneities such as ice fractures should be transparent to such long acoustic wavelengths. Meteor impacts typically occur at a monthly rate and also have potential use as sound sources.

According to current plans at NASA, the first Europa landing mission is probably two decades away and will likely only carry a single acoustic sensing device. Many valuable measurements can be made with a single sensor. For example, the first task should be to determine the level of acoustic activity on Europa by time series and spectral analysis. Correlations should be made of ambient noise level versus tidal stress to determine whether noise levels respond directly to orbital eccentricities. I have actually conducted such an analysis of noise levels in the Arctic Ocean using hydrophones suspended underwater from drifting pack ice for my PhD thesis at MIT in the 1980s. A near perfect correlation was found between underwater noise level and wind, current and drift stresses and moments applied to the ice sheet.

Estimates can be made of Europa's ice and ocean depths even with a single acoustic sensor. This can be done by first finding the range to an isolated cracking event by comparing compressional and shear wave arrivals and then exploiting subsequent echoes to determine ice and ocean thicknesses.

With later NASA missions, more sensors will inevitably be available and more robust inversions involving triangulation, matched field processing and tomography can be employed.

We are presently investigating the robustness of these various acoustic sensing techniques with fully elastic 3-D models developed for arctic acoustic propagation and scattering. One of the primary issues is that of signal-to-noise ratio. To determine conditions in which ambient noise from the sum of a large number of cracking events distributed over a wide area may overwhelm signal echoes from a distant ice-ocean or ocean-core interface, we have developed a European waveguide noise model that is based on classical ocean acoustic noise models. Our present simulations indicate that signal echoes from an ice-ocean interface and ocean-core interface can stand robustly above European ambient noise if the spatial distribution of active surface cracks is on the order of a typical cycloidal crack length.

I am often asked how an ocean acoustician became involved in an extraterrestrial problem. It began when NASA's scientist in charge of the Europa program gave a talk at my weekly freshmen seminar entitled "Acoustical Oceanography." Plans for the current NASA landing craft included a device to melt through a very thick ice sheet. I mentioned the idea of using remote acoustic sensing techniques and natural sound sources as possible alternatives. We were invited to give a talk at NASA and have been working with the planetary science community ever since.

With me on this project are my MIT graduate students Sunwoong Lee, Purnima Ratilal, Josh Wilson, Yisan Lai and Post-Docs Aaron Thode and Michele Zanolin. We have more recently been collaborating with planetary scientist Prof. Robert Pappalardo of the University of Colorado. The work is partially funded by the Office of Naval Research under my Secretary of the Navy/Chief of Naval Operation Scholar of Oceanographic Sciences award.

References

- [1] Pappalardo, R. T., *et al.*, "Does Europa have a subsurface ocean? Evaluation of the geological evidence," *Journal of Geophysical Research*, E, Planets **104**, 24, 015-24, 055 (1999).
- [2] Kilvelson, M. G., Khurana, K. K., Russell, C. T., Volwerek, M., Walker, R. J., Zimmer, C., "Galileo Magnetometer Measurements: A stronger Case for a Subsurface Ocean at Europa," *Science* **289**, 1340-43, 25 (2000).
- [3] Hoppa, G. V., Tufts, B. R., Greenberg, R., and Geissler, P. E., "Formation of Cycloidal Features on Europa," *Science* **285**, 1899-1902 (1999).

Nicholas Makris is a professor in the Department of Ocean Engineering at the Massachusetts Institute of Technology. He served as a Research Physicist in the Advanced Acoustic Concepts Section of the Naval Research Laboratory, Washington, DC from 1991 until 1997 when he joined the faculty of the Acoustics Group at MIT. He was named Secretary of the Navy/Chief of Naval Operations Scholar of Oceanographic Sciences in 1998.

A Microphone Array for Hearing Aids

by Bernard Widrow

There is a big difference between hearing speech and understating speech. Most hearing-impaired people will be able to hear speech when given sufficient amplification from their hearing aids. In many cases, however, they will hear but will not understand.

There are limitations to the benefits of amplification alone. In a noisy place, hearing aids will amplify the noise as well as the desired speech signal. In a reverberant place, hearing aids will amplify late multipath arrivals as well as the direct first-arrival signal. Furthermore, feedback associated with high output hearing aids distorts the frequency response of the hearing aid (which was carefully tuned to compensate for the individual's hearing loss) and sometimes causes oscillation.

A microphone array for hearing aids is described that overcomes some of these limitations and has the capability of enhancing speech understanding for hearing-impaired patients. The microphone array is worn on the chest as part of a necklace, in accord with the diagram of Fig. 1. A processed signal from the array drives current through a conducting neck loop thus creating a time-variable magnetic field that is representative of the received sound. The magnetic field provides a wireless means for carrying the sound signal to conventional hearing aid devices located in the ears of the wearer. In order to receive the signal, the hearing aid must be equipped with a "telecoil," a small induction coil contained within the hearing aid whose output can be switch selected by the wearer to serve in place of the hearing aid's microphone signal. When

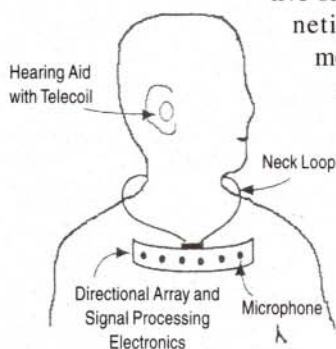


Figure 1. Chest-mounted "necklace," directional microphone array with neck loop, and hearing aid with telecoil.

switching the hearing aid to telecoil position, the wearer hears the sound received by the array. When switching the hearing aid to the microphone position, the wearer hears the usual sound received by the hearing aid's own microphone.

The original purpose of the telecoil was to enable the hearing aid wearer to converse over the telephone. A hearing-aid compatible telephone receiver radiates a time varying magnetic field corresponding to the telephone signal. This is generally leakage flux from the receiver. Using the telecoil, many patients can hear over the telephone much more effectively. We are able to take advantage of the telecoil, which is commonly available in the most powerful behind-the-ear hearing aid types, to provide a wireless link between the chest-mounted array and the hearing aid. Telecoils can be fitted to almost all hearing aids.

Use of the array enhances the patient's hearing in the following three ways:

- (1) The array enhances signal-to-noise ratio. The patient aims his or her body toward the person to be listened to. The array beam is 60° wide in both azimuth and elevation. The sound in the beam is enhanced relative to the surrounding sound. The speech of interest is enhanced relative to omnidirectional background noise by about 10 dB, from about 200 Hz to 6 kHz. The gains of the array sidelobes vary between 20–35 dB below the gain at the center of the main beam.
- (2) The array, which reduces the effects of reverberation, is generally steered toward the sound of interest. The direct primary path is thus aligned with the beam. The secondary paths for the most part arrive at angles outside the beam and are thus attenuated by the array. Reducing reverberation enhances sound clarity since the ear and the brain are somewhat confused by multiple arrivals. This is specially the case with hearing impaired individuals.
- (3) Use of the array reduces feedback by about 15 dB, since the chest is at a much greater distance from the hearing-aid loudspeaker than is the microphone on the hearing aid itself. Reduction of feedback makes available louder sound for the patient, without oscillation, and allows the hearing aid to function with a frequency response closer to the desired compensation curve.

The current array design and geometry is shown in Fig. 2. The device is comprised of an array of six microphones, four pushbuttons for control, and a plastic case designed to fit both the adult male and female torso. The plastic case was designed by computer, completely specified in software. It contains batteries and all of the signal processing electronics. Two custom chips were designed for this device, one for signal processing and the other to serve as an interface between a PC computer and the signal processing chip when this chip is being programmed.

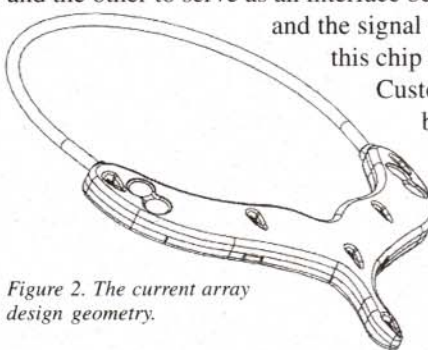


Figure 2. The current array design geometry.

Custom chips were needed because of the tight space requirements and the requirements for low battery drain.

In this device, the audio spectrum from 200 Hz

to 6 kHz is divided into twelve bands, each with its own digital gain control. The six microphone signals are amplified and weighted and then fed to each of the twelve band-pass filters. Different microphone-signal weightings were designed for each frequency band so that the beam width was able to be held at approximately 60° over the entire frequency range of interest. The microphone weights were designed off-line by using adaptive beamforming techniques to achieve the desired beam shape and to achieve a specified robustness to inherent

A Microphone Array for Hearing Aids

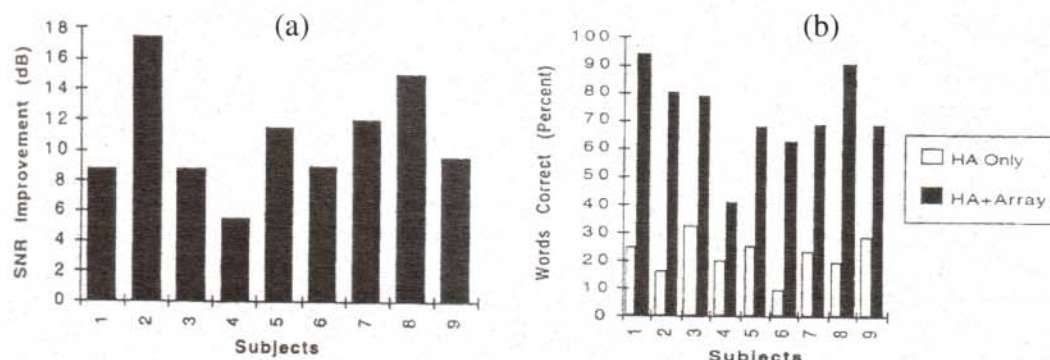


Figure 3. Results obtained on HINT and Intelligibility tests. (a) Magnitude of improvement in sentence speech recognition threshold in noise (HINT) with the microphone array, in comparison with the hearing aid alone. (b) Percent speech intelligibility in the presence of noise. For each test subject, the hollow bar is the result obtained using the hearing aid and the solid bar is the result using the array with hearing aid.

variations in microphone characteristics. A least square error criterion was used for the design. Anechoic chamber testing was used to verify the design. Theoretical and measured beam patterns turned out to be remarkably close.

U.S. Patent number 5,793,857 has been granted to Michael A. Lehr and Bernard Widrow for this technology. Canadian, European, and Australian patents have been granted, and patents are pending in other countries.

Patient testing was performed to evaluate the effectiveness of the microphone array and to compare listening with the hearing aid alone with listening to the array and hearing aid in telecoil mode. The patient was seated before a loudspeaker that carried the sound of a male test voice. Four loudspeakers on the floor in the four corners of the room carried spectrally weighted bandpass noise. Four additional loudspeakers in the four corners at the ceiling were also used to carry the same noise. The room was not anechoic but had some sound damping. The noise carried by the eight corner loudspeakers produced a noise field that was approximately isotropic.

The test voice and the test noise were stored in a PC computer. The voice and noise data were obtained from Dr. Sigfrid Soli of the House Ear Institute in Los Angeles. We performed a modified version of his HINT test (hearing in noise test).

With the patient seated at a prescribed location marked on the floor, the volume control of the hearing aid and the volume control of the array were set so that the measured volume delivered to the patient's ear would be the same when listening to the test voice through the hearing aid and through the array. The volume level of the test voice was set to be comfortable for the patient, in the absence of noise.

Word phrases were spoken to the patient by the test voice, with some noise applied. The patient was asked to repeat the words. If any word in the phrase was repeated incorrectly, the response was considered to be incorrect. The noise level was reduced by 2 dB, and another randomly chosen phrase was read. If the response was incorrect again, the noise was lowered by another 2 dB and so forth. When a correct response was obtained, the noise level for the next phase was raised by 2 dB. If another correct response was obtained, the noise level was raised by another 2 dB and so forth. The noise level went

up and down, and the average noise level was observed over ten or twenty phrases.

The average noise level when using the hearing aid was compared to that when using the array. The improvement in signal-to-noise ratio when using the array is plotted in Fig. 3 (a) for nine test patients. This improvement averages more than 10 dB, which is consistent with anechoic chamber measurements and theoretical calculations.

Other testing was done with the noise volume fixed and the volume level of the test voice fixed. Individual words randomly selected were presented by the test voice. The responses of the patients were observed when using the hearing aid, and when using the array. The results are shown for the same nine patients, in Fig. 3 (b). Patient # 1 had a 25% correct response with the hearing aid, and a 95% correct response with the array. Patient #2 had a 15% correct response with the hearing aid, and 80% correct response with the array. And so forth. These improvements are rather dramatic.

One young woman in Palo Alto, CA, has been wearing one of these devices on a daily basis over the past five years. As the design evolved, she always had the latest for testing. She is totally deaf in one ear and is 95–105 dB below normal in her "good" ear. Using her hearing aid and with good lip reading, she can correctly recognize zero to two words in a typical long sentence. With her hearing aid and an array, she gets essentially every word. She can do very well even with her eyes closed. Her hearing loss is in the profound range. Hearing losses are generally characterized as mild, moderate, severe and profound. The array will find its best application with the difficult cases, the severe and profound ones.

The microphone array devices are being manufactured by Starkey Laboratories, 6700 Washington Ave, Eden Prairie, MN, 55344, U.S.A. They are the most powerful hearing devices on the market. It remains to be seen how well they will be accepted by the hearing impaired community.

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Echoes from Chicago

More than 1300 attendees at the 141st meeting of the Acoustical Society learned that Chicago weather changes fast. But the cold breezes off Lake Michigan the first couple of days didn't really affect most attendees who were totally immersed in the rich menu of acoustical papers and events. Besides 108 sessions with 1026 papers, there were committee meetings, buffet socials, an awards session, a distinguished lecture, a tutorial, a short course, and lots of interesting poster presentations.

Architectural acoustics was especially prominent at this meeting, with 10 special sessions, including some fine poster displays. In addition, the Technical Committee on Architectural Acoustics co-sponsored a student design competition (see the report on page 2) and a walking tour of three remodeled theaters in the Loop (downtown area). Acoustics education also was a prominent theme, with four special sessions, including a session of hands-on demonstration experiments for high school students, an undergraduate research poster session, a "take-five" session, and a tutorial lecture on Demonstration Experiments for Teaching Acoustics.

Bernard Widrow's (Stanford University) distinguished lecture on "A microphone array for hearing aids" included dramatic demonstrations of the device with normal and hearing impaired subjects (see paper on page 4). The "hot topics in

acoustics" session included reports on new architectural materials, new methods for measuring and controlling noise, optical imaging of surface vibrations, and an analysis of papers in *JASA* from 1970 to 1999. Ira Hirsh lectured on the "History of Psychological Acoustics," and Murray Sachs presented a lecture on the "History of Physiological Acoustics."

At the Awards Session, Herman Medwin received the Gold Medal, William Hartmann was awarded the Helmholtz-Rayleigh Interdisciplinary Silver Medal, and Andrew Oxenham received the R. Bruce Lindsay Award. Incoming president William Hartmann presented outgoing president Katherine Harris with a ceremonial tuning fork.

At right, William Hartmann presents a tuning fork to Katherine Harris.



At left, Gold medalist, Herman Medwin with his wife, Eileen.



Chicago area physics teachers who demonstrated at the tutorial lecture.



Twirly hose demonstration.

Barry Larkin, demonstrates "The Wing" at Experimental Musical Instruments Session.



Scanning the Journals

- Physicists at the Ecole Normale Supérieure in Paris have observed an **acoustically driven liquid-solid transition** in helium, according to a paper by X. Chavanne, *et al.* in *Physical Review Letters* (86, 5506). The researchers focused a short, powerful burst of 1-MHz ultrasound in a small region of liquid helium near a clean glass plate and monitored the helium density with a laser. During the positive overpressure portion of the ultrasound, crystallites were observed growing up to 15 μm in size. The crystals grew in a mere 150 ns and melted some 250 ns later when the negative pressure swing took place. The researchers believe that they can generate helium crystals without the glass plate in more powerful sound waves.
- Fruit flies have antennae that are capable of **picking up sound** as well as smell, according to a paper by Daniel Robert and Martin Göpfert in the 21 June issue of *Nature*. The scientists, who wrote about active auditory mechanics in mosquitoes in the Spring issue of *ECHOES*, used a laser-based motion detector to track vibrations in the arista of *Drosophila*. They found that the arista oscillates as a whole and sets the larger part of the base moving. The happy partnership of the senses enables a fruit fly to perceive complex sets of signals, including smelling and tasting.
- Magnetoencephalography has been used to study the way the **brain processes speech and music**, according to a paper by Burkhard Maess *et al.* in the May issue of *Nature Neuroscience*. The authors report that the brain response to "wrong" musical sequences differed from the response to musically coherent sequences. The difference in response was localized to a brain region known as Broca's area which is involved in the analysis of linguistic syntax.
- During its first 100,000 years, according to the Inflationary Hot Big Bang model of cosmology, the universe was a fully ionized plasma with a tight coupling between photons and matter. The trade-off between gravitational collapse and photon pressure caused **acoustic oscillations** in this primordial fluid, according to a paper by Christopher Miller, *et al.* in the 22 June issue of *Science*. Evidence of these acoustic oscillations has been observed in the cosmic microwave background which is the radio remnant of the hot early phase of the universe.
- **Localization in binaural recordings** made with artificial heads is inferior to real-life localization as well as to localization in binaural recordings made in the ears of selected humans, according to a paper by Pauli Minnaar, *et al.* in the May issue of the *Journal of the Audio Engineering Society*. In a series of experiments it was shown that artificial heads are still not as good for binaural recording as a well-selected human head, although some of the new artificial heads approach the performance of human heads.
- The early **universe rang like a bell**, but according to an article by Ron Cowen in the April 28 issue of *Science News*, it wasn't until recently that scientists appreciate the full richness of that ancient ringing. Before the universe was 300,000 years old, it was so hot that atoms and electrons were separate. Whenever gravity caused matter to compress, the pressure exerted by trapped photons offered resistance, and the tug-of-war between gravity and radiation pressure generated acoustic oscillations. Cosmic inflation theory predicts that these sound waves would be generated at a variety of wavelengths. In 1992, the Cosmic Background Explorer (COBE) satellite became the first detector to observe the tiny temperature fluctuations in the microwave background, but it didn't have sufficient resolution to discern the small patches of the sky over which temperature variations were greatest. Analysis of data collected by two balloon flights have confirmed that the first peak in the early universe's temperature variation occurred on the same spatial scale predicted by inflation theory. One of these balloons was called BOOMERANG (Balloon Observations of Millimeter Extragalactic Radiation and Geophysics) and the other was called MAXIMA (Millimeter Anisotropy Experiment Imaging Array). Further data analysis has revealed a second peak and the hint of a third one. "We are in the midst of the most exciting period ever in cosmology," Michael Turner of the University of Chicago is quoted as saying, "and it's only going to get better."
- A method of electronic music synthesis based on the generation of trains of sonic particles, called **pulsar synthesis**, is discussed in a paper by Curtis Roads in the March issue of the *Journal of the Audio Engineering Society*. Pulsar synthesis can produce either rhythms or tones and generates sounds similar to vintage electronic music sonorities with several important enhancements.
- The April 2001 issue of *Acoustics Australia* is a special issue on **Speech Science and Technology**. Among the topics dealt with are modeling the human vocal tract in 3D space, sound separation with a cochlear implant and a hearing aid in opposite ears, coding wideband speech at narrowband bit rates, speaker verification, adaptive dynamic range optimization of hearing aids, speech technology in the Oceania region, forensic speaker discrimination, and a forensic investigation of auditory and F-pattern variations in Australian.

Acoustics in the News

- A sniper-detection device developed by BBN Technologies allows soldiers to track the trajectory of a bullet back to a hidden enemy using microphones and a compass mounted on a helmet, according to a note in the July issue of *Scientific American*. These sensors could also be mounted on a truck, aircraft, streetlight or even a building facade. The bullet tracker works when two or more sensors pick up the acoustic signal from the muzzle blast and also the supersonic crack as the bullet speeds along. The system can estimate the trajectory, caliber, and speed of the bullet, the distance it traveled, and the elevation of the sniper.

- Because of the phaseout of older, louder engines, completed in January 2000, the number of people around O'Hare airport exposed to a DNL (day-night level) of 65 dB has decreased about 54%, according to a story in the June 17 *Chicago Tribune*. However, the FAA projects that the number of annual operations—takeoffs and landings—at O'Hare will grow from the current 946,000 to 1.15 million by 2015. If capacity is expanded to meet this projection, the number of people affected by airport noise levels above the 65 dB federal standard would increase by 25 to 30 percent.

- More about the highly directional loudspeaker invented by Joseph Pompei (see "Scanning the Journals" in the Fall 2000 issue of *ECHOES*) appeared in the May 15 issue of the *New York Times*. The "audio spotlight," as the inventor calls it, converts audible sound into ultrasound, which can be shaped into a narrow beam. Distortion in the ultrasonic beam in the air can generate audio frequencies through self-demodulation. One possible application is aboard ships, where the audio spotlight may substitute for radio operators' headsets. Consumer applications may be a few years off.

- The recipient of the first successful larynx transplant three years ago now speaks with a perfectly normal voice, according to a recent story in the *Miami Herald*. Timothy Heidler, a Pennsylvanian who spoke his first raspy "hello" three days after the operation, has continued to improve. Doctors replaced Heidler's larynx along with part of his trachea, throat and nerves. He had been unable to speak normally for 20 years after his throat was crushed in a motorcycle accident. Because

they did not want to disrupt the larynx's blood supply, they also transplanted the nearby thyroid and parathyroid glands. The donor was a 40-year old man who had died of a stroke.

- Researchers in Paris have used sound waves to convert a liquid into a solid, according to a United Press International story on June 4. Sebastien Balibar, a physicist at the Ecole Normale Supérieure, led a research team that applied a burst of 1-MHZ ultrasound to liquid helium, causing minute crystals to form and then disappear an instant later. The sound was directed to helium near a clean glass plate which provided a structure where the crystals could form. Crystals up to 15 microns formed during a compression but melted some 250 nanoseconds later during the negative pressure swing.

(Student Design Competition, continued from page 2)

First Honors with a cash prize of \$1000 was awarded to Jessica Newton and Byron Harrison from the University of Hartford (faculty advisor: Bob Celmer). Four Commendations with cash prizes of \$500 each were awarded to the following groups: Mona Tamari and Jorge Carbonell from the Massachusetts Institute of Technology (faculty advisor: Carl Rosenberg); Lance Hayes and Derrick Knight from Rensselaer Polytechnic Institute (faculty advisor: Rendell Torres); Brian Corry and Lucy Williams from the University of Kansas (faculty advisor: Bob Coffeen); and Greg Hughes, Ryan O'Halloran, and Jon Peterson from the University of Kansas (faculty advisor: Bob Coffeen).

The competition was also supported by the Wenger Corporation, the Newman Student Award Fund, Telex/Electro-Voice, and Auralex Acoustics, Inc. Photographs from the competition can be viewed at:

<http://www.ae.unomaha.edu/lwang/asa2001.htm>.

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